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In Need of a Booster: How to Improve Childhood Vaccination Coverage in Canada

Recent outbreaks of infectious diseases have highlighted the gaps in Canada's vaccination coverage for children. Who's to blame? Not the anti-vaxxers. How to fix it? With targeted outreach to "vaccine hesitant" parents, greater involvement of public health nurses, and a system of checkpoints that encourages those who fall behind schedule to catch up.

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THE STUDY IN BRIEF

Recent outbreaks of infectious disease are a troubling reminder of insufficient vaccination coverage in many communities across Canada. These outbreaks should renew efforts in policies and programs that can expand vaccination coverage, especially among young children. There is also a good economic case. Evidence shows that public funds spent on childhood measles, mumps and rubella immunization results in major cost savings from reduced visits to healthcare providers, fewer hospitalizations and premature deaths, as well as reduced time off by parents to care for sick children.

Parents who do not have their children vaccinated cannot be classified neatly as “anti-vaccine.” Some feel they lack information or have safety concerns, others might find themselves too busy and many are unaware of the risks of infectious disease. The reasons behind incomplete immunization are complex, context- and often community-specific. In this *Commentary*, we explore the many reasons immunization coverage is falling below national targets and we analyze the differences in how provinces organize their immunization programs, encouraging provinces to share lessons learned and embrace common challenges.

A vocal few Canadians – perhaps 2 percent of the population – hold anti-vaccine views, but they are not the main reason for insufficient vaccination coverage, and arguably too much attention and energy are spent trying to engage them. A more sensible strategy would instead target the large group of “vaccine hesitant” parents, whose children get some but not all vaccines, or fall behind schedule. The diverse reasons that these children are unimmunized or underimmunized rule out a simple solution; instead, we advocate varied, multifaceted interventions.

Most provinces need to supplement the unique aspects of their childhood vaccination frameworks with features that help to bolster uptake, including rigorous, early interventions that target vaccine-hesitant parents; greater involvement of public health nurses; use of electronic registries to enable reminders and targeted interventions; and a system of school-based, and increasingly daycare-based, checkpoints and prompts that encourage those who fall behind schedule to catch up.

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Recent outbreaks of infectious diseases are stark reminders of the dangers they pose and of the need for expanded vaccination coverage.

Quebec reported over 700 cases of measles in a 2011 outbreak. There were pertussis (whooping cough) outbreaks in Ontario in 2013, Prince Edward Island in 2014 and 2017, and in Manitoba and New Brunswick in 2015. These, and many others, have occurred even though immunization has reduced the incidence and spread of infectious diseases. The success of vaccination over the past century has removed the once highly visible evidence of the consequences of infectious diseases, particularly for newer generations of parents. When societal benefits are shared, as with vaccinations, people might become less motivated to immunize themselves or their children, thereby eroding the benefits of widespread vaccination for society. Yet everyone – including the unvaccinated – benefits when an individual gets vaccinated. Immunization is especially important for young children, for whom infection can be debilitating or even fatal.

The Public Health Agency of Canada estimates that each dollar spent on childhood measles, mumps and rubella immunization results in \$16 in cost savings from reduced visits to healthcare providers, fewer hospitalizations and premature deaths, as well as reduced time off by parents to care for sick children (Canada 2016).¹ In fact, studies suggest that widespread vaccination was second only to better

access to safe drinking water in its contribution to the improvement in human health over the twentieth century (Andre et al. 2008; Rappuoli 2014).

In this *Commentary*, we explore the many reasons immunization coverage is falling below national targets, including complacency, the costs associated with time off work and the effort both to access a provider and to assess vaccination-related benefits and risks. In addition, there appear to be significant misconceptions about the costs and benefits of immunization. Despite scientific evidence to the contrary, more and more parents are concerned about the risks of immunization than they were in the past (EKOS Research Associates 2011).

One great strength of the Canadian federation is the provinces' ability to learn from one another's experiences. The differences in how provinces organize their immunization programs present an opportunity to profile successes and identify shared challenges.² On this score, we investigate the provinces' experience with the mix of providers, early engagement, school-based interventions, and the collection of data on, and the monitoring of, immunization coverage, among other policy interventions.

Frustration with vocal individuals who hold anti-vaccine views and the wide-ranging reasons

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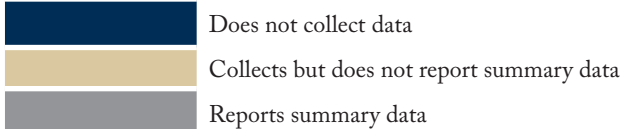
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1 Additional estimates are provided for other common childhood immunizations.

2 This *Commentary* is a more in-depth and extensive analysis of provincial models and their key features than we originally explored in Busby and Chesterley (2015).

Table 1: Provinces that Report Fully Immunized Coverage

Province	Fully up-to-date at:				
	Age 1	Age 2	School Age ³	Grade 6	Grade 9
British Columbia ¹	Collects but does not report summary data	Reports summary data	Reports summary data	Collects but does not report summary data	Collects but does not report summary data
Alberta	Reports summary data	Reports summary data	Collects but does not report summary data	Does not collect data	Does not collect data
Saskatchewan	Collects but does not report summary data	Collects but does not report summary data	Collects but does not report summary data	Collects but does not report summary data	Collects but does not report summary data
Manitoba	Reports summary data	Reports summary data	Reports summary data	Reports summary data	Reports summary data
Ontario ²	Does not collect data	Does not collect data	Collects but does not report summary data	Does not collect data	Does not collect data
Quebec	Reports summary data	Reports summary data	Collects but does not report summary data	Does not collect data	Does not collect data
New Brunswick ²	Does not collect data	Does not collect data	Reports summary data	Does not collect data	Does not collect data
Nova Scotia	Does not collect data	Does not collect data	Does not collect data	Does not collect data	Does not collect data
Prince Edward Island	Collects but does not report summary data	Reports summary data	Collects but does not report summary data	Collects but does not report summary data	Collects but does not report summary data
Newfoundland & Labrador	Collects but does not report summary data	Collects but does not report summary data	Collects but does not report summary data	Collects but does not report summary data	Collects but does not report summary data



Notes: (1) Data from B.C. does not include the Vancouver region. (2) Ontario and New Brunswick does not specifically collect data at ages 1 and 2, but they do collect data from licenced daycares, which means that these age groups should be partially represented there. (3) Provinces differ slightly in their definition of school age.

Sources: Various provinces' immunization coverage reports.

for incomplete childhood immunization might lead some to favour compulsory approaches as solutions, such as removing parents' option to object conscientiously to having their children vaccinated. We believe, however, that such approaches would be misguided, and would lead to further entrenched positions among parents with safety concerns. More important, they ignore the likelihood of accomplishing much higher levels of coverage with stricter voluntary policy measures and more targeted interventions.

We thus urge the provinces to pursue a range of voluntary approaches to overcome the various reasons for incomplete childhood immunization. Provinces that have not already done so should

embrace more nurse-led vaccination programs, emphasize reminders and record-keeping, and use school and daycare entry as an opportunity to assess and promote coverage. There might also be scope for parents to be given financial incentives, although the exact mechanism by which these could be set in Canada is not apparent, and they likely would require substantial collaboration among senior governments. Given our still-limited and likely community-specific knowledge of how to overcome parental concerns about the risks of vaccines, the federal government's direct funding for research into provincial experiments and evaluations of innovative methods to overcome hesitancy would be an important initiative on which to build.

Table 2: Reporting by Infectious Disease at Age 2 and School Age, by Province

	BC ¹	AB	SK	MB	ON	QC ²	NB	NS	PE ³	NL
	2015	2015	2014	2014	2012-13	2014	2014-15		2015	2013-14
	Coverage at Age 2 (percent)									
Fully up-to-date ⁴	70			65.5		73.0				
Measles	86	87.1	75.9	86.3		92.3			86.8	98.2
Mumps	86	87.1	75.6	86.2		92.3			86.0	98.2
Rubella	86	87.1	75.6	86.2		92.3			86.4	98.2
Pertusis	75	75.4	75.7	70.9		93.4			86.3	98.5
Polio	78	75.4	75.5	87.6		93.4			86.6	98.5
Diphtheria	75	75.4	75.7	71.0		93.4			87.1	98.5
Tetanus	75	75.4	75.7	71.0		93.4			87.1	98.5
Hib	79	75.4	76.5	70.4		93.1			86.0	98.5
Varicella	84	86.6	74.9	86.2		94.1			84.7	98.8
Meningococcal	86	81.7	87.8	84.8		96.5			91.0	99.2
Pneumococcal	83	84.9	85.7	84.0		94.3			89.6	98.8
Coverage at School Age (percent)										
Fully up-to-date	63			61.7			69.1			
Measles	90		91.1	75.0	88.3		87.0		95.8	97.2
Mumps	90		90.7	92.4	87.9		87.0		95.7	97.2
Rubella	96		90.7	92.4	95.2		87.0		95.7	97.2
Pertusis	77		77.8	67.1	72.6		76.3		90.7	96.8
Polio	77		85.5	83.8	74.2		75.8		90.3	96.8
Diphtheria	77		78.0	67.4	74.6		75.8		90.8	96.8
Tetanus	77		78.0	67.4	74.6		75.8		90.8	96.8
Hib				91.6					93.0	96.8
Varicella	69		89.4	83.5			78.0		90.1	96.9
Meningococcal	93		93.1	17.2	81.5		89.6		96.9	97.1
Pneumococcal				88.9					88.7	96.2

Does not collect data
 Collects but does not report
 Reports data

Notes: (1) Data from B.C. do not include the Vancouver region. (2) Data from Quebec are estimated from survey data, and likely overstates coverage. (3) Data for PEI come from an in-progress report provided to us by the province. (4) There have been changes in the required vaccines over time, including between these two age groups, so the definition of 'fully up-to-date' is not wholly consistent. This measure also includes Rotavirus vaccines in some provinces, including Quebec.

Sources: Various provinces' immunization coverage reports and authors' calculations.

IMMUNIZATION UNDERCOVERAGE: THE SIZE OF THE PROBLEM

Many provinces publish reports of immunization coverage, but these are highly inconsistent. Provinces profile coverage at different ages, consolidated or broken down by vaccine and even by geographic region. Few provinces produce the natural summary measure: children who are fully up-to-date with their immunization schedule at a given age, even if they collect the vaccination-level data needed to do so (Table 1).³ Importantly, it is not possible to construct credible estimates of national coverage from the vaccination-level data available in each province (Table 2), especially because the two largest provinces choose to monitor different age groups.⁴

Nonetheless, outside of the exemplary performance of Newfoundland and Labrador, most provinces fail to meet the 95 percent or higher national immunization target for many infectious diseases, especially among pre-school-age children. Further, the share of those fully vaccinated at a given age falls 10 or more percent below the share covered for any specific vaccine, indicating that children often miss one or two of their vaccines. This is reinforced by dose-level data reported by some provinces, which frequently display a pattern of missed or late doses, especially for immunizations

that require two or more shots to be effective: at age two, take-up rates for two-dose vaccines (such as measles, mumps and rubella) are significantly higher than for four-dose vaccines (such as diphtheria, polio, pertussis and tetanus).

Why People Are Not Getting Vaccinated

Parents who do not have their children vaccinated cannot be classified neatly as “anti-vaccine.” Some feel they lack information or have safety concerns, others might find themselves too busy and many are unaware of the risks of infectious disease. The World Health Organization’s SAGE Working Group on Vaccine Safety uses the term *vaccine hesitancy* to cover the many reasons for delaying or refusing vaccination. The WHO identifies vaccine hesitancy as a complex, content-specific issue with three main determinants (the “3C” framework): *complacency*, which speaks to the low perceived risks of contracting an infectious disease relative to other pressing responsibilities; *confidence*, such as low trust in vaccines and the decision-makers behind them; and *convenience*, which covers the physical or economic costs involved in accessing immunization services (MacDonald 2015). Although vaccine hesitancy tries to capture the complex drivers of incomplete immunization, and

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- 3 Reporting a measure of those fully up-to-date on their immunizations (also termed “up to date for age” or “fully immunized”) is also the key recommendation of the federally backed Canadian Immunization Registry Network (Canada 2015). See the notes to Table 1 for more information on each province’s reporting activities.
- 4 A second standardization issue is reporting at the level of infections for a given age group. What it means to be fully immunized has changed over time, so older children might or might not meet modern provincial standards, despite having received all the required immunizations for infants at the time. A good illustration of this is the introduction of the Rotavirus vaccine, which began in several provinces in 2013. Poor take-up of this vaccine, however, has dropped fully up-to-date rates considerably in some provinces, even though the rates of other constituent immunizations have risen. Note that headline coverage figures are not the only determination of population immunity, since unvaccinated individuals tend to be found in geographic clusters (Ernst and Jacobs 2012; Smith, Chu, and Barker 2004).

its use in policy discussions might not always be clear,⁵ its main advantage, in our view, is that the underlying categories of determinants – complacency, convenience and confidence – make it easier for policymakers to analyse and address the reasons for incomplete immunization.

The “3C” framework intersects with behavioural economics theories, which have been applied to improved policy in a number of areas in Canada, including retirement savings, education, employment programs and tax compliance (French and Oreopoulos 2016). The application of behavioural economics theories and concepts – such as the role of prevailing norms, opt-in frameworks for consent and the bias and myopic tendencies inherent in perceiving risk – are relevant to discussions of vaccine undercoverage (see Box 1). We use these concepts to guide our analysis.

Summarizing the International and Domestic Evidence on Incomplete Immunization

The WHO characterizes vaccine hesitancy as a continuum: at one end are total accepters of vaccines and at the other end are absolute refusers. Absolute refusers represent the smallest tranche on the continuum, estimated to be around 1 or 2 percent of the population internationally – an estimate corroborated by provincial data from Alberta, Quebec, Ontario, British Columbia and New Brunswick.⁶ Although they are a diverse group, the vast majority of vaccine-hesitant individuals are in the middle of the continuum: they are likely to

be underimmunized, as opposed to unimmunized, meaning they that have received some vaccines but not others, or some doses but not the entire schedule.

Who are incompletely immunized in Canada? Some provinces and regions have investigated demographic and health factors associated with boosting or lowering the likelihood of immunization. For instance, a study in Edmonton found new parents with an older mother, fewer siblings in the house and having a Caesarean section tended to have higher immunization coverage for their children than others (Zhang et al. 2008). The study also found that common-law marital status, single parents, social assistance or low-income healthcare subsidy recipients and the presence of a midwife at delivery were factors associated with lower immunization coverage.

In Vancouver, data for vaccination coverage of kindergarten students was merged with school-level demographic data to investigate the characteristics of schools and student populations associated with lower coverage. The study found that private, non-religious schools, larger schools and schools with a greater proportion of indigenous students and those with English as a second language, as well as schools with students from lower-than-average socio-economic backgrounds, were associated with lower immunization coverage (Carpiano and Bettinger 2016).

In Quebec, the provincial biennial survey of immunization coverage investigates the factors associated with incomplete vaccination at ages one and two (Quebec 2015). It finds that missing

5 A reviewer of an earlier draft objected to a broad application of “vaccine hesitancy” to all reasons for under coverage, and strongly suggested that issues of access should remain clearly outside this definition, as mentioned in MacDonald et al (2015). We acknowledge this point, but counter that access issues do strongly underpin the “convenience” determinant and some further clarity on how access relates to hesitancy might be helpful.

6 Ontario and New Brunswick collect data on those who request exemptions to vaccines at school entry; Alberta and B.C. publish the share of children who refuse all immunization; Quebec calculates the unimmunized in a rigorous investigation after a measles outbreak in the province (Quebec 2014).

Box 1: Behavioural Economics and Public Health

An area of research known as behavioural economics could offer simple policy changes to help Canadians make better, more informed healthcare choices (see Kahneman and Tversky 2000; Roberto and Kawachi 2015; Thaler and Sunstein 2008). Several themes are applicable to childhood immunization. One is the importance of the “default option” in the immunization choices presented to parents. Many provinces already have an opt-out model of consent, but as a general principle it could be applied to many design aspects of the immunization process. For instance, automatically scheduling appointments (with the option to cancel or reschedule them) has been shown to be effective at improving vaccine take-up (Chapman et al. 2010). So has asking individuals to write down the date they will get their shots (Milkman et al. 2011).

A second theme of behavioural economics is the general problem of “availability bias,” which is similar to the complacency aspect of vaccine hesitancy. Many parents do not feel any immediate threat posed by vaccine-preventable diseases, which leads them to undervalue the benefits of immunization. Chen and Stevens (2016) propose to overcome this bias by personalizing the abstract threats through instructional videos and attempting to persuade parents to make more objective decisions.

A third theme is the strength of prevailing norms in influencing decisions. Appealing to individuals’ social identity by pointing out that most of their peers behave a certain way has been shown to influence decisions in many contexts (French and Oreopoulos 2016). In the case of immunization, the strength of this peer pressure is readily available: more than 90 percent of Canadian parents get their children to their first shots, a figure that might be quite compelling to new parents.

A fourth theme is the importance of “framing” immunization messages. The design and wording of pamphlets and forms has been shown to affect outcomes in many cases (French and Oreopoulos 2016). These are some of the most celebrated “nudges,” relatively easy to implement and sometimes surprisingly successful. As one example, phrasing the benefits of vaccination in terms of losses instead of gains (and taking advantage of individual’s loss aversion in doing so) might well improve uptake (Chen and Stevens 2016). There is likely room for many such “nudges” to improve vaccine uptake in Canada. Any approach, however, should include some commitment to experimentation: staging interventions, measuring the results and deciding which to implement on a wider scale (see Thaler 2016).

a vaccination at the two-month post-partum visit, receiving vaccines at a doctor’s office rather than in a community clinic, being the parents’ third or later child and, not surprisingly, feeling insufficiently informed or concerned about the risks of vaccines are all strong predictors of not being fully vaccinated. The study further finds that mothers in the lowest income quintile, below age 30, who are single parents and have less than a

university education are also factors associated with incomplete vaccination. Other research in Quebec has highlighted complacency – parents who do not see why getting vaccinated is important to prevent the spread of disease in the community – as another factor (Dubé et al. 2016).

Internationally, the story is much the same: perceived risk of illness, cost (including a lack of time), inconvenience, distrust, lack of information,

fear of adverse side effects and safety are highlighted as major reasons for hesitancy (Yaquub et al. 2014). Other studies have found that, in addition to demographic characteristics of parents, the main reasons for undervaccination are related to the difficulty of accessing services, the attitudes and beliefs of health professionals, the fear of side effects and lack of trust in health providers (Favin et al 2012).⁷

In sum, a single source of incomplete vaccination is not easy to identify: the reasons for undercoverage likely vary across provinces and geographic regions and between vaccines and population groups. In this *Commentary*, we focus on the efforts of, and tools available to, policymakers to improve childhood immunization coverage, but we do not address ways to change the minds of parents who have strict anti-vaccine opinions because we do not think additional effort here would be a good use of resources and energy. We are primarily concerned with how hesitancy relates to behavioural economic issues, such as organizational design, incentives and opportunity costs, as well as with how applied behavioural sciences can better help explain vaccination decisions.

Overview of Immunization Programs in Canada

In Canada, the federal, provincial and territorial governments share responsibilities for immunization. In 2003, collaboration among the three levels of government established a National

Immunization Strategy (NIS) to improve equity of access to vaccines, increase coordination of program planning and immunization registries and develop national goals.⁸ The priorities of the NIS were reviewed in 2011 and new objectives announced in 2016, including setting new targets for coverage, the identification of the under- and unimmunized, access to and information about vaccines and strategies to boost immunization coverage.

Critically, the federal government organizes the bulk purchases of vaccines by the provinces and helps coordinate the Canadian Immunization Committee, which acts as a national forum to implement the NIS, foster collaboration among provinces and improve immunization programs. The major responsibilities of the federal government include vaccine approval, regulation, safety monitoring and providing advice on use. The National Advisory Committee on Immunization (NACI) reviews evidence on safety, efficacy and optimal use, and soon will provide advice on the cost-effectiveness of vaccines to those who make recommendations on the use of new ones (Gemmill 2016).⁹ That said, provinces continue to make their own independent assessments of vaccine use. More important for the focus of this *Commentary*, the delivery and administration of vaccination programs are provincial responsibilities; as a result, program designs and the efforts provinces undertake to encourage vaccination uptake vary widely.

7 In the United States, children with incomplete immunizations tended to be black, have a younger unmarried mother, have a mother without a college degree and live near the poverty level (Smith et al. 2004).

8 Funding for the NIS was supported by a federal commitment in the 2005 budget of \$45 million over five years to strengthen a national collaboration framework and \$300 million over three years to introduce four new vaccines, and another \$300 million, three-year commitment in 2007 to introduce HPV vaccines.

9 Since 2004, when the CIC was created, there has tended to be some overlap with the NACI, as the CIC reviews the recommendations on vaccines made by NACI and provides additional recommendations, including cost-effectiveness. The NACI's mandate will be reviewed and updated in 2017.

Key Features of Provincial Models

Among the key features of provincial immunization programs – for details, see the Appendix – is the mix of healthcare professionals who administer vaccines. In some provinces, such as Alberta and Prince Edward Island, public health nurses are exclusively responsible for administering vaccines to infants and children (Table 3).¹⁰ In other provinces, such as British Columbia, Manitoba and Quebec, family doctors and pediatricians play a major role in urban centres, but public health nurses (and sometimes registered nurses) still administer most vaccines; typically, as one moves farther from urban centres, public health nurses play a more exclusive role in vaccine administration. In Saskatchewan and Newfoundland and Labrador, public health nurses play a major role, and only a small portion of urban physicians are involved in childhood immunization.¹¹ Finally, in Ontario, Nova Scotia and New Brunswick, family physicians and pediatricians are responsible for giving most vaccines, with public health nurses administering vaccines in rural regions.

Provinces also vary in how they monitor immunization coverage. A number operate a registry, with records created near the time of birth and immunizations recorded when administered. For example, Alberta, Saskatchewan, Manitoba,¹² Prince Edward Island and Newfoundland and Labrador have official registries containing a record of every childhood immunization given in the province. Quebec estimates that it will have

expanded its existing registry to physicians' offices and hospitals by 2018, so that it covers all childhood immunizations. The province currently runs biennial surveys of parents to estimate coverage among 15- and 24-month-old children.¹³ Neither Ontario nor New Brunswick collects data when a vaccine is administered – instead, immunization status is collected by schools and licensed daycares. In Nova Scotia, coverage data are not published, and the province has no standard method for collection.

The method of data collection and the provider mix strongly influence the policy interventions each province takes to boost immunization uptake. Generally speaking, provinces with nurse-led models and complete registries focus on bolstering vaccination uptake using targeted and scheduled early interventions. In Alberta, Saskatchewan, Manitoba, Quebec, Prince Edward Island and Newfoundland and Labrador, this normally begins with a post-partum home visit by a public health nurse, when parents are informed about immunization benefits and risks and can book appointments for the first round of vaccinations. Enabled by provincial registries, Alberta, Saskatchewan and Manitoba send out reminders prior to and/or after the scheduled first round of vaccinations.¹⁴

In British Columbia, information about vaccines and local public health units is provided all parents as part of the pre-natal process. A public health nurse normally calls after the expected due date to schedule a vaccination appointment. For those in the Vancouver region, one's family doctor or

10 Physicians and RNs are also able to administer vaccines in these provinces, but generally do not.

11 Physicians mainly operate in St. John's, and from April 1 2017, the regional health authority has indicated it will no longer distribute childhood vaccines to family physicians.

12 B.C.'s comprehensive registry does not cover the Vancouver Mainland, where phone surveys are used to estimate coverage instead.

13 Currently, Quebec surveys 1,000 parents in the province to obtain information about vaccine coverage at ages 1 and 2.

14 In Manitoba, many physicians have their own notification systems or approaches for their patients. Public health nurses may send reminder letters at 15 months and at ages 2 and 7. In Alberta, the procedure starts with the arranging of a visit by a nurse, who will make up to three phone calls if the initial attempt to reach the family is unsuccessful. Quebec plans to use its registry for automatic reminders once it is fully implemented.

Table 3: Features of Provincial Models

Province	Who Administers Childhood Vaccines?	Percent of Total Vaccines Administered (approx.)	Registry	Record Created at Birth/first dose	Key Feature of Vaccination Model
British Columbia	Family Doctors or Physicians	30	Yes	Yes (except for physicians who don't enter into registry in Vancouver)	<ul style="list-style-type: none"> Information about vaccines and contact information about the public health unit provided to all parents as part of the pre-natal visit. Public health nurse will call after expected due date to schedule appointment for vaccination. In Vancouver Mainland, half of the children are vaccinated by family physicians and the other half by public health nurses. Some public health units run programs targeting low-income and vulnerable mothers.
	Public Health Nurses	70			
Alberta	Family Doctors or Physicians	0	Yes	Yes	<ul style="list-style-type: none"> Physicians cannot bill for vaccines and nurses were assigned with administering childhood immunization. Healthy Beginnings Nurse informs parents about immunization benefits, and to arrange visit within first 14 days. Systematic reminders. Infants not immunized get follow up call, upto three calls are made.
	Public Health Nurses	100			
Saskatchewan	Family Doctors or Physicians	1	Yes	Yes	<ul style="list-style-type: none"> Launched electronic registry in 1996. Hospitals notify Public Health of each birth, nurse contacts new parents to set up home visit providing immunization information. Systematic reminders.
	Public Health Nurses	99			
Manitoba	Family Doctors or Physicians	50	Yes	Yes	<ul style="list-style-type: none"> Parents get visits from Public Health nurses within a day or two providing immunization information. Systematic reminders. Physician billing data tied to Public Health to track immunization records.
	Public Health Nurses	50			

Table 3: Continued

Province	Who Administers Childhood Vaccines?	Percent of Total Vaccines Administered (approx.)	Registry	Record Created at Birth/first dose	Key Feature of Vaccination Model
Ontario	Family Doctors or Physicians	85	Yes	No	<ul style="list-style-type: none"> Mandated choice at school entry. Reminders are sent before the child is subject to suspension from school for those without up-to-date immunizations. Registry used only to monitor coverage; data not entered at time of administration.
	Public Health Nurses	15			
Quebec	Family Doctors or Physicians	20	In Development	In Development	<ul style="list-style-type: none"> Vaccination information provided as part of pre-natal information booklet, with postpartum visit by nurse to arrange vaccination. Emphasis is to ensure no delays in take up in early infancy. No fault compensation provided for vaccine injuries. Registered Nurses are legally allowed to administer vaccines by themselves.
	Public Health Nurses and Registered Nurses	80			
New Brunswick	Family Doctors or Physicians	Majority	No	No	<ul style="list-style-type: none"> Mandated Choice at School Entry. Nurses enter data into public and mental health system; while doctors use a green vaccination card. Daycares also require proof of immunization serving as a check point.
	Public Health Nurses				
Nova Scotia	Family Doctors or Physicians	70-75	No	No	<ul style="list-style-type: none"> Vaccination information is part of standard prenatal information. There is no comprehensive data collection or reporting of immunization coverage. Physician offices run independent programs to encourage immunization.
	Public Health Nurses	25-30			

pediatrician is primarily responsible for scheduling and follow-up. Although every new parent receives a phone call from the public health nurse, there is no systematic approach to follow-up if parents are not responsive. Some local public health units run their own programs that target uptake among low-income or vulnerable mothers.

Provinces without registries, and where physicians are mainly responsible for administering vaccines, tend to focus their policy efforts on capturing those who might fall through the cracks by screening at school entry (and daycares) – New Brunswick and Ontario both require proof of up-to-date immunizations at school entry. The key

Table 3: Continued

Province	Who Administers Childhood Vaccines?	Percent of Total Vaccines Administered (approx.)	Registry	Record Created at Birth/first dose	Key Feature of Vaccination Model
Prince Edward Island	Family Doctors or Physicians	0.5	Yes	Yes	<ul style="list-style-type: none"> Hospitals provide information and contact Public Health as part of discharge process. Nurses do post-natal visit within 48 hours, where immunizations are discussed. Launched electronic registry in 2004 (data starts in 1995). The PEI Public Health Act, Immunization Regulations requires any immunization delivered to be recorded and reported quarterly to the Central Public Health Officer.
	Public Health Nurses	99.5			
Nfld. & Lab.	Family Doctors or Physicians	10	Yes	Yes	<ul style="list-style-type: none"> At birth, information is entered into database with follow-up appointment scheduled. Parents who do not submit consent forms are followed up.
	Public Health Nurses	90			

Source: Authors' compilation.

feature of these models is mandated choice: parents are required to provide proof of immunization or submit a form, signed by a notary public, stating their opposition (on religious or conscientious objection grounds). Pre-school-age immunizations are the responsibility of a family doctor or pediatrician, except in some rural regions, and there is no standardized approach to ensure complete vaccination among physician practices. Ontario, however, offers incentives and bonuses to family health teams that meet vaccination targets for children in their practice.

Saskatchewan is unusual in emphasizing both early interventions and checks to ensure coverage at school entry. Parents in Saskatchewan, however, are not asked to complete a form requesting exemption. In late 2016, Alberta announced it would also begin matching school class lists to the province's vaccination registry, with public health officials contacting parents with incomplete records and requiring those who choose not to get their children immunized to sign an exemption form.¹⁵

15 Although all provinces follow a policy of "informed consent" for new parents, they may require parents to express consent in different forms: some require or encourage written consent for the schedule of vaccines, but most require only verbal consent. All school-based immunizations require consent in writing. Quebec is unique in Canada in offering a no-fault compensation program for victims of vaccine injuries.

Success Stories and Lessons from the Provinces

Nurse-led Models Generally Result in Better Uptake

Although encouraging multiple providers to administer vaccines has some notable advantages, such as providing numerous points of access, this approach has limitations. One is varying access to health professionals: Canadians – in nearly all provinces – face major difficulties accessing a family doctor in a timely manner. Timely and flexible access matters because individuals incur private costs from having to take time out of a busy schedule to get their child vaccinated (Deuson et al. 1999; Guay et al. 2003). Yet, only 34 percent of Canadians claim to have access to after-hours care, 43 percent say they are able to obtain same- or next-day access to their family doctor (CIHI 2017), while the many Canadians who do not have a family doctor are particularly vulnerable in provinces with physician-led programs. Public health nurses, in contrast, generally offer flexible after-hours care, so that nurse-led programs are able to provide more opportunities to reduce the costs associated with planning and taking time off work.

Ontario has put in place financial incentives to encourage doctors to bolster immunization coverage among toddlers. In 2004, the province offered bonus payments based on the proportion of children ages 30 to 42 months among the physician's patients who received at least five immunizations: \$440 if 85 percent of such patients hit the target, \$1,100 if 90 percent did so and \$2,200 if 95 percent of eligible patients were covered. Li et al. (2013) find, however, little empirical support that Ontario's measures have boosted coverage.

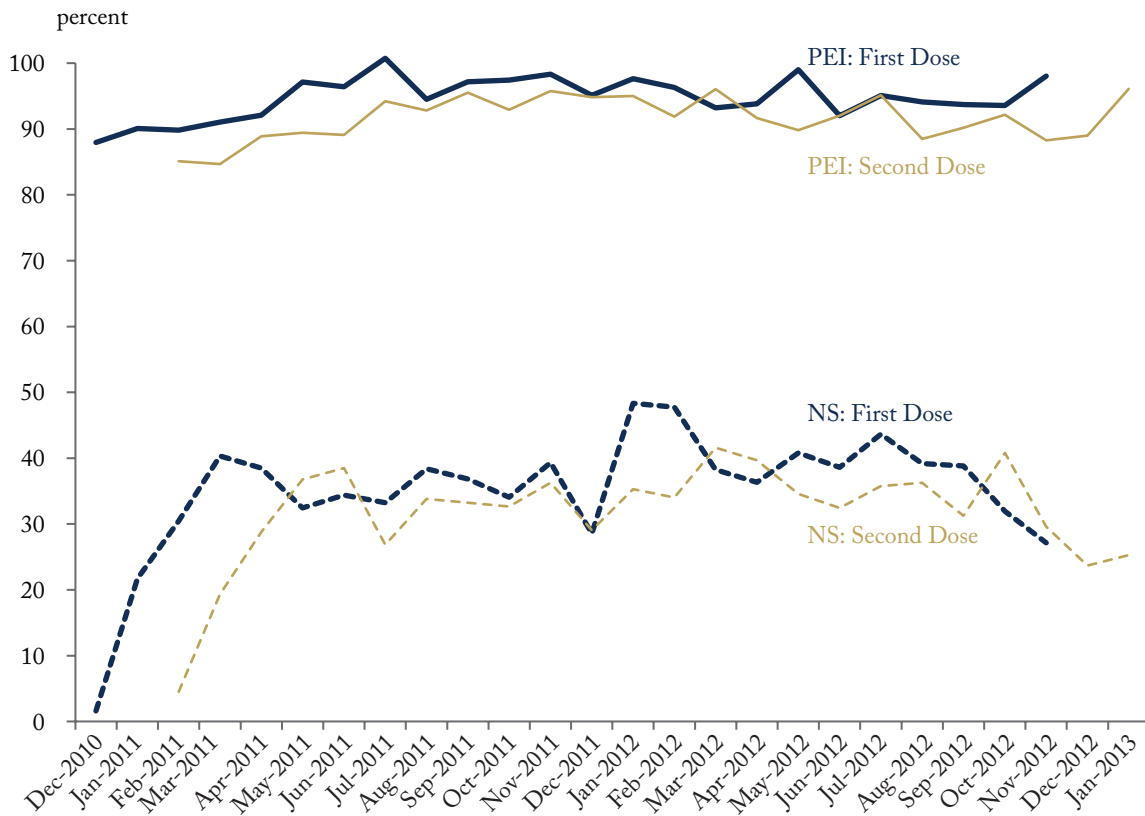
When it comes to the use of multiple providers to administer vaccines, a larger issue is how expanded access might also restrict the ability of public health departments to coordinate immunization programs. Individual physician practices are more likely to vary in their approaches to vaccine hesitancy, improving access and patient follow-up. Some family practices might do an excellent job overcoming concerns and ensuring timely immunization, while others might perform poorly. In contrast, public health departments can set province-wide protocols for the nurses or other caregivers directly in their employ to discuss, record and follow up with parents on childhood immunization.

A number of examples offer evidence of the ability of public health authorities in Canada to coordinate nurse-led programs effectively. Zelman et al. (2014), in a study of comparable regions in a fully nurse-led model (Prince Edward Island) and a mixed-provider model (the Capital Health Region of Nova Scotia), find that, over the two years after a new Rotavirus vaccine was introduced in 2011, coverage exceeded 90 percent for both doses in PEI while barely reaching 40 percent in Nova Scotia (Figure 1).¹⁶ The authors note that, in Nova Scotia, a lack of awareness of the new vaccine among physicians persisted despite numerous outreach attempts to bolster participation.¹⁷

Another example is Quebec, which has shifted the location of vaccinations toward community clinics (Centres locaux de services communautaires, or CLSCs) and away from physicians' offices. Between 2006 and 2015, the number of vaccines delivered to the one-year-old cohort at CLSCs

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- 16 The Rotavirus vaccine was offered free of charge in Nova Scotia's Capital Health Region only for the two-year duration of the study; this is no longer the case. The results of the study are still illustrative of the issues, however; if anything, the limited availability of free vaccines in Nova Scotia should have biased the results upwards.
- 17 Alarmingly, the authors also observe that the reimbursement rate for these vaccines was sometimes deemed too low by physicians to be worth administering.

Figure 1: Comparing the Introduction of Rotavirus Vaccine in PEI and the Capital Health Region of Nova Scotia



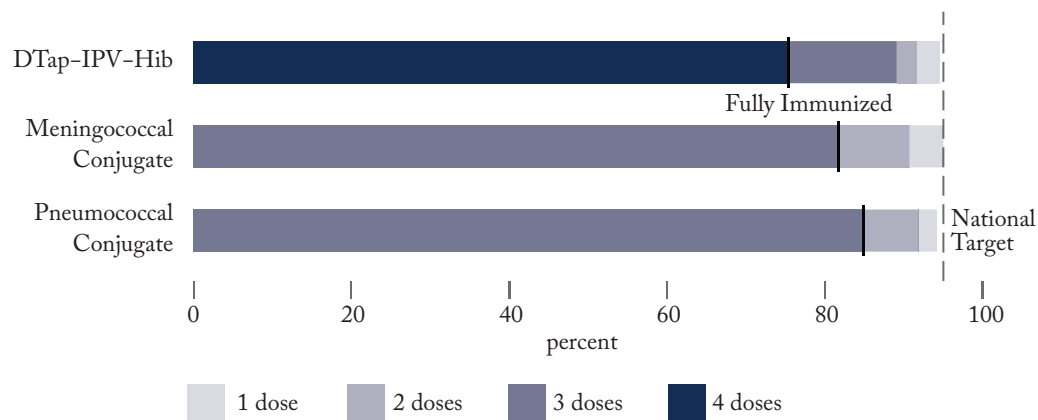
Source: Zelman et al. (2014).

increased by 15 percentage points, while the share of children with fully up-to-date and on time vaccinations rose from 23 to 62 percent (Quebec 2015).

Although some of the evidence presented here might capture multiple policy changes over time, and perhaps even geographic characteristics unique to each province, we nonetheless think it supports the idea that there are greater advantages in nurse-led models that should improve uptake. This, of course, does not mean that physicians should not have a critical role in supporting immunization efforts – they always will.

Mixed-provider models also might hinder immunization efforts due to the inconsistent use of registries – provinces with registries are overwhelmingly those where nearly all vaccinations are given by nurses. In the Vancouver region, for example, physicians are exempt from the otherwise province-wide requirement to enter children’s immunization information in the provincial registry; as a result, little is known about immunization coverage in the province’s largest city, and surveys are being used to help fill the gaps. Manitoba stands apart as having a true mixed-provider model with a complete registry,

Figure 2: Immunization Coverage at Age 2 for Vaccines with More than 1 Dose, Alberta (2015)



Notes: The DTaP-IPV-Hib vaccine is administered in four doses, recommended at 2, 4, 6, and 18 months of age. Meningococcal and pneumococcal conjugate vaccines each require three doses of their respective vaccine before age 2. Thus children are only fully immunized for these diseases if they have received all of the required doses.

Sources: Alberta Health Services and authors' calculations.

but even here physicians do not actually enter the data themselves – billing data are imported into the registry system after the fact by public health authorities.

Successful Interventions to Keep Young Children on Schedule

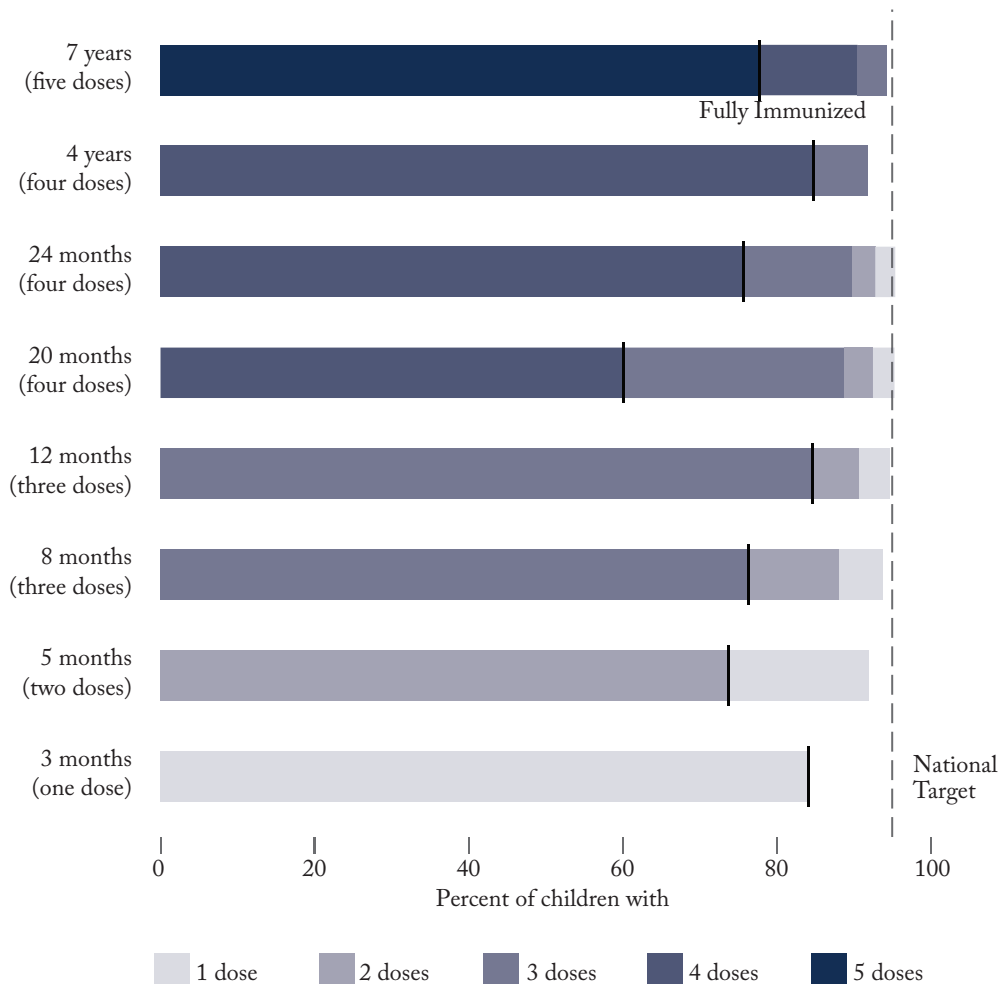
Provincial immunization schedules emphasize that children should receive as many vaccines as possible before age two, because young children are disproportionately vulnerable to infectious diseases. It should be no surprise that this front-loaded schedule means that children commonly fail to receive all the required doses of a vaccine. Figure 2 shows coverage at age 2 in Alberta for

vaccines that require more than one dose: although enough children get the first dose to meet target coverage rates, there is significant fall-off for later doses. In Quebec, one of the strongest predictors of whether a child is up-to-date on its vaccines at an older age is whether it received the first one on time – usually at two months of age (Quebec 2015). Hence, underimmunization is partly a problem of establishing good habits from the first two-month vaccines and keeping parents on schedule.

In light of this, many provinces – particularly those with registries that support healthcare providers' activities – directly target underimmunized populations with early interventions.¹⁸ In Quebec, gains in coverage have occurred over

¹⁸ There is also potential to intervene prior to birth, presenting information to would-be parents and dealing with issues and concerns prior to the stressful post-partum period. Research on the success of pre-birth interventions is, however, scarce.

Figure 3: Uptake of Pertussis Vaccine by Age and Dose, Saskatchewan (2014)



Notes: DTaP-IPV-Hib is administered in four doses, recommended at 2, 4, 6, and 18 months of age. An additional “booster” is recommended between ages 4 to 6. Although partial vaccination makes contracting and transmitting these infections less likely, it does not eliminate them. Infants too young for vaccination often contract infections from adults or adolescents who are missing one or both boosters (Saskatchewan Ministry of Health 2015).

Sources: Saskatchewan Ministry of Health and authors’ calculations.

successive surveys from the timely completion of early scheduled vaccinations (Quebec 2015). In some provinces, this emphasis is more implicit, as illustrated by the strong commitment to implementing and maintaining reminder systems in Alberta, Saskatchewan, Manitoba

and Newfoundland and Labrador. In Alberta, for instance, parents are called or sent a letter of reminder up to three times if they miss the two-month immunization milestone. Relatedly, such reminders have been found to be useful in other contexts: in Manitoba, there is evidence of the

effectiveness of mailed reminder letters to seniors ages 65 and older (Hilderman et al. 2011).

School-Based Prompts to Catch Those Who Fall through the Cracks

Despite all the good reasons to focus on early interventions and to find new and more effective ways to boost vaccine take-up, a rigorous system to catch those with missed vaccinations is nonetheless a valuable backstop. Aside from interventions before age two, the other main source of coverage assessment and intervention in Canada is at entry into primary school. Both New Brunswick and Ontario place heavy emphasis on this milestone, although coverage is also assessed at school entry in Saskatchewan and, most recently, in Alberta.

This checkpoint system could induce higher coverage rates. For example, the Toronto public health department reports that reminders and the threat of suspension – if parents make no formal vaccination choice – increased coverage from an initial 75 percent to 97 percent (Toronto 2012). Indeed, for the many provinces with comprehensive data, there is a distinct “catch-up” pattern, with coverage increasing as children reach school age. In Saskatchewan, 76 percent of two-year-olds have all four required doses of pertussis vaccine, but this share rises to 85 percent among four-year-olds and to 91 percent by seven years of age, when children are in first grade (Figure 3).

Of course, checking coverage at school entry is a natural and beneficial exercise – for many children, this is their first major exposure to the risk of infectious disease. However, with the number of dual-earner families with children nearly doubling from 1976 to 2015 (Statistics Canada 2016), strict enforcement is somewhat shifting away from school entry and toward daycare. Ontario and New Brunswick have already moved in this direction by monitoring coverage at licensed daycares, but there is no strict protocol at daycares to ensure sufficient coverage.

Screening at school is also valuable as a way to ensure that interprovincial and international

migrant children are up-to-date with their vaccinations. In the past decade, roughly 840,000 Canadians ages seventeen or younger moved between provinces, while Canada received 940,000 international migrants of those ages, so it is hard to think of an effective approach to vaccine uptake that would not cover such new arrivals rigorously, which is precisely what backstop, school-based checkpoints allow.

INTERNATIONAL APPROACHES TO INCREASE VACCINE UPTAKE

Other countries and regions are also trying to overcome vaccine hesitancy, some with unique and multifaceted approaches. Behaviourally driven experimental interventions – for instance, the automatic scheduling of appointments with the option to cancel or reschedule – have been shown to be effective at improving take-up (Chapman et al. 2010), and so has asking individuals to write down the date they will get their shots (Milkman et al. 2011).

Yet despite some clear success stories, systematic reviews of the international literature on interventions generally conclude there is no “silver bullet” with which to ameliorate vaccine hesitancy (Dubé, Gagnon, and MacDonald 2015; Jarrett et al. 2015). Most efforts to date have focused on education and awareness-raising, and differ little from other programs to improve vaccination uptake over the decades. There are also dangers in a confrontational, education-based approach: Nyhan et al. (2014) report that messages intended to refute the link between vaccines and autism *decreased* the intention to vaccinate among the most vaccine hesitant. A similar pattern was observed in combating the notion that the influenza vaccine can cause the flu (Nyhan and Reifler 2014). The evidence on successful face-to-face communications between parents and healthcare providers is also quite mixed (Dubé, Gagnon, and MacDonald 2015), even though such contact is the most direct way such providers interact with vaccine-hesitant

parents (Gust et al. 2008). Along these same lines, both reminder/recall systems and mandatory vaccination prior to school entry have been shown to increase coverage, but it is not clear that these interventions by themselves address all reasons for incomplete immunization (Dubé, Gagnon, and MacDonald 2015).

There are, however, also some important examples of successful interventions abroad. In the United Kingdom, for example, after years of increasing measles cases, a nationwide catch-up campaign was launched in 2013 with the aim of ensuring that 95 percent of children ages ten to sixteen received at least one dose of the MMR vaccine. The campaign included targeted communication to raise awareness, tasking general practitioners with identifying at-risk populations, charging directors of public health with ensuring specific plans for at-risk populations, and establishing a comprehensive reporting procedure. The coverage targets were met at roughly the midpoint of the campaign (Simone et al. 2014; Public Health England 2013)

Another important example of a multifaceted approach is that taken in Australia in its response to low vaccination coverage in the mid-1990s. The country put in place financial incentives for physicians, reminder systems and school-based checks to ensure up-to-date vaccinations. New parents were also offered financial incentives in the form of a bonus Maternity Immunisation Allowance and by making the receipt of child benefits (the Australian Childcare Allowance) partly conditional on the child's immunization status. Doctors were also given financial incentives to immunize infants, and when children reach school, they are required to show evidence of immunization (Australia 2013). Since

these programs were put in place, Australia's immunization coverage has improved dramatically, and now exceeds 90 percent for all recommended vaccines (Australia 2014).

The Australian federal government has also pushed to eliminate conscientious objection as a valid exemption from childhood immunization – thereby moving toward a more mandatory system. Beginning in 2016, parents could no longer claim conscientious objection to vaccination and also qualify for unreduced child benefits. By September that year, 19 percent of those who had previously qualified for this exemption had immunized their children – although these amounted to just 0.3 percent of young children overall (Leask and Danchin forthcoming). The federal government has also urged the states to remove parents' ability to conscientiously object when their children enter childcare services and pre-schools. At time of writing, however, less than 50 percent of Australian children live in a state that excludes the children of vaccine objectors from childcare services and pre-school, because of states' reservations about the unintentional consequences of moving toward a mandatory immunization model.¹⁹

What emerges from the international literature is that most successful interventions have been comprehensive in their approach, sometimes tailored to a specific context and region – awareness-raising alone is inadequate (Jarrett et al. 2015). Australia's experience illustrates the need to tackle the diverse reasons for hesitancy with a variety of approaches, and also that high levels of vaccination coverage are possible with voluntary measures.

RECOMMENDATIONS

The provincial and international evidence suggests that a combination of voluntary policies and

19 Leask and Danchin (2017) give a number of examples of how the removal of vaccination objections has affected some families.

Table 4: Provincial Recommendations

Jurisdiction	Major Recommendations
Federal	<ul style="list-style-type: none"> Collaborate with provinces to experiment and evaluate targeted approaches to overcome hesitancy. Set new mandate and funding for Canadian Immunization Research Network (CIRN). Encourage one harmonized measure of coverage for fully vaccinated at school entry. Lead the economic evaluation processes for individual vaccines, and as part of the empirical exercise in economic evaluations demonstrate the relationship between vaccine coverage and cost effectiveness. Small financial reward if registry meets desired capabilities mentioned in the National Immunization Strategy.^a Support coordinated responses to outbreaks that attempt to bolster coverage.
British Columbia	<ul style="list-style-type: none"> Embed Public Health nurses in primary care practices in the Vancouver region. Set up automatic reminders. Mandated choice at school entry. Input data into the immunization registry at time of administration in the Vancouver region.
Alberta	<ul style="list-style-type: none"> Report coverage data at age 7. Follow through with mandated choice at school entry. Use registry to target hesitant with interventions and aim for less delays in uptake at 2,3,6 months – set good habits early on.
Saskatchewan	<ul style="list-style-type: none"> Move from just checking coverage at school entry to mandated choice. Use registry to target new and innovative approaches to identify and overcome hesitancy.
Manitoba	<ul style="list-style-type: none"> Embed more Public Health nurses in primary care practices in Winnipeg. Use registry to target new and innovative approaches to identify and overcome hesitancy. Mandated choice at school entry.
Ontario	<ul style="list-style-type: none"> Report coverage at school, daycare and region level. Embed Public Health nurses in primary care practices. Try to link physician billing data to registry to circumvent problem of incomplete physicians' data entry. Better utilize registry by inputting data at time of immunization.
Quebec	<ul style="list-style-type: none"> Complete registry transition. Report coverage to include physicians' offices and hospitals at school, daycare and region level. Continue shifting place of vaccine administration to CLSC's. Mandated choice at school entry.
New Brunswick	<ul style="list-style-type: none"> Report coverage at school, daycare and region level. Embed Public Health nurses in primary care practices. Plan to move towards registry that starts at birth.
Nova Scotia	<ul style="list-style-type: none"> Embed Public Health nurses in primary care practices. Start collecting data at school entry with mandatory choice. Plan to move towards registry that starts at birth.
Prince Edward Island	<ul style="list-style-type: none"> Report at ages and milestones other than fully immunized at age 2. Utilize registry to identify and target interventions for vaccine hesitant. Implement automatic reminder system.
Newfoundland & Labrador	<ul style="list-style-type: none"> No major recommendations.

^a <http://www.phac-aspc.gc.ca/publicat/nis-sni-03/index-eng.ph>.

procedures could address many of the complex, varied reasons for immunization undercoverage among children, including appropriate provider interventions, the timely collection and use of data, the need for prompts at entry to school and rigorous and targeted interventions to overcome specific hesitancy issues. Some provinces already have a number of these features in place, and are well equipped to reach higher immunization coverage ratios; others, particularly those without a registry or that enter data at or before two months of age, face a steeper challenge. Our major recommendations for each province can be found in Table 4.

Expand the Role of Public Health Nurses in Administering Vaccines

Many studies have underscored that the opinions and advice of confident, trustworthy and knowledgeable health professionals underpin all efforts to increase vaccination uptake (see, for example, Dubé et al. 2013). We argue that this observation further demands that healthcare providers be trained and empowered to address vaccine hesitancy in its many forms, although the training required for this task will become increasingly specialized over time.²⁰ This, in concert with the evidence on provider-linked uptake across Canada militates strongly in favour of expanding the role of public health nurses where possible.²¹

At the same time, primary care across Canada increasingly is moving to more comprehensive, team-based physician care models – with team-based family practices intending to serve as a “patient’s home.” Embedding more public

health nurses within these primary care teams is a pragmatic way to proceed in the short run. Nurses could become the primary providers in charge of vaccinations, with physicians and other caregivers acting in a complementary manner. This recommendation is especially relevant in Ontario, New Brunswick, Nova Scotia and in the Vancouver region, where physicians are now mainly responsible for administering vaccines.

In discussions of the scope of practice for administering vaccines, pharmacists are often – and rightly – seen as a low-cost way to remove barriers to immunization. Most provinces, however, do not allow pharmacists to deliver childhood vaccines, and given that the challenges of childhood immunization differ from those of adults, we do not now envision a vastly expanded role for pharmacists in childhood immunization.²²

Establish Provincial Registries and Make Better Use of Existing Ones

Some provinces lack any kind of registry, while others fail to start a file at birth or to input data when a vaccine is administered. Some registries are also more valuable than others for the day-to-day activities of healthcare providers (see Wilson et al. 2016). The lack of a timely registry prevents healthcare providers and policymakers from identifying the undercovered, the specific reasons behind their incomplete immunization history and the best approaches for tackling it. Registries also enable many interventions – including automatic reminders and the recording of reasons for hesitancy – that help to tailor the approach to addressing hesitancy early in the process. Some provinces – Nova Scotia and New Brunswick

20 We acknowledge here the many provincial efforts in this regard, including the position statements and practice points advocated by the Canadian Pediatric Society (MacDonald and Finlay 2013), which is a valuable and ever-changing guide.

21 Alberta, recognizing this challenge, stopped paying physicians to give vaccinations. Today, nearly all childhood vaccinations in the province are given by public health nurses.

22 A future *Commentary* will look at issues specific to adult immunization.

– need to take steps to establish a registry; others – Ontario and British Columbia – should make better use of the registry already in place.²³ Although we believe having more public health nurses embedded in family practices should improve opportunities for appropriate data entry, in the interim the provinces could make better efforts to link physician billing data to the registries, as Manitoba has done.

Harmonize Coverage Reporting across Provinces

Inconsistent availability and collection of vaccination coverage data prevent any robust estimate of the extent of coverage at the national level, for any age group.²⁴ Only 20 percent of Canadian children are born in provinces with a registry that starts near birth, while the two largest provinces focus on reporting at two different age groups: Quebec at ages one and two, and Ontario at school entry. We believe all provinces should report the results for those fully immunized at school entry, aiming to produce these reports sometime in the next decade. We choose school entry as the reference point because it represents the most feasible option, given current provincial data collection capabilities, to put forth a comparable national figure of vaccination coverage. The long-term goal should be to report coverage at age two across the country, in keeping with most common immunization schedules and in line with the core

recommendation of the federally backed Canadian Immunization Registry Network (Canada 2015).

Use Checks and Signposts to Ensure Adequate Coverage

School-based prompts ensure that policymakers capture those who might have missed a vaccine, usually due to complacency, as well as new migrants to a province. More important, such prompts have proved to have a significant impact on uptake, particularly in Ontario. These checks are lacking in a number of provinces; accordingly, we suggest provinces put in place a screen for coverage at school entry that requires parents to fill out a form if they wish to opt out, and to have it signed by a notary public. On this score, we support Alberta's decision in late 2016 to move in this direction.

Traditionally, policymakers have focused on school entry, likely because the vast majority of schools are publicly funded and administered, which simplifies coordination with public health authorities. But the ever-growing prevalence of dual-earner couples should compel provinces to start deliberations on how they can move towards making daycare entry a more central point of intervention. Although parents may enroll their child in daycare at any age, in Ontario and Quebec only around 5 percent of all regulated daycare spaces are available from 0-18 months of age – care for children aged 18 months and older amounts

23 Ontario's incomplete use of its registry has been well documented; see Ontario (2014),

24 This obvious gap at the national level has received attention before, motivating the childhood National Immunization Coverage Survey, available most recently for 2013 (Canada 2017). Infection-level coverage in this survey was generally in the 70 to 90 percent range. Surveys provide only estimates of coverage, and are generally inferior to the precise figures generated from a registry. Moreover, province-level results from the 2013 survey are in many cases inconsistent with registry-generated data. For provinces without a registry, rates are likely overstated: for provinces that introduced registries in the 1990s or 2000s, it was not uncommon to find actual coverage rates 10 percent or more below the survey data. New Brunswick demonstrates this phenomenon well: when the province began collecting data from daycare centres in 2011, it found that only about 45 percent of children were up-to-date with their immunizations, far below what was expected (New Brunswick 2015).

to over 90 percent of all childcare (Robson 2017). Given that the early childhood immunization schedule is complete at 18 months, this might be the ideal age in which mandatory choice could be introduced to childcare.

This approach is complicated, however, because unlike schools not all daycares fall under the purview of provincial or local authorities, which increases the operational challenges for public health. True, there are many informal childcare arrangements – through family caregivers, nannies or unlicensed daycares – but private and religious schools, not to mention homeschooling options, also frustrate interventions at school entry. Thus, to begin, provinces should, as public health officials debate the options for mandated choice in daycare, publish data on coverage in individual daycare centres, as they should for schools.

Include an Active Role for the Federal Government

An oft-highlighted element of the Australian model is that child benefits are reduced if a child is not vaccinated. Although in Canada the federal government is responsible for the largest child benefit transfer, such an approach is likely a poor option for this country. Cash transfers to parents are administered separately from provincial vaccination programs, so implementation would require a herculean effort of interjurisdictional data-sharing.²⁵ Further, the federal child benefit is no longer universal, as high-income families no longer qualify, which would further undermine federal efforts along these lines. Another option would be a tax deduction for childcare expenses – but again,

since not all informal (unlicensed, family or nanny) childcare providers collect or report vaccination coverage data, but would qualify for the deduction, the use of this tool to create financial incentives for parents would be uneven.

The federal government could also offer small grants to push the provinces toward more standardized reporting and metrics, with the goal of creating a federal report that collates the provincial data and outlines the gaps. This might one day better support a system of financial incentives. More important, grants could be offered to ensure the establishment and appropriate use of registries.

We endorse the federal government's recently announced support for the evaluation of interventions to overcome vaccine hesitancy through the Immunization Partnership Fund. As part of this effort, we suggest shifting the mandate of the Canadian Immunization Research Network toward investigating approaches to overcoming vaccine hesitancy at the regional and community level, particularly in geographic pockets identified as having major issues of lack of coverage or undercoverage.²⁶ This effort could include establishing, in cooperation with the provinces, teams of public health providers that go to pockets of undercoverage to address hesitancy and boost coverage within identified communities.²⁷

The coordination of joint provincial-territorial bulk purchasing of vaccines is a key part of the federal government's role in immunization policy. We think Ottawa should go further and take over the economic evaluation process for individual vaccines, which is currently an ad hoc provincial process. (See Box 2 for a discussion of one challenge for the federal government here, given

25 Provincial child benefit transfers in Canada are highly targeted to low-income families, which reduces the potential effectiveness and attractiveness of this option.

26 We also suggest that behavioural economists should be included as researchers in this new network.

27 This approach could build upon the lessons learned in Quebec's Opération rougeole (Operation Measles) in 2011 and 2012.

Box 2: Vaccine Cost-Effectiveness and the Relationship with Vaccine Coverage

A unique feature of cost-effectiveness evaluations of vaccines, relative to those of drugs, is the additional sensitivity of the results due to assumptions about vaccination uptake. Traditional Markov models for evaluating vaccines' cost-effectiveness make assumptions about coverage rates and then perform sensitivity analysis around these baseline assumptions. The concept of "herd immunity," however, creates a non-linear response in calculated health benefits as they relate to coverage rates. In other words, as coverage rates approach and fall below herd immunity levels, there is a dropoff in cost-effectiveness. This link is especially important in the context of this *Commentary* because the decision to approve new vaccines is, as a result, closely linked to the effectiveness of provincial programs that encourage vaccine uptake. Provinces with ineffective uptake programs that struggle to hit herd immunity thresholds will be more likely to miss standard cost-effectiveness thresholds to qualify for public funding, even if the vaccines are clinically effective. Consequently, the federal government will be challenged to make universal recommendations for new vaccines on behalf of all provinces in performing cost-effectiveness analysis. At the same time, these analyses can serve to draw more attention to the important differences in uptake programs across provinces.

that economic evaluations of vaccines are linked with the effectiveness of provincial vaccination programs.)

Use No-fault Insurance to Support Efforts to Encourage Uptake

As more people are actively persuaded by governments to get their children vaccinated and as the suite of policies mentioned here is pursued, the greater will be the need for provinces to create a no-fault insurance fund, as in Quebec, for when unlikely problems arise. Although a federally coordinated insurance plan is a possibility, we currently favour creating independent provincial plans because many factors that could cause rare risks occur at the provincial and local levels. Such insurance programs would be affordable – Quebec has spent around \$5 million to resolve 40 accepted claims (among the 258 submitted) in nearly 30 years of existence (see Quebec 2016).

Such insurance plans would be ethically justifiable in the sense that they would provide a clear path for compensation for rare risks, as opposed to the existing opaque and expensive judicial processes claimants must follow in most provinces.

Eschew Mandatory Vaccination

Were the provinces and the federal government to pursue a number of the recommendations here and move to more comprehensive and multifaceted approaches to boosting coverage, we think provincial vaccination frameworks would be better equipped to meet immunization coverage targets. Some commentators, however, might view this suite of voluntary recommendations as insufficient; a number have recently suggested that the best way to ensure "herd immunity" is to make vaccinations mandatory – in other words, no parent should be able to make a conscientious objection and refuse a vaccine for a non-medical reason (Hospital

News 2016).²⁸ This response, however, would be misguided. Such an approach would not directly overcome parental concerns or anxieties. It would not prevent the need for special approaches in certain religious schools and communities, and it would likely alienate individuals who have some mistrust of government or the medical community – perhaps further entrenching their opposition. Moreover, excluding the children of parents with concerns over vaccination safety from the benefits of public education would be difficult to justify. The responsible approach instead would be to ensure coverage among the largest share of individuals possible so as to insulate the small fraction that remains.

CONCLUSION

A vocal few Canadians hold anti-vaccine views, but they are not the main reason for insufficient vaccination coverage, and arguably too much attention and energy are spent trying to counteract

their perspective. A much more sensible strategy would be to target the “fence-sitters”²⁹ – those who are not fully immunized for an assortment of reasons. The diverse reasons children are unimmunized or underimmunized necessitate multifaceted approaches; the solutions require less precision and more varied simultaneous initiatives. Most provinces need to supplement the unique aspects of their vaccination frameworks with features that help to bolster uptake, including rigorous, early interventions that target vaccine-hesitant parents; greater involvement of public health nurses; use of registries to enable reminders and targeted interventions; and a system of school- and daycare-based checkpoints and prompts that encourage those who fall behind schedule to catch up.

28 This is distinct from related policies, such as those that remove unimmunized children from schools in the case of an outbreak, which are common in Canada and many other jurisdictions (Leask 2017).

29 This is a term used by Leask (2011) that we think summarizes the approach we advocate in this *Commentary*.

APPENDIX: PROVINCIAL VACCINATION FRAMEWORKS

The British Columbia Model: Mixed Providers in the Lower Mainland; Public Health Nurses Elsewhere

In the Vancouver region, which is home to about 60 percent of the province's population, about half the children are vaccinated by family physicians and the other half by public health nurses. Elsewhere in the province, vaccines are administered almost exclusively by public health nurses. Data on vaccination coverage come from surveys and a registry, and although it is common practice for nurses to enter data directly into the registry when vaccines administered, doctors do not do so routinely. Consequently, the province must survey individuals in the Vancouver region to obtain a more complete picture of coverage. Information about vaccines and contact information for the local public health unit are given all parents as part of the pre-natal process, and a public nurse normally calls after the expected due date of the child to schedule an appointment for a vaccination. Parents must sign an approval form to consent to the full schedule of childhood vaccinations. There is no systematic follow-up of non-responsive parents. Some local public health units independently run programs that target low-income or vulnerable mothers.

The Alberta Model: Public Health Nurses and a Registry

In Alberta, all routine infant immunizations are done by registered nurses at one of over 100 Community Health Centres operated by Alberta Health Services. Physicians cannot bill for administering vaccines, a move implemented to reduce overlap in administering vaccines and to make data collection more consistent (Keelan 2008). An immunization record is created for any

child born in a hospital, and a Healthy Beginnings nurse is in touch with the parents shortly afterward to discuss health services, including the importance of immunization, and to arrange a visit within the first 14 days. Consent is given the public health nurse by the parent/guardian in person. If the infant is not immunized within two months, the parents are called or sent a letter to remind them. Up to three calls are made if the initial attempt to reach the family is not successful. A refusal to immunize is recorded in the registry.

The Saskatchewan Model: Public Health Nurses and a Registry

Roughly 99 percent of childhood vaccinations in Saskatchewan are administered by public health nurses, with the remainder mostly given by pediatricians. Saskatchewan launched an electronic registry of immunization records in 1996; all publicly funded vaccinations are entered into this system when administered. Hospitals automatically notify the public health authorities of each birth, and a nurse then contacts the new parents to set up a preliminary home visit. This visit, usually in the first weeks after birth, includes a discussion of immunization and dates may be scheduled on which the newborn child can receive its vaccinations – automatic reminders are then put in place. Informed consent by a parent or guardian – verbally in person, in writing or over the telephone – is required before a vaccine can be administered. School-based vaccinations require parents to complete a written consent form. As a later check to ensure full immunization, when children enter school their immunization records are scrutinized by public health for missing or out-of-date vaccinations.

The Manitoba Model: Mixed Providers and a Registry

Manitoba has a mixed-provider model, with physicians, registered nurses, public health nurses and pharmacists all administering vaccines depending on the patient and particularly on the region of the province. In Winnipeg, more than 90 percent of childhood vaccines are given by a physician, the share falling as distance from the city increases; in rural areas, vaccines are exclusively administered by public health nurses. Babies born in Winnipeg are assigned a pediatrician as part of the normal hospital discharge; the province's public health department is also notified. Most people take the pediatrician they are assigned; some opt to go to their family physician. The pediatrician or family doctor sets follow-up meetings and gives vaccines. New parents across the province also get a visit from a public health nurse within a day or two, who provides immunization information. Manitoba recommends public health nurses and some providers use a written consent form, but in urban areas most consent is given verbally by the parents to the doctor administering the vaccine.

Manitoba's registry sends out automatic reminder letters to parents of children who are not fully vaccinated at set intervals. Many physicians have their own notification systems or approaches, but these are essentially up to individual providers, and nothing about them is regulated or structured. Depending on the child, public health nurses may follow up numerous times, including reminder letters at fifteen months, two years, and seven years of age.

The Ontario Model: "Mandated Choice"

In Ontario, immunizations normally are given at the office of one's family doctor. Nurses and midwives can also give vaccinations, although midwives generally do not play a significant role because post-partum care ends before the initial set of immunizations at eight weeks. Although Ontario's vaccination schedule for newborns begins at two months, and many parents begin to vaccinate their children at that time, data are not officially recorded until a child enters school. Ontario's *Immunization of School Pupils Act* (IPSA) and *Day Nurseries Act* create a mandated choice model whereby parents must either provide proof that their child is immunized or submit a form requesting an exemption, which, under the ISPA, must be witnessed by a commissioner of oaths, notary public or justice of the peace.³⁰ If the parents do neither, the child is subject to suspension from school (although not from a nursery).

An exemption can be based on religious concerns or conscientious objection, broadly defined – meaning that parents need not show particular evidence of any given objection. Conscientious objection rates have been rising over time, but still represent only around 1 percent of Ontario students (Wilson et al. 2015). Each regional public health unit may decide exactly how it carries out the school-based exemption process, including how many reminders are sent before a suspension notice is issued. In 2016, Ontario announced it would require parents who file a religious or moral objection to complete a course intended to inform them of the importance of immunization and the dangers of foregoing it.

30 A restricted list of vaccines is enforced under this legislation, expanded in 2014 to account for new dose requirements for tetanus, diphtheria, polio and mumps, and new vaccines for diseases such as whooping cough, chickenpox and meningococcal disease. The ISPA applies to private, public and Catholic elementary and secondary schools; the *Day Nurseries Act* applies to licensed nursery schools.

The Quebec Model: Mixed Providers and a Registry

In Quebec, children can receive vaccinations from a family doctor, pediatrician, public health nurse or registered nurse; about 80 per cent are given by nurses. Vaccination information is included in the normal pre-natal information booklets, and a nurse makes a post-partum visit to arrange vaccination. An immunization card is given to parents at the child's birth or first vaccination appointment. At each vaccination, at two, four, six and twelve months, the nurse talks the parents through the process and obtains verbal (implicit) consent. A province-wide vaccination registry is due to be completed by December 2018. Biennial surveys collect vaccination coverage data to help inform the province of coverage at ages one and two. Data are also gathered from schools – for example, concerning the administration of HPV vaccine for girls. Quebec is unique in Canada in offering a no-fault compensation program for victims of vaccine injuries.

The New Brunswick Model: Mixed Providers; Mandatory Choice at School Entry

In New Brunswick, publicly funded vaccines are administered through a mixed-provider model, with the vast majority of vaccinations given by either a public health nurse or a family physician. Usually, if a family first goes to a physician, the physician will continue to provide the immunizations; if a family first goes to a public health clinic, the clinic will continue the vaccination schedule. The mixed-provider model varies by region: Fredericton is serviced primarily by physicians, while smaller communities such as Bathurst are overseen predominately by public health nurses. Public health nurses enter data in a system, while physicians use a green vaccination card. The province does not have a registry, but vaccination coverage is measured at school entry, when parents must make a choice in case to fully immunize their

child, similar to mandatory choice in Ontario. Daycare centres also require proof of immunization of a certain number of doses, serving as the checkpoint for the 18-month booster; parents of unimmunized or underimmunized children can then be encouraged to get them vaccinated.

The Nova Scotia Model: Mixed Providers

In Nova Scotia, 70 to 75 percent of vaccinations of children up to age five are administered by a family physician located in one of nine District Health Authorities; the rest, typically in rural areas with limited primary care, are administered by public health officials and nurses. Written consent for immunization is the norm, although it can also be given verbally. Vaccination information is part of the standard pre-natal information, but the setting up of reminders and other aspects of vaccination frameworks according to the provincial schedule varies depending on the provider. Data on coverage are spotty, with some obtained from physicians who use an electronic record system and some obtained at school entry, but no collection method is in place to determine province-wide coverage.

The Prince Edward Island Model: Public Health Nurses and a Registry

Immunization programs in PEI are administered by public health nurses. Hospitals provide information and contact public health automatically as a part of the discharge process. Public health nurses make a post-natal visit within 48 hours of birth at which vaccination is discussed and written consent is obtained from parents for all pre-school immunizations; consent is required again at age four. All vaccinations must be recorded and reported in the province's registry system, which has data back to around 1995. The province reports vaccination coverage at grade one, grade 6 and grade 9.

The Newfoundland and Labrador Model: Nurse-led, Non-compulsory, Informed Choice

Newfoundland and Labrador has a nurse-led model whereby, upon birth, information is entered into a database and a follow-up appointment is scheduled with the new parents in the following weeks. The public health nurse gives the parents full information about the vaccination decision, and requires written consent to schedule an appointment for the first phase of the immunization regimen. The process is one of informed consent, meaning the nurse must explain the purpose, risks and side effects of the procedure, and provide an opportunity for questions. If parents are hesitant, the nurse will follow up later and answer any further questions. Written consent must be renewed at kindergarten and again for grades four, six and nine. Parents who do not submit consent forms are followed up, but there are no penalties for not returning the written forms. The province's approach is to "take every opportunity" – meaning asking and offering vaccinations at many different times, even if doses have been missed before.

The Territories Model: Nurse Providers and Community Focus

Childhood immunization, like most healthcare services, is provided by specially-trained, embedded community health nurses. For larger communities, there may also be a public health clinic where public health nurses may administer childhood vaccines.³¹ Although the procedure depends on the clinic

and the community, nurses generally follow up with parents by phone, and sometimes in person, with some communities making use of local radio. There is a requirement both in Nunavut and the Northwest Territories to report all immunizations administered. There are no electronic registers. Standardized paper record-keeping is extensive, however, and the Northwest Territories began moving towards centralized immunization records in 2012. Electronic medical records, including for childhood immunization, are being considered for implementation. Anecdotally, coverage is perceived as high given existing information.

The embedded nature of community nurses puts them in a unique position to encourage immunization uptake because they are empowered to make decisions and aware of all births and community needs. Immunization status is regularly checked at school entry, and in larger communities in the Northwest Territories school vaccines are evaluated during the year of a vaccination program. These checks occur at the local clinic, making it easy to correct missed doses or vaccines.³²

The territories face unique challenges. Many communities suffer from nurse attrition and a general lack of health care resources, which results in shifting of nurses' time towards acute needs and away from timely childhood immunization. Remote communities may also face technological constraints in that they lack the bandwidth for comprehensive electronic communication or record keeping.

31 Public health nurses do not usually administer childhood vaccines in Nunavut.

32 Unlike the provinces, immunization against tuberculosis is provided as part of the vaccination schedule for population health purposes.

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