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Improved vaccine coverage for First Nations children receiving first dose on-reserve: a retrospective cohort study in western Canada

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ABSTRACT

Introduction Fragmentation in immunisation reporting systems pose challenges in measuring vaccine coverage for First Nations children in Canada. Some Nations have entered into data-sharing agreements with the province of Alberta's health ministry, enabling novel opportunities to calculate coverage.

Methods Partnering with a First Nations community in Alberta, this retrospective cohort study calculated routine childhood vaccine coverage. Administrative data for vaccines delivered within and outside the community were linked to calculate partial and complete immunisation coverage in 2013–2019 at ages 2 and 7 years for children living in the community. We also compared vaccine coverage each year for (a) children who were and were not continuous community residents and (b) children who received or not their first vaccine at the on-reserve community health centre. We also calculated the mean complete coverage across all study years with 95% CIs.

Results For most vaccines, coverage was higher ($p<0.05$) at ages 2 and 7 years for children that received their first vaccine at the First Nations health centre, compared with those who received their first dose elsewhere. For example, for pneumococcal vaccine, the mean level of complete coverage in 2-year-olds was 55.7% (52.5%–58.8%) for those who received their first vaccine in the community, compared with 33.3% (29.4%–37.3%) for those who did not; it was also higher at 7 years (75.6%, 72.7%–78.5%, compared with 55.5%, 49.7%–61.3%).

Conclusion Initiating the vaccine series at the on-reserve community health centre had a positive impact on coverage. The ability to measure accurate coverage through data-sharing agreements and vaccine record linkage will support First Nations communities in identifying individual and community immunity. The findings also support the transfer of health funding and service delivery to First Nations to improve childhood immunisation uptake.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Incomplete data prevents accurate measurement of vaccine coverage for First Nations communities in Canada, creating challenges in assessing individual and community protection from disease.

WHAT THIS STUDY ADDS

⇒ Vaccine coverage was low across all vaccines in all years of the study.

⇒ For children who received their first dose of vaccine in the First Nations community health centre, there was consistently higher coverage than those who received their first dose elsewhere in Alberta.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Improved measurement of vaccine coverage in First Nations communities is possible when electronic data, technological advances and data-sharing agreements enable linkage of vaccine records.

⇒ Indigenous self-determination and the provision of immunisation services on-reserve can improve vaccine coverage.

BACKGROUND

Immunisation is a critical preventive health measure for the protection of child health.[1] However, vaccine coverage in the province of Alberta, like the rest of Canada, is below the level needed to maintain herd immunity (ie, community protection), with coverage even lower in specific subpopulations.[2 3] Suboptimal coverage contributes to outbreaks of potentially deadly diseases, such as Alberta's 2013–2014 measles outbreaks.[4]

Inequities in the health status of Indigenous peoples in Canada are well documented.[5] In Canada, the term 'Indigenous' refers to First Nations, Métis and Inuit peoples. Although significant diversity exists between and within these groups, Indigenous peoples share a common history of colonisation, dispossession from lands and sovereignty, and experiences of state-sanctioned violence.[6] First Nations people in Alberta, and across Canada overall, experience a higher incidence of

vaccine-preventable diseases than their non-First Nations counterparts.[7] With respect to immunisation coverage, recent studies from the USA[8 9] and Australia[10 11] show lower immunisation coverage and significant delays in the timeliness of immunisation for Indigenous children. Existing Canadian studies show mixed results[12–16]; however, there is a lack of accurate information on immunisation coverage among First Nations children in Canada. Enhancing knowledge in this area would enable the identification of gaps in service, with the goal of improving immunisation coverage to ensure that First Nations children are protected against vaccine-preventable diseases.

Gaps in knowledge regarding vaccine coverage among First Nations children are largely explained by 'record scattering', that is, immunisation data for this group are often stored in disparate locations and/or are difficult to access. In Alberta, individual-level data on vaccine doses delivered outside First Nations communities (ie, off-reserve) are held by the Alberta Ministry of Health, while historically, doses delivered on-reserve are retained within the community and only reported at the aggregate level to the federal-level First Nations and Inuit Health Branch, making accurate measurement of coverage difficult.[7] This highlights the critical need to merge data sources for doses administered on-reserve and off-reserve to determine accurate measures of immunisation status for First Nations children.

To address this issue, some First Nations communities in Alberta have entered into data-sharing agreements with the provincial Ministry of Health to enable sharing of individual-level data held in on-reserve electronic immunisation registries with the provincial immunisation repository, known as ImmARI. The purpose of this partnership project was to use this linked data to accurately measure vaccine coverage by age 2 and 7 years for children living in a large First Nations community in Alberta, Canada.

We had three specific research questions:

1. What was the level of coverage for each vaccine for all 2-year-old and 7-year-old children living in the community at the age of assessment? This enabled assessment of the level of community protection.
2. Of the children living in the community at the age of assessment, what was the level of vaccine coverage for children who were continuous residents in the community, as compared with those who were not? This enabled assessment of the ability of the community health centre to immunise children who were continuous residents in the community.
3. Of the children living in the community at the age of assessment, what was the level of vaccine coverage for children who received the first dose of any vaccine at the First Nations community health centre, as compared with those who did not? This allowed assessment of the ability of the community health centre to immunise children who initiated their vaccines within the community.

METHODS

Using linked administrative health data, this retrospective cohort study calculated vaccine coverage for select publicly funded routine childhood vaccines for children aged 2 and 7 years in a First Nations community in Alberta. These ages were selected as they are the ages when coverage for early childhood vaccines are routinely measured in Canada.[17 18] The vaccines assessed were: diphtheria-containing vaccines (diphtheria-tetanus-acellular pertussis vaccine with or without polio and/or Haemophilus influenzae type b [DTaP, DTaP-IPV, DTaP-IPV-Hib]), measles-containing vaccines (measles-mumps-rubella [MMR] or MMR-varicella [MMRV]), pneumococcal conjugate vaccine and meningococcal-C conjugate vaccine. Birth cohorts were created for 2-year-olds born in each year from 2011 to 2017 (coverage assessed in 2013–2019) and 7-year-olds born from 2008 to 2012 (coverage assessed in 2015–2019).

Setting, population and data sources

The study occurred in the province of Alberta, population 4.4 million. The delivery of routine childhood vaccines in Alberta is carried out solely by public health nurses based in community health centres. Alberta has 200 health centres operated by the provincial health authority that offer immunisation services, plus 44 First Nations communities that offer immunisation services on-reserve. Immunisation service delivery on-reserve is the responsibility of Indigenous Services Canada or the communities themselves, depending on the governance structure. All childhood vaccines in the provincial recommended schedule (see online supplemental appendix A) are provided free of charge, regardless of where they are delivered.

The population of focus for this study was First Nations children from a rural First Nations community in central Alberta, which is home to over 17 000 people[19] from four First Nations. The community is served by an on-reserve community health centre, which provides vaccines to children (and adults) living in or affiliated with the community. In addition, children can also access vaccines at the provincially operated community health centres located off-reserve. Data for vaccines administered on-reserve are recorded in the community's electronic immunisation database. Data for vaccines administered off-reserve are captured in the provincial health authority databases and then submitted to the Alberta Ministry of Health's province-wide immunisation data repository, known as ImmARI. Since March 2018, the First Nations community in this study has had a data-sharing agreement with the Ministry, which allows records for off-reserve vaccines to be accessed by providers within the on-reserve health centre, and allows on-reserve vaccine records to be automatically submitted to ImmARI on a daily basis. Data from the community have been entered into ImmARI retrospectively for vaccines administered since 2007. On submission to ImmARI, the data are cleaned, and duplicate records are removed. The Ministry is the steward of

this data, although the First Nations community maintains data ownership and control.

The birth cohorts for this study were created using administrative health databases held by the Ministry of Health, which can be linked using the unique lifetime identifier issued to each Alberta resident. The initial cohorts were generated using the Vital Statistics database, which contains all the births that occur within the province of Alberta. Then the Alberta Health Care Insurance Plan (AHCIP) registry was used to exclude study participants who died or left the province during the study period. Quarterly AHCIP registry data were used to identify current and continuous residence in the First Nations community, based on a unique geographic postal code for the community. The record of immunisation, including location of first immunisation, was obtained by combining on-reserve and off-reserve vaccine data in ImmARI.

Patient and public involvement

This study was part of a larger project conducted in partnership with the First Nations community's health service providers and leadership, and includes engagement with parents in the community, as vaccine decision makers for their children. The purpose and design of this current study were developed in partnership with the community health service leadership, to ensure that the project met the needs and expectations of the community, and was respectful of First Nations community processes and data governance.[20] The dissemination of findings was approved prior to submission for publication and will be shared back to the community through a community report.

Data analysis

Immunisation status for each child was assessed on the day the child turned the relevant age (2 or 7 years). We calculated 'complete' immunisation (ie, receipt of all doses scheduled by the age of assessment) and 'partial' immunisation (ie, receipt of one or more, but not all, doses scheduled by the age of assessment). We counted only one dose of antigen administered per day and counted only those with an effective dose flag (eg, MMR vaccine is only deemed effective if received after 1 year of age). The number of required doses was adjusted for the variation in dose number based on age at the first dose where appropriate (eg, only one dose of meningococcal vaccine is needed if the first dose is administered after 1 year of age). Because the meningococcal immunisation schedule changed from three doses to two doses in 2014, we considered 'complete' coverage to be two doses.

To answer our three research questions, we first calculated complete and partial vaccine coverage, with 95% CIs, for all children living in the community at the age of assessment. Next, using Pearson χ^2, we (a) compared coverage for those who had continuous residence in the community from birth to age of assessment, versus those who did not, and (b) compared coverage for those who received the first dose of any vaccine at the First Nations community health centre, versus those who did not.

Vaccine coverage was calculated as the proportion of the eligible population who had received all doses (complete coverage) or some but not all doses (partial coverage) of each vaccine. Vaccine coverage was calculated for each vaccine for each birth cohort that turned 2 years old from 2013 to 2019 and those who turned 7 years old from 2015 to 2019. We then calculated the mean complete vaccine coverage over all the years of study (with 95% CIs), for each vaccine at ages 2 and 7 years. Data extraction and cleaning were done in SAS (Enterprise Guide V.8.3). Analysis of coverage, 95% CIs, group comparisons, figures and summary tables were created using R (V.3.6.3).

RESULTS

During the study, 2684 children were born to families with postal codes on reserve. Due to the migration of families on and off-reserve during the study period, 3810 children were included in the cohorts for calculation of vaccine coverage at 2 years of age (2013–2019), and 2739 children were included in the cohorts for the calculation of vaccine coverage at 7 years of age (2015–2019). Complete and partial coverage at 2 and 7 years of age for all the vaccines studied are presented in figures 1–4, while numerators and denominators (and 95% CIs) for each vaccine coverage calculation can be found in online supplemental appendix B.

Diphtheria-containing vaccines

At age 2 years, complete coverage (ie, four doses) for diphtheria-containing vaccines for all children living in the community in the study years (2013–2019) ranged from 19.9% (95% CI 14.9% to 25.0%) to 29.6% (95% CI 23.9% to 35.4%) (figure 1 and online supplemental appendix B). Complete coverage each year was similar for the subset of children who lived continuously in the community between birth and 2 years, versus those who did not ($p>0.05$). Complete coverage each year for the subset of children who received their first dose of any vaccine in the community health centre was higher (24.8%–33.9%) than those who did not receive their first dose in the community (13.2%–22.8%), although the difference was only statistically significant for the cohort that turned 2 years old in 2013 ($p=0.02$). Partial coverage at 2 years (ie, one, two, or three doses) ranged from 83.0% (95% CI 78.2% to 87.7%) to 90.5% (95% CI 86.9% to 94.2%) for all children living in the community in the study years. This was similar for the subset of children who lived continuously in the community, compared with those who did not ($p>0.05$). Partial coverage each year for children who received their first dose of any vaccine in the community health centre was 99.2%–100%, since, by definition, children who received their first dose of any vaccine in the community received their first dose

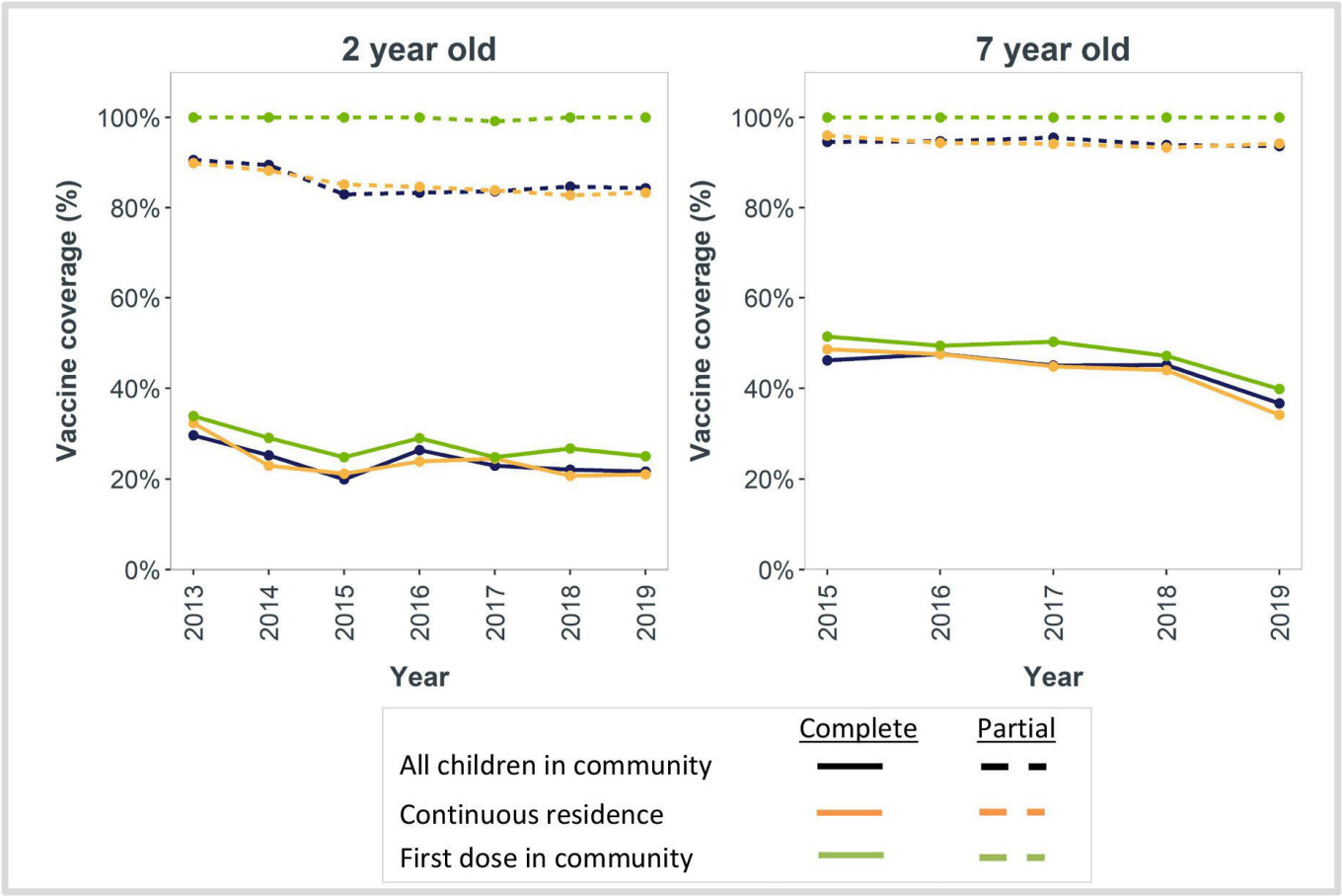

Figure 1 Vaccine coverage for diphtheria-containing vaccines: four doses due by age 2 years and five doses due by age 7 years.

of diphtheria-containing vaccine (which is scheduled for 2 months of age) at the health centre.

At age 7 years, complete coverage for diphtheria-containing vaccines (ie, five doses) for all children living in the community during the study years (2015–2019) ranged from 36.7% (95% CI 29.8% to 43.6%) to 47.6% (95% CI 41.1% to 54.1%) (figure 1 and online supplemental appendix B). Complete coverage each year was similar for children who lived continuously in the community, compared with those who did not (p>0.05), while coverage each year was higher (39.8%–51.4%) for children who received their first dose of any vaccine in the community health centre, compared with those who did not (26.5%–42.6%), although the difference was only statistically significant for children turning 7 years old in 2015 and 2017. Partial coverage at 7 years (ie, one, two or three doses) ranged from 93.6% (95% CI 90.1% to 97.1%) to 95.5% (95% CI 92.8% to 98.2%) for all children in the community and was similar for those with continuous residence versus not (p>0.05). Partial coverage for those who received their first dose in the community was again 100%, as described previously.

Table 1 presents mean complete coverage across all years of the study for each vaccine. The mean complete coverage for diphtheria-containing vaccines at age 2 years was 24.1% (95% CI 21.9% to 26.2%) among all children resident in the community. The mean coverage for children who were continuous residents in the community (24.0%, 95% CI 21.6% to 26.4%) was not statistically significantly different from those who were not (24.3%, 95% CI 19.6% to 29.0%) (p=0.97). In contrast, the mean complete coverage for those who received their first dose of vaccine at the community health centre was higher (28.0%, 95% CI 25.2% to 30.8%) compared with those who did not receive their first dose of vaccine at the community health centre (17.1%, 95% CI 14.0% to 20.3%) (p<0.01). We did not compare mean partial coverage for these two variables, given that, by definition, partial coverage was 100% for those who received their first dose in the community.

At 7 years of age, the mean complete coverage for diphtheria-containing vaccines across all the years studied among all children resident in the community was 44.5% (95% CI 41.6% to 47.4%). The mean complete coverage for children who were continuous residents in the community (44.2%, 95% CI 40.5% to 47.9%) was not statistically significantly different from those who were not (44.9%, 95% CI 40.3% to 49.6%) (p=0.85). The mean complete coverage for those who received their first dose of vaccine at the community health centre was higher (48.2%, 95% CI 44.8% to 51.5%), compared with those who did not (33.2%, 95% CI 27.7% to 38.7%; p<0.01).

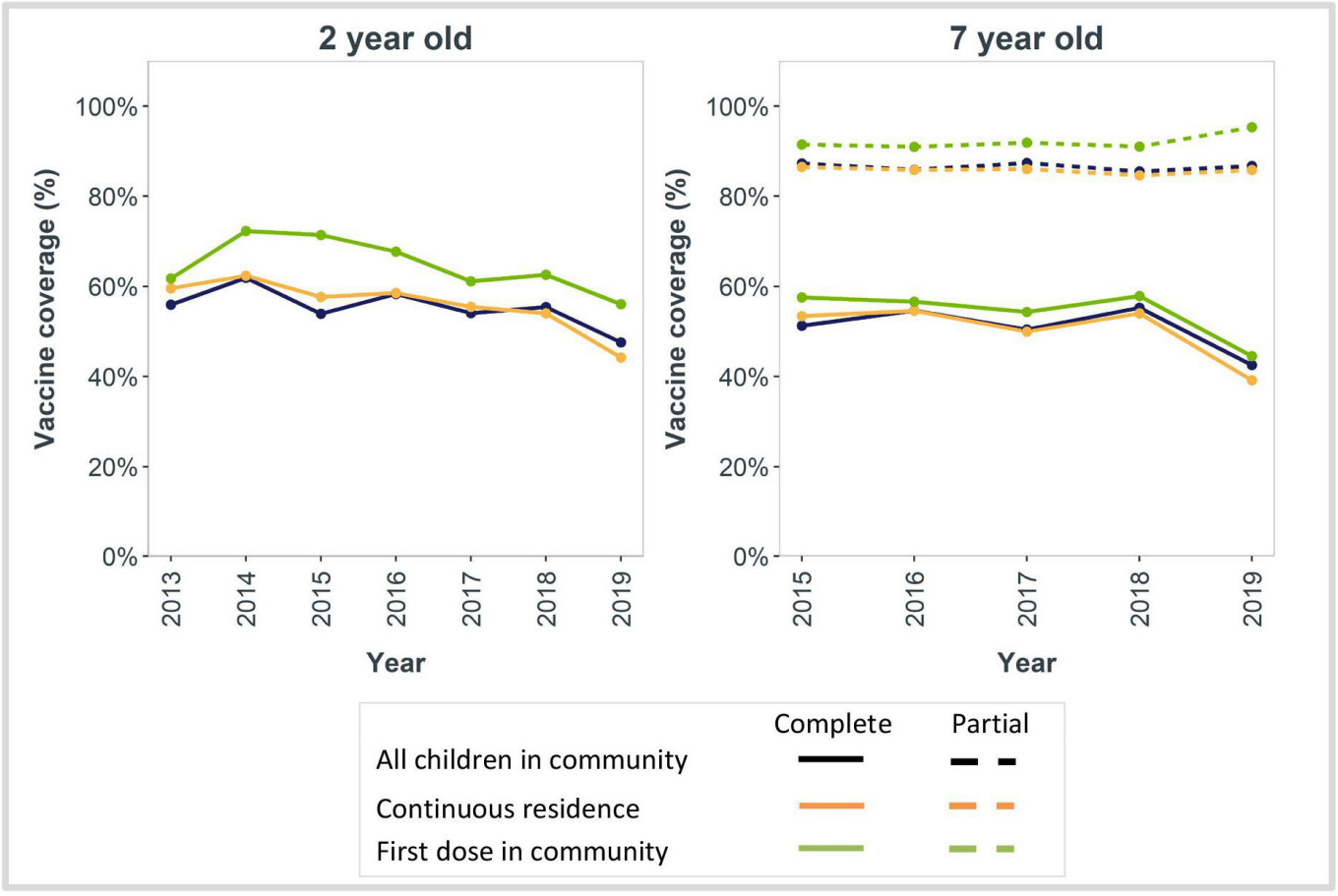

Figure 2 Vaccine coverage for measles-containing vaccine: one dose due by age 2 years and two doses due by age 7 years.

Measles-containing vaccines

Figure 2 presents the vaccine coverage for 2-year-olds for measles-containing vaccines, which has one dose due before age 2 years. From 2013 to 2019, coverage ranged from 47.6% (95% CI 40.4% to 54.8%) to 61.9% (95% CI 55.5% to 68.4%) for all children resident in the community at the age of assessment. For children who were continuous residents of the community, coverage was higher in 2013 and 2015, compared with those who were not ($p<0.05$); but not for other years ($p>0.05$). Coverage was consistently higher across the years for children who received their first dose of measles-containing vaccine in the community health centre (ranging 56.1%–72.3%), as compared with those who did not (26.4%–45.1%) ($p<0.05$).

At age 7 years, complete coverage (ie, two doses) for measles-containing vaccines for all children resident in the community during the study years (2015–2019) ranged from 42.6% (95% CI 35.5% to 49.6%) to 55.3% (95% CI 48.8% to 61.7%). Complete coverage each year was similar for children who lived continuously in the community, compared with those who did not ($p>0.05$). Higher complete coverage was noted for children who received their first dose of any vaccine in the community health centre (44.5%–57.9%), compared with those who did not (30.2%–49.2%), though the difference was only statistically significant for those who turned 7 years in 2015 and 2017. Partial coverage at 7 years (ie, one dose) ranged from 85.5% (95% CI 81.0% to 90.1%) to 87.4% (95% CI 83.0% to 91.8%) for all children in the community. Partial coverage was similar for children with and without continuous residence ($p>0.05$), but higher for those with first dose on reserve versus not ($p<0.05$).

The mean complete coverage across all the years studied (see table 1) at age 2 years for measles-containing vaccines (ie, one dose) was 55.5% (95% CI 53.0% to 58.0%) among all children living in the community. The mean coverage for 2-year-old children who were continuous residents in the community was not statistically significantly different from those who were not ($p=0.18$). Whereas, the mean complete coverage for those who received their first dose of vaccine at the community health centre was higher 64.7% (95% CI 61.7% to 67.7%), compared with those who did not 39.2% (95% CI 35.1% to 43.2%) ($p<0.01$).

The mean complete coverage for measles-containing vaccines (ie, two doses) across all years for all 7 years old living in the community at age of assessment was 51.1% (95% CI 48.2% to 54.0%). Coverage for children who were continuous residents in the community was not statistically significantly different from those who were not ($p=0.72$), but was higher for those who received their first dose of vaccine at the community health centre

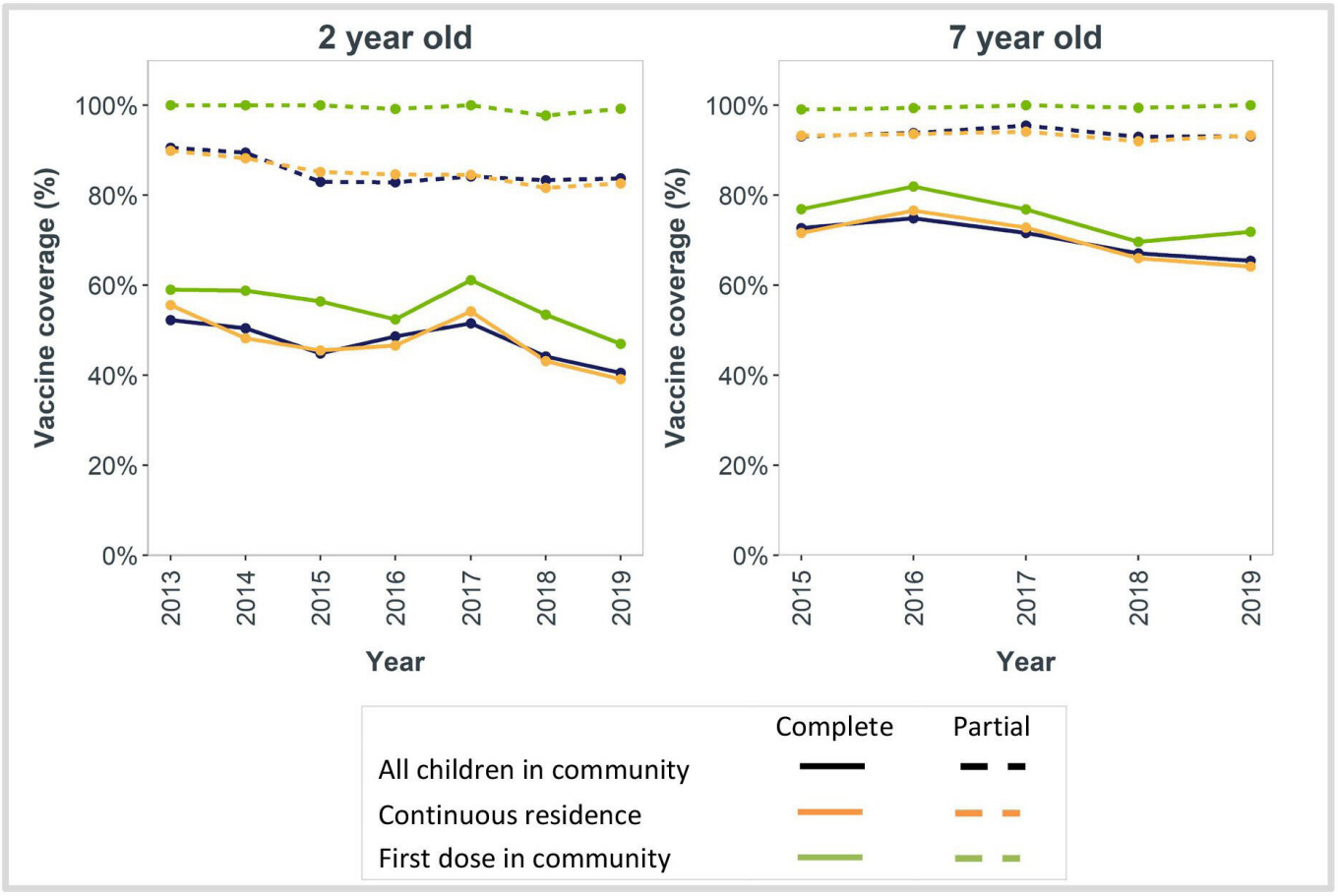

Figure 3 Vaccine coverage for pneumococcal vaccine: four doses due by age 2 years and no additional doses due by age 7 years.

54.8% (95% CI 51.5% to 58.2%), compared with those who did not 39.9% (95% CI 34.2% to 45.6%) (p<0.01).

Pneumococcal vaccine

Figure 3 illustrates vaccine coverage for the pneumococcal vaccine, which has four doses scheduled by age 2 years for First Nations children (differing from the three doses scheduled for non-Indigenous children); no additional doses are scheduled before age 7 years.

At age 2 years, complete coverage (ie, four doses) in 2013–2019 ranged from 40.5% (95% CI 33.5% to 47.6%) to 52.3% (95% CI 46.0% to 58.5%) for all children resident in the community at the age of assessment. For children who were continuous residents of the community, coverage was similar to those who were not continuous residents, ranging from 39.1% to 55.6% (p>0.05). There was only 1 year (2016), where there was no significant difference between first dose in the community health centre (52.4%, 95% CI 43.6% to 61.2%) compared with not (43.5%, 95% CI 33.3% to 53.6%) (p=0.25).

Partial coverage at 2 years (ie, one, two or three doses) ranged from 82.9% (95% CI 77.8% to 87.9%) to 90.5% (95% CI 86.9% to 94.2%) for all children living in the community at the age of assessment. Coverage was similar for children who lived continuously in the community, compared with those who did not (p>0.05). Partial coverage for each year for children who received their first dose of any vaccine in the community health centre ranged from 97.7% to 100%, as the first dose of pneumococcal vaccine is scheduled for 2 months of age (although some children may have received one of their 2-month vaccines, for example, diphtheria-containing vaccine and not others). At age 7 years, complete coverage (ie, four doses) for pneumococcal vaccine for all children living in the community at the age of assessment ranged from 65.4% (95% CI 58.6% to 72.2%) to 74.9% (95% CI 69.2% to 80.5%). Complete coverage each year was similar for children who lived continuously in the community, compared with those who did not (p>0.05), but was significantly higher for children who received their first dose of any vaccine in the community health centre (71.9%–81.9%), compared with those who did not (51.7%–58.7%) (p<0.01) for all years except 2018 (p=0.17).

Partial coverage at 7 years (ie, one, two or three doses) ranged from 93.0% (95% CI 89.7% to 96.3%) to 95.5% (95% CI 92.8% to 98.2%) for all children in the community. Partial coverage was similar for children with and without continuous residence (p>0.05). Partial coverage for children who received their first dose in the community health centre was again near 100%, as described previously.

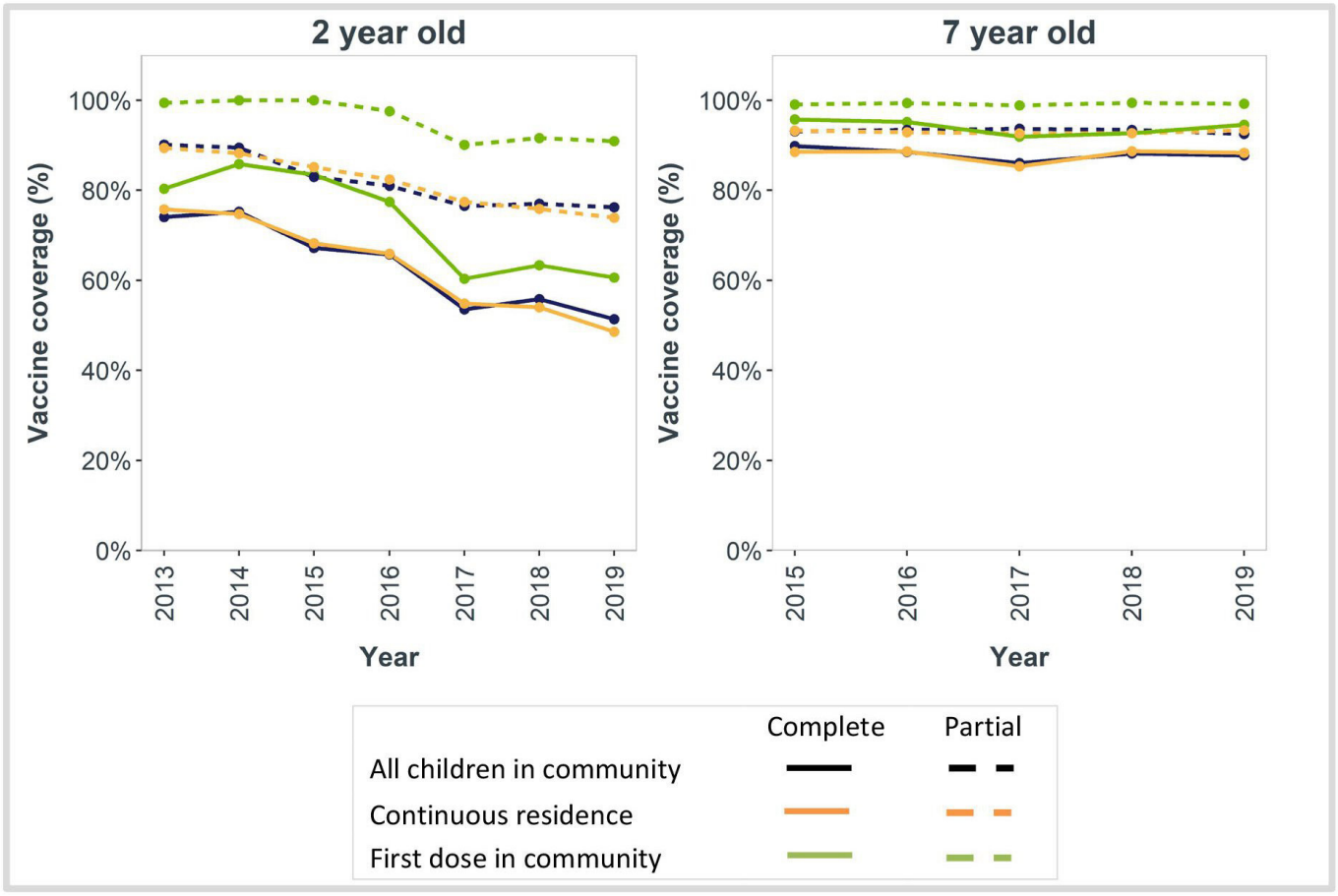

Figure 4 Vaccine coverage for meningococcal vaccine: two doses due by age 2 years and no additional doses due by age 7 years.

The mean complete coverage at age 2 years across all study years for pneumococcal vaccine was 47.6% (95% CI 45.1% to 50.1%) among all children living in the community (table 1). The mean coverage for 2-year-old children who were continuous residents in the community was not statistically significantly different from those who were not (p=0.87). Whereas, the mean complete coverage for those who received their first dose of vaccine at the community health centre was higher 55.7% (95% CI 52.5% to 58.8%), compared with those who did not 33.3% (95% CI 29.4% to 37.3%) (p<0.01).

The mean complete coverage for 7-year-olds for pneumococcal vaccine across all the years studied was 70.6% (95% CI 68.0% to 73.3%) for all children living in the community at age of assessment. Coverage for children who were continuous residents in the community was not statistically significantly different from those who were not (p=0.87), but was higher for those who received their first dose of vaccine at the community health centre, at 75.6% (95% CI 72.7% to 78.5%), compared with those who did not 55.5% (95% CI 49.7% to 61.3%) (p<0.01).

Meningococcal vaccine

Vaccine coverage for the meningococcal vaccine is shown in figure 4. At age 2 years, complete coverage (ie, two doses) in 2013–2019 ranged from 51.4% (95% CI 44.1% to 58.6%) to 75.2% (95% CI 69.5% to 81.0%) for all children living in the community at the age of assessment. For children who were continuous residents of the community, coverage was similar to those who were not (p>0.05). Coverage was consistently higher across the years for children who received their first dose of meningococcal vaccine in the community health centre (ranging 60.3%–85.8%), as compared with those who did not (28.3%–55.0%) (p<0.05). Partial coverage at 2 years (ie, one dose) ranged from 76.2% (95% CI 70.1% to 82.4%) to 90.1% (95% CI 86.4% to 93.9%) for all children living in the community at the age of assessment. Partial coverage was similar for children with and without continuous residence (p>0.05). Partial coverage for children who received their first dose in the community ranged from 90.1% to 100%, consistently higher than those who did not receive their first dose in the community (p<0.05).

At age 7 years, complete coverage for the meningococcal vaccine for children (ie, two doses) ranged from 86.0% (95% CI 81.5% to 90.6%) to 89.8% (95% CI 86.2% to 93.4%) for all children resident in the community at the age of assessment (2015–2019). Complete coverage each year was similar for children who lived continuously in the community, compared with those who did

Table 1 Mean complete coverage across all years by vaccine at age 2 (2013–2019) and 7 years (2015–2019)

Vaccine	Age	All children living in the community n/N, % (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community n/N, % (95% CI)		
			Yes	No	P value*	Yes	No	P value†
Diphtheria-containing vaccines	2 years	366/1521, 24.1 (21.9 to 26.2)	288/1200, 24.0 (21.6 to 26.4)	78/321, 24.3 (19.6 to –29.0)	0.97	272/972, 28.0 (25.2 to 30.8)	94/549, 17.1 (14.0 to 20.3)	<0.01
	7 years	507/1140, 44.5 (41.6 to 47.4)	307/695, 44.2 (40.5 to 47.9)	200/445, 44.9 (40.3 to 49.6)	0.85	413/857, 48.2 (44.8 to 51.5)	94/283, 33.2 (27.7 to 38.7)	<0.01
Measles-containing vaccines	2 years	844/1521, 55.5 (53.0 to 58.0)	677/1200, 56.4 (53.6 to 59.2)	167/321, 52.0 (46.6 to 57.5)	0.18	629/972, 64.7 (61.7 to 67.7)	215/549, 39.2 (35.1 to 43.2)	<0.01
	7 years	583/1140, 51.1 (48.2 to 54.0)	352/69, 50.6 (46.9 to 54.4)	231/445, 51.9 (47.3 to 56.6)	0.72	470/857, 54.8 (51.5 to 58.2)	113/283, 39.9 (34.2 to 45.6)	<0.01
Pneumococcal vaccine	2 years	724/1521, 47.6 (45.1 to 50.1)	573/1200, 47.8 (44.9 to 50.6)	151/321, 47.0 (41.6 to 52.5)	0.87	541/972, 55.7 (52.5 to 58.8)	183/549, 33.3 (29.4 to 37.3)	<0.01
	7 years	805/1140, 70.6 (68.0 to 73.3)	489/695, 70.4 (67.0 to 73.8)	316/445, 71.0 (66.8 to 75.2)	0.87	648/857, 75.6 (72.7 to 78.5)	157/283, 55.5 (49.7 to 61.3)	<0.01
Meningococcal vaccine	2 years	972/1521, 63.9 (61.5 to 66.3)	768/1200, 64.0 (61.3 to 66.7)	204/321, 63.6 (58.3 to 68.8)	0.93	717/972, 73.8 (71.0 to 76.5)	255/549, 46.4 (42.3 to 50.6)	<0.01
	7 years	1005/1140, 88.2 (86.3 to 90.0)	611/695, 87.9 (85.5 to 90.3)	394/445, 88.5 (85.6–91.5)	0.82	806/857, 94.0 (92.5 to 95.6)	199/283, 70.3 (65.0–75.6)	<0.01

*Children living in the community at the age of assessment who were continuous residents of the community, versus those who were not.
†Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, versus those who did not.

not (p>0.05), but was higher for children who received their first dose of any vaccine in the community health centre (91.9%–95.8%), compared with those who did not (65.3%–73.3%) (p<0.01). Partial coverage at 7 years (ie, one dose) ranged from 92.6% (95% CI 88.8% to 96.3%) to 93.7% (95% CI 90.5% to 96.9%) for all children in the community at the age of assessment. Partial coverage was similar for children with and without continuous residence (p>0.05). Partial coverage for children who received their first dose in the community health centre ranged from 98.8% (95% CI 97.3% to 100.4%) to 99.4% (95% CI 98.2% to 100.6%), significantly higher than those who did not (p<0.05).

The mean complete coverage at age 2 years for meningococcal vaccine across all the years studied was 63.9% (95% CI 61.5% to 66.3%) among all children living in the community. The mean coverage for 2-year-old children who were continuous residents in the community was not statistically significantly different from those who were not (p=0.93). Whereas, the mean complete coverage for those who received their first dose of vaccine at the community health centre was higher 73.8% (95% CI 71.0% to 76.5%), compared with those who did not 46.4% (95% CI 42.3% to 50.6%) (p<0.01).

The mean complete coverage for 7-year-olds for meningococcal vaccine across all the years studied was 88.2% (95% CI 86.3% to 90.0%) for all children living in the community at age of assessment. Coverage for children who were continuous residents in the community was not statistically significantly different from those who were not (p=0.82), but was higher for those who received their first dose of vaccine at the community health centre 94.0% (95% CI 92.5% to 95.6%), compared with those who did not 70.3% (95% CI 65.0% to 75.6%) (p<0.01).

DISCUSSION

Summary of findings

Complete vaccine coverage was low across all vaccines in all years. At 2 years of age, there was a noticeable decrease in completion rates over the years of the study; this trend is less prominent in the 7-year group. For children who

received their first dose of vaccine in the First Nations community health centre, there was consistently higher coverage for all vaccines, as compared with those who received their first dose elsewhere in Alberta. No significant difference was seen between children who were continuous residents of the community, compared with those who were not.

Historical and contextual factors contributing to vaccine coverage

It is essential to contextualise the vaccine coverage levels in First Nations communities within an understanding of the structural and historical barriers to immunisation for First Nations children. In one qualitative study conducted in First Nations communities in northern Ontario,[16] researchers found that uptake of childhood vaccines was influenced by many of the same knowledge and beliefs that influence parents across Canada, such as concern about vaccine safety and effectiveness, and time constraints. Yet, there is a glaring gap in knowledge regarding the uniqueness of the First Nations immunisation experience or how historical and cultural factors act as barriers or supports to uptake. Additionally, institutional colonialism and legacy policies continue to impact the delivery of vaccine services on-reserve,[21] resulting in further challenges to access, despite parental, family and community labour to ensure immunisations are delivered. Given the higher rates of vaccine-preventable diseases in many First Nations communities,[7 16] we know that First Nations parents are often motivated by the genuine threat of diseases, which may act as an incentive to immunise children. However, vaccine acceptance must also be viewed in the context of entrenched historical distrust, harm, racism and centuries of problematic interactions with the Canadian government and healthcare system.[22] In addition, structural barriers such as challenges with transportation and childcare, one child per appointment approaches,[22] and low and inconsistent staffing levels in First Nations reserve health centres may impact coverage levels.[7]

Disparities between partial coverage and complete coverage

There are notable disparities between partial coverage and complete coverage at both ages 2 and 7 years. The disparity is greatest for vaccines that have more doses scheduled, such as diphtheria-containing vaccines, which have four doses due by age 2 years and five doses due by age 7 years (figure 1). The disparity is somewhat less for vaccines that have fewer doses, such as meningococcal vaccine, which has two doses due by age 2 years and no additional doses due by age 7 years (figure 4). This is a common pattern seen in studies of the general population, explained by structural and logistic barriers to accessing immunisation services, which becomes more pronounced for completion of a multidose series.[23 24] This issue is exacerbated in subpopulations that experience multiple competing priorities (eg, large number of children, lack of stable housing) to accessing vaccine services,[24 25] and even more so when movement in and out of the community poses challenges to health centre staff in contacting guardians with immunisation reminders.[22]

Value of initiating the vaccine series on-reserve

The higher vaccine coverage for children who received their first vaccine dose in the on-reserve health centre is noteworthy. This knowledge is particularly useful for informing vaccine programme evaluation of the on-reserve community health centre and nearby public health services that are not necessarily part of the communities they serve. As noted in previous research,[16 22] barriers and enablers of immunisation are often complex and multiple, including the interactions with health professionals and the immunisation experience, which may be linked to these findings. This information may be useful to parents and families to help inform them of the potential benefits of seeking care in their own community, as well as to vaccine funding agencies and policymakers regarding resource allocation and fostering emerging practices that might increase the uptake of vaccines on-reserve. Previous research indicates that infrastructure gaps, resource constraints and mistrust of health systems are contributing factors to lower immunisation rates in First Nations communities.[26] Additionally, research on community control of primary care services in First Nations communities supports community delivery of such services,[27] as well as the work of undoing colonial elements of clinical practices in on-reserve health services as beneficial to engaging parents.[21] These findings support further investigation into the promising practices that are occurring at this on-reserve health centre, which may be beneficial learning for other immunisation settings both on and off-reserve. Further research might include qualitative,[16] organisational,[21] human factors[28] or Indigenous approaches[29] to understanding the experiences of families accessing immunisation services at the health centre and the practices that foster increased engagement in immunisation.

Value of linked data and data-sharing agreements

These findings also highlight the value of having data-sharing agreements between First Nations and the local health or governmental authorities who collect and analyse immunisation data. As we have demonstrated here, by looking at immunisation coverage data in a novel way, such as examining the impact of continuous residence in the community or of receiving the first dose of vaccine on or off-reserve, we were able to identify unique trends and an important previously unexplored factor that highlights the success of this Indigenous community in improving complete childhood immunisations.

This work supports the Alberta First Nations Information Governance Centre and the Ministry's efforts to communicate the potential benefits of connected data systems supported by information-sharing agreements. By compiling data on all immunisations (on-reserve and off-reserve) to calculate coverage, it is possible

to overcome the problem of record-scattering, which has made accurate measurement of coverage so challenging. There are considerable benefits to being able to accurately measure childhood immunisation coverage for First Nations children. At the individual level, this information allows parents and healthcare providers to ascertain the child's immunisation status and resulting protection from disease. At the population level, this information permits First Nations communities to assess whether community protection ('herd immunity') has been achieved, that is, enough children are immunised to prevent outbreaks of dangerous infectious diseases within the community, as well as to develop targeted interventions to increase engagement in immunisation practices within the community.

In addition to data-sharing enabling more accurate measurement of coverage, it allows healthcare providers in the community health centre to access the child's complete (on and off-reserve) vaccine record, as well as to share vaccine records across on-reserve and off-reserve sites. This ability to view and maintain up-to-date records for children should in itself contribute to improved vaccine coverage by reducing missed opportunities to vaccinate eligible children.

Strengths and limitations

The strengths of this research included the strong relationships between researchers, community partners and the Ministry's Analytics and Performance Reporting Branch. In particular, the project was conducted with ongoing input from First Nations community partners through every stage of study design, data analysis, interpretation and communication of findings. Additional strengths include the unique ability to link multiple sources of data to assess complete immunisation coverage for children in this First Nations community.

Potential limitations in this study include the fact that some vaccine doses may have been administered on other reserves that do not submit data to the Ministry. This has the potential of underestimating vaccine coverage levels, but likely would not change the effect seen of higher coverage for children receiving their first dose in their home community.

This study focused on a single First Nations health centre. We respectfully acknowledge that First Nations people and communities have diverse histories, cultures and experiences, so the specific findings of this study may not be generalisable to other Nations or contexts. However, the learnings about data-sharing approaches, and the benefits derived from these, are likely transferable to other Indigenous communities within and outside Canada.

CONCLUSION

Our findings indicate that First Nations children who receive their first dose of vaccine on-reserve are more likely to complete their immunisation series than children who begin their immunisation journey off-reserve. This highlights the value of children engaging with the on-reserve health centre at the initiation of their vaccine series. The findings also speak to the benefits of Indigenous self-determination and devolved healthcare services in First Nation communities, providing improved immunisation access for families living on-reserve. The study highlights the ability to measure accurate vaccine coverage through data-sharing agreements and linkage of vaccine records that support First Nations communities to identify individual and community immunity for their Nations. This also enhances the ability of programme evaluation for quality improvement. The findings also support the transfer of health funding and service delivery to First Nations to improve childhood immunisation uptake. Recommendations for further research include the need for a more comprehensive understanding of barriers and supports to immunisation, which should capture the diverse perspective of First Nations parents, healthcare providers, and federal and provincial health officials. The application of qualitative and Indigenous methodologies to further understand the experiences of families accessing immunisation services in these Nations, as well as further exploring the experiences of other Nations with data-sharing agreements and devolved health resources, is also important to avoid generalising to other diverse and unique Indigenous settings and peoples.

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Contributors SEM conceptualised and designed the study, acquired and interpreted the data, drafted the manuscript, approved the final version and is the corresponding author that is responsible for the overall content as guarantor; BG conceptualised and designed the study, interpreted the data, critically reviewed the manuscript, and approved the final version; KDK interpreted the data, drafted the manuscript, and approved the final version; LH acquired, analysed and interpreted the data, critically reviewed the manuscript, and approved the final version; LS conceptualised and designed the study, and acquired and interpreted the data, but was not able to critically review or approve the final version due to his untimely death; GN conceptualised the study, critically reviewed the manuscript and approved the final version.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval The community health services leadership approved the project, which has delegated authority to participate in projects of benefit to the community. The project followed the principles of the Tri-Council Policy Statement (TCPS) regarding Research Involving First Nations, Inuit and Métis (FNIM) Peoples of Canada, particularly Respect for FNIM Governing Authorities (Article 9.3) and Engagement with Organisations and Communities of Interest (Article 9.4). All research conducted within the scope of this project followed the principles of the TCPS and OCAP principles regarding ownership, control, access and possession of First Nations data, to ensure that the research was used to derive positive impacts for communities while preserving traditional ways of knowing and governance. The project also received ethical approval from the University of Alberta Health Research Ethics Board (PRO#00073138).

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Supplementary File

Appendix A: Alberta Routine Childhood Vaccination Schedule for children up to 7 years of age - 2013-2019

Age in months	Starting Sept 2014	Starting Jan 2015[a]	Starting June 2015[b]	Starting May 2018[c]	Starting Sept 2018[d]
2	• DTaP-IPV-Hib • PCV13 • Men C	• DTaP-IPV-Hib • PCV13	• DTaP-IPV-Hib • PCV13 • Rotavirus	• DTaP-IPV-Hib • PCV13 • Rotavirus	• DTaP-IPV-Hib-HB • PCV13 • Rotavirus
4	• DTaP-IPV-Hib • PCV13 • Men C	• DTaP-IPV-Hib • PCV13 • Men C	• DTaP-IPV-Hib • PCV13 • Men C • Rotavirus	• DTaP-IPV-Hib • PCV13 • Men C • Rotavirus	• DTaP-IPV-Hib-HB[a] • PCV13 • Men C • Rotavirus
6	• DTaP-IPV-Hib • PCV13[e]	• DTaP-IPV-Hib • PCV13[e]	• DTaP-IPV-Hib • PCV13[e]	• DTaP-IPV-Hib • PCV13[e] • Rotavirus	• DTaP-IPV-Hib-HB • PCV13[e] • Rotavirus
12	• MMRV • Men C • PCV13	• MMRV • Men C • PCV13	• MMRV • Men C • PCV13	• MMRV • Men C • PCV13	• MMRV • Men C • PCV13
18	• DTaP-IPV-Hib	• DTaP-IPV-Hib	• DTaP-IPV-Hib	• DTaP-IPV-Hib	• DTaP-IPV-Hib
48 - 72	• DTaP-IPV • MMRV	• DTaP-IPV • MMRV	• DTaP-IPV • MMRV	• DTaP-IPV • MMRV	• DTaP-IPV • MMRV

Abbreviations: Diphtheria-Tetanus-Acellular Pertussis- Polio-Haemophilus Influenzae type b- Hepatitis B conjugate (DTaP-IPV-Hib-HB), Pneumococcal conjugate (PCV13), Meningococcal conjugate group C (Men-C), Measles-Mumps-Rubella-Varicella (MMRV)

[a] Two-month dose of Meningococcal conjugate dropped

[b] Rotavirus added

[c] Switch from Rotarix (2 doses) to Rota-teq (3 doses) (effective May 1, 2018)

[d] Switch from DTaP-IPV-Hib to DTaP-IPV-Hib-HB

[e] Indigenous children (defined as having at least one parent who is indigenous; includes First Nations, Inuit and Metis) beginning immunization at younger than 7 months should receive an additional dose of PCV-13 vaccine at 6 months

Appendix B: Coverage by Vaccine at Ages 2 and 7 Years

Table 1: Vaccine coverage for diphtheria-containing vaccines at two years of age

Year	Vaccination status	All children resident in community n/N, % (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community[a] n/N, % (95% CI)		
			Yes	No	p-value[b]	Yes	No	p-value[c]
2013	Complete	72/243 29.6% (23.9-35.4)	64/198 32.3% (25.8-38.8)	8/45 17.8% (6.6-28.9)	0.08	62/183 33.9% (27.0-40.7)	10/60 16.7% (7.2-26.1)	0.02
	Partial	220/243 90.5% (86.9-94.2)	178/198 89.9% (85.7-94.1)	42/45 93.3% (86.0-100.6)	0.67	183/183 100.0% (100.0-100.0)	37/60 61.7% (49.4-74.0)	< 0.01
2014	Complete	55/218 25.2% (19.5-31.0)	39/170 22.9% (16.6-29.3)	16/48 33.3% (20.0-46.7)	0.2	43/148 29.1% (21.7-36.4)	12/70 17.1% (8.3-26.0)	0.08
	Partial	195/218 89.4% (85.4-93.5)	150/170 88.2% (83.4-93.1)	45/48 93.8% (86.9-100.6)	0.41	148/148 100.0% (100.0-100.0)	47/70 67.1% (56.1-78.1)	< 0.01
2015	Complete	48/241 19.9% (14.9-25.0)	40/189 21.2% (15.3-27.0)	8/52 15.4% (5.6-25.2)	0.47	33/133 24.8% (17.5-32.2)	15/108 13.9% (7.4-20.4)	0.05
	Partial	200/241 83.0% (78.2-87.7)	161/189 85.2% (80.1-90.2)	39/52 75.0% (63.2-86.8)	0.13	133/133 100.0% (100.0-100.0)	67/108 62.0% (52.9-71.2)	< 0.01
2016	Complete	57/216 26.4% (20.5-32.3)	42/176 23.9% (17.6-30.2)	15/40 37.5% (22.5-52.5)	0.12	36/124 29.0% (21.0-37.0)	21/92 22.8% (14.2-31.4)	0.39
	Partial	180/216 83.3% (78.4-88.3)	149/176 84.7% (79.3-90.0)	31/40 77.5% (64.6-90.4)	0.39	124/124 100.0% (100.0-100.0)	56/92 60.9% (50.9-70.8)	< 0.01

2017	Complete	45/196 23.0% (17.1-28.8)	38/155 24.5% (17.7-31.3)	7/41 17.1% (5.6-28.6)	0.42	30/121 24.8% (17.1-32.5)	15/75 20.0% (10.9-29.1)	0.55
	Partial	164/196 83.7% (78.5-88.8)	130/155 83.9% (78.1-89.7)	34/41 82.9% (71.4-94.4)	1	120/121 99.2% (97.6-100.8)	44/75 58.7% (47.5-69.8)	< 0.01
2018	Complete	49/222 22.1% (16.6-27.5)	36/174 20.7% (14.7-26.7)	13/48 27.1% (14.5-39.7)	0.45	35/131 26.7% (19.1-34.3)	14/91 15.4% (8.0-22.8)	0.07
	Partial	188/222 84.7% (79.9-89.4)	144/174 82.8% (77.1-88.4)	44/48 91.7% (83.8-99.5)	0.2	131/131 100.0% (100.0-100.0)	57/91 62.6% (52.7-72.6)	< 0.01
2019	Complete	40/185 21.6% (15.7-27.6)	29/138 21.0% (14.2-27.8)	11/47 23.4% (11.3-35.5)	0.89	33/132 25.0% (17.6-32.4)	7/53 13.2% (4.1-22.3)	0.12
	Partial	156/185 84.3% (79.1-89.6)	115/138 83.3% (77.1-89.6)	41/47 87.2% (77.7-96.8)	0.69	132/132 100.0% (100.0-100.0)	24/53 45.3% (31.9-58.7)	< 0.01

[a] Partial coverage for children receiving their first dose in the community is often 100%, because diphtheria-containing vaccine is typically delivered at the child's first appointment (scheduled for age 2 months). Occasionally, the value will be less than 100%, if a child received one of the other 2-month vaccines (e.g. pneumococcal-containing vaccine) and did not receive diphtheria-containing vaccine at that appointment.

[b] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[c] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no

Supplemental files - Improved vaccine coverage for First Nations children receiving first dose on-reserve: A retrospective cohort study in western Canada

Table 2: Vaccine coverage for diphtheria-containing vaccines at seven years of age

Year	Vaccination status[a]	All children resident in community n/N, %, (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community[a] n/N, % (95% CI)		
			Yes	No	p-value[b]	Yes	No	p-value[c]
2015	Complete	127/275 46.2% (40.3-52.1)	72/148 48.6% (40.6-56.7)	55/127 43.3% (34.7-51.9)	0.44	109/212 51.4% (44.7-58.1)	18/63 28.6% (17.4-39.7)	< 0.01
	Partial	260/275 94.5% (91.9-97.2)	142/148 95.9% (92.8-99.1)	118/127 92.9% (88.5-97.4)	0.4	212/212 100.0% (100.0-100.0)	48/63 76.2% (65.7-86.7)	< 0.01
2016	Complete	108/227 47.6% (41.1-54.1)	67/141 47.5% (39.3-55.8)	41/86 47.7% (37.1-58.2)	1	82/166 49.4% (41.8-57.0)	26/61 42.6% (30.2-55.0)	0.45
	Partial	215/227 94.7% (91.8-97.6)	133/141 94.3% (90.5-98.1)	82/86 95.3% (90.9-99.8)	0.98	166/166 100.0% (100.0-100.0)	49/61 80.3% (70.4-90.3)	< 0.01
2017	Complete	100/222 45.0% (38.5-51.6)	61/136 44.9% (36.5-53.2)	39/86 45.3% (34.8-55.9)	1	87/173 50.3% (42.8-57.7)	13/49 26.5% (14.2-38.9)	< 0.01
	Partial	212/222 95.5% (92.8-98.2)	128/136 94.1% (90.2-98.1)	84/86 97.7% (94.5-100.9)	0.36	173/173 100.0% (100.0-100.0)	39/49 79.6% (68.3-90.9)	< 0.01
2018	Complete	103/228 45.2 (38.7-51.6)	66/150 44.0% (36.1-51.9)	37/78 47.4% (36.4-58.5)	0.72	84/178 47.2% (39.9-54.5)	19/50 38.0% (24.5-51.5)	0.32
	Partial	214/228 93.9% (90.7-97.0)	140/150 93.3% (89.3-97.3)	74/78 94.9% (90.0-99.8)	0.87	178/178 100.0% (100.0-100.0)	36/50 72.0% (59.6-84.4)	< 0.01
2019	Complete	69/188 36.7% (29.8-43.6)	41/120 34.2% (25.7-42.7)	28/68 41.2% (29.5-52.9)	0.42	51/128 39.8% (31.4-48.3)	18/60 30.0% (18.4-41.6)	0.25
	Partial	176/188 93.6% (90.1-97.1)	113/120 94.2% (90.0-98.4)	63/68 92.6% (86.4-98.9)	0.92	128/128 100.0% (100.0-100.0)	48/60 80.0% (69.9-90.1)	< 0.01

Supplemental files - Improved vaccine coverage for First Nations children receiving first dose on-reserve: A retrospective cohort study in western Canada

[a] Partial coverage for children receiving their first dose in the community is often 100%, because diphtheria-containing vaccine is typically the first vaccine dose that children receive (scheduled for age 2 months). Occasionally, the value will be less than 100%, if a child received one of the other 2-month vaccines (e.g. pneumococcal-containing vaccine) and did not receive diphtheria-containing vaccine at that appointment.

[b] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[c] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no

Supplemental files - Improved vaccine coverage for First Nations children receiving first dose on-reserve: A retrospective cohort study in western Canada

Table 3: Vaccine coverage for measles-containing vaccine (MMR or MMRV) at two years of age

Year	Vaccination status	All children resident in community n/N, %, (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community n/N, % (95% CI)		
			Yes	No	p-value[a]	Yes	No	p-value[b]
2013	Complete	136/243 56.0% (49.7-62.2)	118/198 59.6% (52.8-66.4)	18/45 40.0% (25.7-54.3)	0.03	113/183 61.7% (54.7-68.8)	23/60 38.3% (26.0-50.6)	< 0.01
2014	Complete	135/218 61.9% (55.5-68.4)	106/170 62.4% (55.1-69.6)	29/48 60.4% (46.6-74.3)	0.94	107/148 72.3% (65.1-79.5)	28/70 40.0% (28.5-51.5)	< 0.01
2015	Complete	130/241 53.9% (47.6-60.2)	109/189 57.7% (50.6-64.7)	21/52 40.4% (27.0-53.7)	0.04	95/133 71.4% (63.8-79.1)	35/108 32.4% (23.6-41.2)	< 0.01
2016	Complete	126/216 58.3% (51.8-64.9)	103/176 58.5% (51.2-65.8)	23/40 57.5% (42.2-72.8)	1	84/124 67.7% (59.5-76.0)	42/92 45.7% (35.5-55.8)	< 0.01
2017	Complete	106/196 54.1% (47.1-61.1)	86/155 55.5% (47.7-63.3)	20/41 48.8% (33.5-64.1)	0.56	74/121 61.2% (52.5-69.8)	32/75 42.7% (31.5-53.9)	0.02
2018	Complete	123/222 55.4% (48.9-61.9)	94/174 54.0% (46.6-61.4)	29/48 60.4% (46.6-74.3)	0.53	82/131 62.6% (54.3-70.9)	41/91 45.1% (34.8-55.3)	0.01
2019	Complete	88/185 47.6% (40.4-54.8)	61/138 44.2% (35.9-52.5)	27/47 57.4% (43.3-71.6)	0.16	74/132 56.1% (47.6-64.5)	14/53 26.4% (14.5-38.3)	< 0.01

[a] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[b] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no

Table 4: Vaccine coverage for measles-containing vaccine (MMR or MMRV) at seven years of age

Year	Vaccination status[a]	All children resident in community n/N, %, (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community n/N, % (95% CI)		
			Yes	No	p-value[a]	Yes	No	p-value[b]
2015	Complete	141/275 51.3% (45.4-57.2)	79/148 53.4% (45.3-61.4)	62/127 48.8% (40.1-57.5)	0.53	122/212 57.5% (50.9-64.2)	19/63 30.2% (18.8-41.5)	< 0.01
	Partial	240/275 87.3% (83.3-91.2)	128/148 86.5% (81.0-92.0)	112/127 88.2% (82.6-93.8)	0.81	194/212 91.5% (87.8-95.3)	46/63 73.0% (62.1-84.0)	< 0.01
2016	Complete	124/227 54.6% (48.1-61.1)	77/141 54.6% (46.4-62.8)	47/86 54.7% (44.1-65.2)	1	94/166 56.6% (49.1-64.2)	30/61 49.2% (36.6-61.7)	0.4
	Partial	195/227 85.9% (81.4-90.4)	121/141 85.8% (80.1-91.6)	74/86 86.0% (78.7-93.4)	1	151/166 91.0% (86.6-95.3)	44/61 72.1% (60.9-83.4)	< 0.01
2017	Complete	112/222 50.5% (43.9-57.0)	68/136 50.0% (41.6-58.4)	44/86 51.2% (40.6-61.7)	0.98	94/173 54.3% (46.9-61.8)	18/49 36.7% (23.2-50.2)	0.04
	Partial	194/222 87.4% (83.0-91.8)	117/136 86.0% (80.2-91.9)	77/86 89.5% (83.1-96.0)	0.58	159/173 91.9% (87.8-96.0)	35/49 71.4% (58.8-84.1)	< 0.01
2018	Complete	126/228 55.3% (48.8-61.7)	81/150 54.0% (46.0-62.0)	45/78 57.7% (46.7-68.7)	0.7	103/178 57.9% (50.6-65.1)	23/50 46.0% (32.2-59.8)	0.18
	Partial	195/228 85.5% (81.0-90.1)	127/150 84.7% (78.9-90.4)	68/78 87.2% (79.8-94.6)	0.75	162/178 91.0% (86.8-95.2)	33/50 66.0% (52.9-79.1)	< 0.01
2019	Complete	80/188 42.6% (35.5-49.6)	47/120 39.2% (30.4-47.9)	33/68 48.5% (36.7-60.4)	0.27	57/128 44.5% (35.9-53.1)	23/60 38.3% (26.0-50.6)	0.52
	Partial	163/188 86.7% (81.8-91.6)	103/120 85.8% (79.6-92.1)	60/68 88.2% (80.6-95.9)	0.81	122/128 95.3% (91.7-99.0)	41/60 68.3% (56.6-80.1)	< 0.01

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[a] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[b] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no

Table 5: Vaccine coverage for pneumococcal-containing vaccine at two years of age

Year	Vaccination status[d]	All children resident in community n/N, %, (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community[a] n/N, % (95% CI)		
			Yes	No	p-value[b]	Yes	No	p-value[c]
2013	Complete	127/243 52.3% (46.0-58.5)	110/198 55.6% (48.6-62.5)	17/45 37.8% (23.6-51.9)	0.05	108/183 59.0% (51.9-66.1)	19/60 31.7% (19.9-43.4)	< 0.01
	Partial	220/24 90.5% (86.9-94.2)	178/198 89.9% (85.7-94.1)	42/45 93.3% (86.0-100.6)	0.67	183/183 100.0% (100.0-100.0)	37/60 61.7% (49.4-74.0)	< 0.01
2014	Complete	110/218 50.5% (43.8-57.1)	82/170 48.2% (40.7-55.7)	28/48 58.3% (44.4-72.3)	0.28	87/148 58.8% (50.9-66.7)	23/70 32.9% (21.9-43.9)	< 0.01
	Partial	195/218 89.4% (85.4-93.5)	150/170 88.2% (83.4-93.1)	45/48 93.8% (86.9-100.6)	0.41	148/148 100.0% (100.0-100.0)	47/70 67.1% (56.1-78.1)	< 0.01
2015	Complete	108/241 44.8% (38.5-51.1)	86/189 45.5% (38.4-52.6)	22/52 42.3% (28.9-55.7)	0.8	75/133 56.4% (48.0-64.8)	33/108 30.6% (21.9-39.2)	< 0.01
	Partial	200/241 83.0% (78.2-87.7)	161/189 85.2% (80.1-90.2)	39/52 75.0% (63.2-86.8)	0.13	133/133 100.0% (100.0-100.0)	67/108 62.0% (52.9-71.2)	< 0.01
2016	Complete	105/216 48.6% (41.9-55.3)	82/176 46.6% (39.2-54.0)	23/40 57.5% (42.2-72.8)	0.28	65/124 52.4% (43.6-61.2)	40/92 43.5% (33.3-53.6)	0.25
	Partial	179/216 82.9% (77.8-87.9)	149/176 84.7% (79.3-90.0)	30/40 75.0% (61.6-88.4)	0.22	123/124 99.2% (97.6-100.8)	56/92 60.9% (50.9-70.8)	< 0.01
2017	Complete	101/196 51.5% (44.5-58.5)	84/155 54.2% (46.3-62.0)	17/41 41.5% (26.4-56.5)	0.2	74/121 61.2% (52.5-69.8)	27/75 36.0% (25.1-46.9)	< 0.01

	Partial	165/196 84.2% (79.1-89.3)	131/155 84.5% (78.8-90.2)	34/41 82.9% (71.4-94.4)	0.99	121/121 100.0% (100.0-100.0)	44/75 58.7% (47.5-69.8)	< 0.01
2018	Complete	98/222 44.1% (37.6-50.7)	75/174 43.1% (35.7-50.5)	23/48 47.9% (33.8-62.0)	0.67	70/131 53.4% (44.9-62.0)	28/91 30.8% (21.3-40.3)	< 0.01
	Partial	185/222 83.3% (78.4-88.2)	142/174 81.6% (75.9-87.4)	43/48 89.6% (80.9-98.2)	0.27	128/131 97.7% (95.1-100.3)	57/91 62.6% (52.7-72.6)	< 0.01
2019	Complete	75/185 40.5% (33.5-47.6)	54/138 39.1% (31.0-47.3)	21/47 44.7% (30.5-58.9)	0.62	62/132 47.0% (38.5-55.5)	13/53 24.5% (12.9-36.1)	< 0.01
	Partial	155/185 83.8% (78.5-89.1)	114/138 82.6% (76.3-88.9)	41/47 87.2% (77.7-96.8)	0.61	131/132 99.2% (97.8-100.7)	24/53 45.3% (31.9-58.7)	< 0.01

[a] Partial coverage for children receiving their first dose in the community is often 100%, because pneumococcal vaccine is typically delivered at the child's first appointment (scheduled for age 2 months). Occasionally, the value will be less than 100%, if a child received one of the other 2-month vaccines (e.g. diphtheria-containing vaccine) and did not receive pneumococcal vaccine at that appointment.

[b] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[c] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no

Supplemental files - Improved vaccine coverage for First Nations children receiving first dose on-reserve: A retrospective cohort study in western Canada

Table 6: Vaccine coverage for pneumococcal-containing vaccine at seven years of age

Year	Vaccination Status[a]	All Children Resident in Community n/N, %, (95% CI)	Continuous Residence n/N, % (95% CI)			First Dose in Community[a] n/N, % (95% CI)		
			Yes	No	p-value[b]	Yes	No	p-value[c]
2015	Complete	200/275 72.7% (67.5-78.0)	106/148 71.6% (64.4-78.9)	94/127 74.0% (66.4-81.6)	0.76	163/212 76.9% (71.2-82.6)	37/63 58.7% (46.6-70.9)	< 0.01
	Partial	256/275 93.1% (90.1-96.1)	138/148 93.2% (89.2-97.3)	118/127 92.9% (88.5-97.4)	1	210/212 99.1% (97.8-100.4)	46/63 73.0% (62.1-84.0)	< 0.01
2016	Complete	170/227 74.9% (69.2-80.5)	108/141 76.6% (69.6-83.6)	62/86 72.1% (62.6-81.6)	0.55	136/166 81.9% (76.1-87.8)	34/61 55.7% (43.3-68.2)	< 0.01
	Partial	213/227 93.8% (90.7-97.0)	132/141 93.6% (89.6-97.7)	81/86 94.2% (89.2-99.1)	1	165/166 99.4% (98.2-100.6)	48/61 78.7% (68.4-89.0)	< 0.01
2017	Complete	159/222 71.6% (65.7-77.6)	99/136 72.8% (65.3-80.3)	60/86 69.8% (60.1-79.5)	0.74	133/173 76.9% (70.6-83.2)	26/49 53.1% (39.1-67.0)	< 0.01
	Partial	212/222 95.5% (92.8-98.2)	128/136 94.1% (90.2-98.1)	84/86 97.7% (94.5-100.9)	0.36	173/173 100.0% (100.0-100.0)	39/49 79.6% (68.3-90.9)	< 0.01
2018	Complete	153/228 67.1% (61.0-73.2)	99/150 66.0% (58.4-73.6)	54/78 69.2% (59.0-79.5)	0.73	124/178 69.7% (62.9-76.4)	29/50 58.0% (44.3-71.7)	0.17
	Partial	212/228 93.0% (89.7-96.3)	138/150 92.0% (87.7-96.3)	74/78 94.9% (90.0-99.8)	0.59	177/178 99.4% (98.3-100.5)	35/50 70.0% (57.3-82.7)	< 0.01
2019	Complete	123/188 65.4% (58.6-72.2)	77/120 64.2% (55.6-72.7)	46/68 67.6% (56.5-78.8)	0.75	92/128 71.9% (64.1-79.7)	31/60 51.7% (39.0-64.3)	0.01

	Partial	175/188 93.1% (89.5-96.7)	112/120 93.3% (88.9-97.8)	63/68 92.6% (86.4-98.9)	1	128/128 100.0% (100.0-100.0)	47/60 78.3% (67.9-88.8)	< 0.01

[a] Partial coverage for children receiving their first dose in the community is often 100%, because pneumococcal vaccine is typically delivered at the child's first appointment (scheduled for age 2 months). Occasionally, the value will be less than 100%, if a child received one of the other 2-month vaccines (e.g. diphtheria-containing vaccine) and did not receive pneumococcal vaccine at that appointment.

[b] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[c] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no

Table 7: Vaccine coverage for meningococcal-containing vaccine at two years of age

Year	Vaccination status[a]	All children resident in community n/N, %, (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community[a] n/N, % (95% CI)		
			Yes	No	p-value[b]	Yes	No	p-value[c]
2013	Complete	180/243 74.1% (68.6-79.6)	150/198 75.8% (69.8-81.7)	30/45 66.7% (52.9-80.4)	0.29	147/183 80.3% (74.6-86.1)	33/60 55.0% (42.4-67.6)	< 0.01
	Partial	219/243 90.1% (86.4-93.9)	177/198 89.4% (85.1-93.7)	42/45 93.3% (86.0-100.6)	0.6	182/183 99.5% (98.4-100.5)	37/60 61.7% (49.4-74.0)	< 0.01
2014	Complete	164/218 75.2% (69.5-81.0)	127/170 74.7% (68.2-81.2)	37/48 77.1% (65.2-89.0)	0.88	127/148 85.8% (80.2-91.4)	37/70 52.9% (41.2-64.6)	< 0.01
	Partial	195/218 89.4% (85.4-93.5)	150/170 88.2% (83.4-93.1)	45/48 93.8% (86.9-100.6)	0.41	148/148 100.0% (100.0-100.0)	47/70 67.1% (56.1-78.1)	< 0.01
2015	Complete	162/241 67.2% (61.3-73.1)	129/189 68.3% (61.6-74.9)	33/52 63.5% (50.4-76.5)	0.63	111/133 83.5% (77.1-89.8)	51/108 47.2% (37.8-56.6)	< 0.01
	Partial	200/241 83.0% (78.2-87.7)	161/189 85.2% (80.1-90.2)	39/52 75.0% (63.2-86.8)	0.13	133/133 100.0% (100.0-100.0)	67/108 62.0% (52.9-71.2)	< 0.01
2016	Complete	142/216 65.7% (59.4-72.1)	116/176 65.9% (58.9-72.9)	26/40 65.0% (50.2-79.8)	1	96/124 77.4% (70.1-84.8)	46/92 50.0% (39.8-60.2)	< 0.01
	Partial	175/216 81.0% (75.8-86.2)	145/176 82.4% (76.8-88.0)	30/40 75.0% (61.6-88.4)	0.39	121/124 97.6% (94.9-100.3)	54/92 58.7% (48.6-68.8)	< 0.01
2017	Complete	105/196 53.6% (46.6-60.6)	85/155 54.8% (47.0-62.7)	20/41 48.8% (33.5-64.1)	0.61	73/121 60.3% (51.6-69.0)	32/75 42.7% (31.5-53.9)	0.02
	Partial	150/196 76.5% (70.6-82.5)	120/155 77.4% (70.8-84.0)	30/41 73.2% (59.6-86.7)	0.72	109/121 90.1% (84.8-95.4)	41/75 54.7% (43.4-65.9)	< 0.01

2018	Complete	124/222 55.9% (49.3-62.4)	94/174 54.0% (46.6-61.4)	30/48 62.5% (48.8-76.2)	0.38	83/131 63.4% (55.1-71.6)	41/91 45.1% (34.8-55.3)	0.01
	Partial	171/222 77.0% (71.5-82.6)	132/174 75.9% (69.5-82.2)	39/48 81.2% (70.2-92.3)	0.55	120/131 91.6% (86.9-96.4)	51/91 56.0% (45.8-66.2)	< 0.01
2019	Complete	95/185 51.4% (44.1-58.6)	67/138 48.6% (40.2-56.9)	28/47 59.6% (45.5-73.6)	0.26	80/13 60.6% (52.3-68.9)	15/53 28.3% (16.2-40.4)	< 0.01
	Partial	141/185 76.2% (70.1-82.4)	102/138 73.9% (66.6-81.2)	39/47 83.0% (72.2-93.7)	0.29	120/132 90.9% (86.0-95.8)	21/53 39.6% (26.5-52.8)	< 0.01

[a] The first dose of the meningococcal-containing vaccine was scheduled for two months of age up until 2015, after which it was dropped. So, partial coverage for children receiving their first dose in the community is often 100%, because meningococcal vaccine is typically delivered at the child's first appointment (scheduled for age 2 months). Occasionally, the value will be less than 100%, if a child received one of the other 2-month vaccines (e.g. diphtheria-containing vaccine) and did not receive meningococcal vaccine at that appointment.

[b] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[c] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no

Table 8: Vaccine coverage for meningococcal-containing vaccine at seven years of age

Year	Vaccination status[a]	All children resident in community n/N, %, (95% CI)	Continuous residence n/N, % (95% CI)			First dose in community[a] n/N, % (95% CI)		
			Yes	No	p-value[b]	Yes	No	p-value[c]
2015	Complete	247/275 89.8% (86.2-93.4)	131/148 88.5% (83.4-93.7)	116/127 91.3% (86.4-96.2)	0.57	203/212 95.8% (93.0-98.5)	44/63 69.8% (58.5-81.2)	< 0.01
	Partial	256/275 93.1% (90.1-96.1)	138/148 93.2% (89.2-97.3)	118/127 92.9% (88.5-97.4)	1	210/212 99.1% (97.8-100.4)	46/63 73.0% (62.1-84.0)	< 0.01
2016	Complete	201/227 88.5% (84.4-92.7)	125/141 88.7% (83.4-93.9)	76/86 88.4% (81.6-95.1)	1	158/166 95.2% (91.9-98.4)	43/61 70.5% (59.0-81.9)	< 0.01
	Partial	212/227 93.4% (90.2-96.6)	131/141 92.9% (88.7-97.1)	81/86 94.2% (89.2-99.1)	0.92	165/166 99.4% (98.2-100.6)	47/61 77.0% (66.5-87.6)	< 0.01
2017	Complete	191/222 86.0% (81.5-90.6)	116/136 85.3% (79.3-91.2)	75/86 87.2% (80.2-94.3)	0.84	159/173 91.9% (87.8-96.0)	32/49 65.3% (52.0-78.6)	< 0.01
	Partial	208/222 93.7% (90.5-96.9)	126/136 92.6% (88.3-97.0)	82/86 95.3% (90.9-99.8)	0.6	171/173 98.8% (97.3-100.4)	37/49 75.5% (63.5-87.6)	< 0.01
2018	Complete	201/228 88.2% (84.0-92.4)	133/150 88.7% (83.6-93.7)	68/78 87.2% (79.8-94.6)	0.91	165/178 92.7% (88.9-96.5)	36/50 72.0% (59.6-84.4)	< 0.01
	Partial	213/228 93.4% (90.2-96.6)	139/150 92.7% (88.5-96.8)	74/78 94.9% (90.0-99.8)	0.72	177/178 99.4% (98.3-100.5)	36/50 72.0% (59.6-84.4)	< 0.01
2019	Complete	165/188 87.8% (83.1-92.5)	106/120 88.3% (82.6-94.1)	59/68 86.8% (78.7-94.8)	0.93	121/128 94.5% (90.6-98.5)	44/60 73.3% (62.1-84.5)	< 0.01
	Partial	174/188 92.6% (88.8-96.3)	112/120 93.3% (88.9-97.8)	62/68 91.2% (84.4-97.9)	0.8	127/128 99.2% (97.7-100.7)	47/60 78.3% (67.9-88.8)	< 0.01

Supplemental files - Improved vaccine coverage for First Nations children receiving first dose on-reserve: A retrospective cohort study in western Canada

[a]The first dose of the meningococcal-containing vaccine was scheduled for two months of age up until 2015, after which it was dropped. So, partial coverage for children receiving their first dose in the community is often 100%, because meningococcal vaccine is typically delivered at the child's first appointment (scheduled for age 2 months). Occasionally, the value will be less than 100%, if a child received one of the other 2-month vaccines (e.g. diphtheria-containing vaccine) and did not receive meningococcal vaccine at that appointment.

[b] Children living in the community at the age of assessment who were continuous residents of the community, yes versus no

[c] Children living in the community at the age of assessment who received their first dose in the on-reserve community health centre, yes versus no