Immunization Data Tool

Technical Notes

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Public Health Ontario

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Immunization Coverage

Introduction

Immunization coverage refers to the proportion of a population that is appropriately immunized against a vaccine preventable disease (VPD) at a point in time. Achieving and maintaining high immunization coverage is essential for effective prevention and control of VPDs. The Canadian National Standards for Immunization Coverage Assessment recommend that antigen-level coverage should be reported annually for 2-, 7- and 17-year-olds, in addition to coverage for school-age programs.[1]

In Ontario, publicly-funded routine infant and childhood immunization programs are primarily delivered by community-based primary care providers[2], whereas Ontario's three publicly-funded school-based immunization programs—hepatitis B (Hep B), human papillomavirus (HPV) and quadrivalent meningococcal conjugate (MCV4)—are typically delivered by public health units (PHUs) to grade 7 students (12-year-olds), with catch-up programs offered for older students.

The Immunization Coverage section of the Immunization Data Tool allows users to view immunization coverage data for school-based and routine infant and childhood immunization programs by antigen, age, PHU and school year.

Data Source

Immunization coverage for school-aged children is assessed using data from the Digital Health Immunization Repository (DHIR), Ontario's provincial immunization repository. The collection and entry of immunization information in the DHIR is largely driven by the Immunization of School Pupils Act (ISPA)[3] for many routine infant and childhood immunizations; among school-based programs, MCV4 is also covered under the ISPA, while Hep B and HPV are not. PHUs rely on parental and/or provider reporting for immunizations administered in primary care, whereas adolescent immunizations administered in school-based immunization programs are entered directly by the PHUs into the DHIR. Immunizations not reported to PHUs for entry into the DHIR are not captured in this tool.

Immunization coverage data in the tool reflect immunizations administered between September 1 and August 31 of each school year. Data are typically extracted from the DHIR in the fall following the relevant school year.

Methods

Data Creation

Data used to generate all coverage estimates were extracted from the DHIR using the Panorama Enhanced Analytical Reporting (PEAR) tool. Extracted data includes:

- demographic information
- immunization records

- immunization exemptions
- education records and school information for students in the 5- to 17-year-old age cohorts for each school year

Cohorts of students that correspond to coverage assessment milestone ages[1] were identified using the calendar year of birth (i.e., children that reach the milestone age by December 31 of the school year). For example, children who had their seventh birthday between January 1 and December 31, 2023 are represented in the 7-year-old cohort for the 2023–24 school year. This method ensures that all children included in our assessment have, at minimum, reached the age milestone at the time of assessment.

Although eligibility for school-based programs is determined by school grade, age cohorts were used to represent grades due to data quality issues with the school grade field in the DHIR. For example, the 12-year-old age cohort was used to assess immunization coverage for school-based immunization programs administered in Grade 7, as children in this grade typically turn 12 years old by December 31 of the school year.

Students were assigned to PHUs to calculate PHU-specific coverage estimates based on the location of the school each student attended during each school year. The use of school-based PHU assignment, as opposed to assigning students to PHUs on the basis of their residential address, was consistent with the implementation of the ISPA and the delivery of school-based immunization programs. Student assignment to individual schools was accomplished using DHIR-extracted education records.

As part of assigning students to a PHU, education records with data quality issues or with content indicating that they were used to capture workflow or other business practices were excluded. For example, education records were excluded if:

- there was no school ID,
- the school name included the term ‘holding’,
- the school type was ‘other’,
- the school was not assigned to one of Ontario’s 34 PHUs, or
- the student’s age conflicted with the school record (e.g., school records for a 17-year-old student with a school type field value of ‘elementary school’).

After this data cleaning was applied, a student was included in the assessment if they had evidence of school attendance at any time during each school year, as determined by the education record’s ‘Effective From’ and ‘Effective To’ dates. Next, education records were processed using a set of decisions rules to assign each student to one PHU. The decisions were made to try to use the most appropriate school record for PHU assignment when students had multiple education records effective during the school year and were effective for the same time period in some cases.

Immunization information was extracted to derive coverage estimates for the following antigens:

- Diphtheria
- *Haemophilus influenzae* type b (Hib)
- Hepatitis B, human papillomavirus (HPV)
- Measles
- Meningococcal conjugate C (MCC)
- Meningococcal conjugate quadrivalent (MCV4)
- Mumps
- Pertussis
- Pneumococcal conjugate
- Polio
- Rubella
- Tetanus
- Varicella
- Rotavirus (was added in March 2024 and trends were available as of the 2019–20 school year)

Immunizations with administration dates on or before August 31 of each school year are included in the calculation of coverage estimates. An antigen is the active component of a vaccine that produces immunity to a specific disease. Although vaccines contain antigens that confer immunologic protection against one or more diseases, our coverage estimates assess the antigen components of combination vaccines separately to derive antigen-specific coverage. For example, we report on measles coverage rather than coverage for the measles, mumps, rubella (MMR) vaccine. In some instances, when a vaccine contains multiple antigens that confer protection against one disease, we report coverage at the level of the vaccine (e.g., MCV4 and pneumococcal conjugate vaccines).

Coverage Estimation

Definitions of up-to-date (UTD) coverage for each antigen are outlined in the Appendix B. The definitions specify the number of doses, minimum intervals between doses and other conditions required for students to be assessed as UTD, by age. All minimum intervals less than one year in length were calculated using a 28-day month (one month = 28 days; six months = 168 days). UTD definitions were developed after consulting multiple resources, including vaccine product monographs, the Ontario publicly-funded immunization schedule[2], the *Canadian Immunization Guide*[4], the *Panorama Ontario Immunization Schedules Logic: Reference Document*[5] and immunization subject matter experts from PHO.

UTD coverage was calculated using the following formula:

$$\text{Coverage} = \frac{\text{Numerator}}{\text{Denominator}} \times 100\%$$

Numerator: The number of students from the denominator that have received the age-appropriate number of valid doses of the specified antigen-containing vaccine (i.e., are UTD) or have a recorded exemption based on evidence of immunity, where appropriate.
Denominator: All students in the specified age cohort with an active client record in the DHIR and at least one school record during each school year.

For measles, mumps, rubella, varicella and hepatitis B, immunization exemption records were examined for documentation of immunity to these diseases, as natural infection confers long-term protection against subsequent infection. Students with an immunization exemption to one of these diseases due to 'Medical - clinical record of disease' or 'Medical - documented immunity' were considered to be UTD, regardless of immunization history, if the immunization exemption had an 'Effective From' date before or on August 31 of each school year. For varicella, the *Canadian Immunization Guide* recommends that children with a history of infection occurring before 12 months of age receive immunization with two doses of varicella-containing vaccine due to an increased risk of a second episode of varicella[4]; however, because we were not able to confidently identify the age of infection using exemption information, it was assumed that all varicella exemptions entered into the DHIR were based on history of disease that occurred at 12 months of age or later. It should be noted that medical exemptions due to immunity or past hepatitis B infection may under-represent the true number of children who are no longer susceptible to hepatitis B, as hepatitis B is not designated under the ISPA.

Immunization information for all live-virus parenteral vaccines, including those not assessed for coverage (e.g., yellow fever and Bacillus Calmette-Guérin (BCG) vaccines), were examined for vaccine interactions with other live-virus vaccines. Doses of parenteral live-virus vaccines administered less than 28 days after the receipt of another live-virus vaccine were considered invalid and not counted towards the dose requirements for UTD coverage. Refer to the antigen-specific sections in the Appendix B for a list of immunizing agents, interactions relevant to vaccines (if applicable) and criteria for valid dose assessment.

In the event that an individual had records of multiple doses of a vaccine containing the same antigen administered on the same day, this was assumed to reflect data entry or data migration errors and only one of the doses from that date was used in the analyses. Refer to the antigen-specific sections in the Appendix B for further details on the selection of doses administered on the same day.

Limitations

COHORT ASSIGNMENT

To assign each student to a PHU, we developed a series of rules to select one education record extracted from the DHIR per student. Our decision rules were based on knowledge of typical school progression and supported by previous data analysis; however, it is possible that our methods may have excluded current students from the analysis or assigned students to a PHU that had not been involved in immunization delivery or ISPA assessment activities for that student. We believe that the likelihood that these events have introduced an error into the coverage estimates is small, given that most student assignments were straightforward using our algorithm.

Education records in the DHIR are updated by PHUs using school-/school board-generated student lists at various times throughout the year. Depending on the timing of these updates, new or transferred students may not have been captured in PHU ISPA enforcement activities for the school year, but may have appeared in our analytic cohort. This could result in underestimating coverage, as students not yet assessed by the ISPA process may have received immunizations, but not reported them to their PHU. Further, students who are not actively attending school may be included in school/school board generated school lists. These students would therefore be captured in our analytic cohort; however, for these students, there is no opportunity for PHUs to deliver immunizations or carry out ISPA assessment activities. This scenario would also result in underestimating coverage.

An additional limitation related to cohort assignment is that there are data quality issues with the school grade field in the DHIR. As a result, we used age cohorts to approximate the school grades at which students are eligible for school-based immunization programs for our analysis. The decision not to use grade to assign age cohorts for this report was based on consistency with methods used for previous coverage reports and because there is notable variability in the correlation between grade and the client's birth year. As a result, coverage may be underestimated for vaccines given in school-based programs, as children who are 12 years of age, but have not yet reached Grade 7, will not have had an opportunity to be vaccinated.

DATA QUALITY

As with any information system, some data quality issues were evident in the data extracted from the DHIR. Data quality issues included inaccurate date values, such as school records, with an 'Effective To' date prior to the 'Effective From' date and immunization records with an administration date prior to the student's date of birth. We did not exclude students with these data quality issues from the analysis.

There were also system-level issues that posed limitations on our coverage analysis. One issue is the absence of unique vaccine terminology to differentiate Twinrix® and Twinrix® Junior at the agent level (both are hepatitis A and hepatitis B combined vaccines, but have different dose schedules). As a result, those two agents can only be differentiated in the presence of a Trade Name, which does not have a high level of completeness and/or accuracy especially for older migrated data. In order to address this issue, certain assumptions were made in developing our decision rules for up-to-date hepatitis B coverage, based on schedule received and age (see the Hepatitis B section of Appendix B for further details). The impact of this limitation on the resulting coverage estimates is unclear.

If errors were made by immunization providers, by PHUs during data entry or by parents using web-based portals, these may also have impacted immunization coverage estimates. Parents and guardians are asked to provide the date of the immunization event(s), rather than to provide formal documentation from the healthcare provider who administered the vaccine(s). Therefore, incorrect information could be relayed from families to the local PHU. Additional errors could also have included incorrect vaccines administered or documented or errors in transcription of administered doses. The impact of these types of errors on the resulting coverage estimates is unknown.

DATA COMPLETENESS

It is possible that students who are described as being under-immunized within this report may have been appropriately immunized. Data entry into the DHIR by PHU staff may not have occurred in time to be reflected in the coverage estimates presented within this report because the information may not have been provided to their local PHU or the family may have provided the information and the PHU had not yet entered it. Both of these scenarios would result in underestimating coverage. The lack of system integration for the documentation of immunizations by health care providers and their inclusion within the DHIR presents important limitations to the timeliness and accuracy of immunization coverage assessment.

A separate issue is that data completeness may vary by antigen. Data completeness is likely to be higher among diseases designated under the ISPA, as documentation of immunization is actively sought by PHUs for these antigens. Practice variation by Ontario PHUs regarding the frequency of immunization coverage assessment activities, including timing of data entry, specific age cohorts assessed and data collection for non-ISPA diseases, was not assessed as part of this report.

The focus of Ontario's enabling legislation and existing processes is documenting immunization records of school-aged students; as a result, timely coverage assessment of infants and pre-school children is challenging and there is limited information on coverage in other groups, including adults and individuals with high-risk medical conditions. Although the regulation that falls under the Child Care and Early Years Act, Ontario Regulation 37/15[6] sets out the requirement for daycare operators to receive proof of immunizations for children who are enrolled in their childcare program as defined in the Act, not all young children in Ontario attend childcare facilities. Therefore, children may not be regularly assessed for coverage until they are enrolled in an Ontario school and fall under the authority of the ISPA. Pre-school aged children (including infants and toddlers) are an important group to monitor because most vaccine-preventable diseases have a higher risk of complications in younger age groups, especially infants, who are particularly vulnerable. Furthermore, the age of two years is a nationally and internationally defined benchmark to monitor progress towards meeting immunization coverage goals.[1]

DATA MIGRATION

As the immunization module of the Panorama system has only been fully implemented in Ontario since 2016, many immunization records stored in the system are historical data migrated to the DHIR. Panorama data standards and best practices recommendations, including drop-down values and field logic, were not applicable to data originally entered; therefore, several data fields for these migrated data do not adhere to the expected values and data quality standards of Panorama. For example, while the Trade Name field is auto-populated for immunization records entered directly into Panorama upon selection of a Lot Number, Trade Name is free-text and Lot Number is not a required field for historical records.[5] This reduces the completeness and usefulness of the Trade Name field for analytic purposes. The impact of this limitation will diminish over time, as all new data will be entered directly into Panorama in accordance with data standards and best practice recommendations.

Vaccine Safety

Introduction

The Vaccine Safety section of the Immunization Data Tool provides users the ability to explore and download Ontario's vaccine safety surveillance data, which are comprised of reports of adverse events following immunization (AEFI). Individual case reports of AEFIs represent an important source of vaccine safety data because they have the potential to identify previously unrecognized or rare AEFIs, identify vaccine safety signals, and detect an increase in frequency or severity of known AEFIs, which can then be further evaluated.[7]

An AEFI (adverse event following immunization) is defined as any untoward medical occurrence that follows immunization and does not necessarily have a causal relationship with the vaccine. The adverse event may be any unfavourable or unintended sign, laboratory finding, symptom or disease.[8]

Note: Adverse events reported following COVID-19 vaccine are currently not included in this tool; AEFIs associated with COVID-19 vaccines are summarized in a separate surveillance report.

Vaccine safety system and public health surveillance of AEFIs

In Canada, vaccines are thoroughly reviewed for efficacy and safety prior to being approved for use. Following approval of a new vaccine, vaccines are highly regulated to ensure safety.[9] Post-marketing surveillance is initiated to ensure there is ongoing monitoring of vaccine safety in the population receiving the vaccine.[8] Vaccine manufacturers are also required to adhere to internationally accepted standards of manufacturing to ensure vaccine quality and consistency. In addition, all lots of vaccine are subject to Health Canada's lot release program, which specifies standards for the production of each lot that must be met before sale in Canada.[8]

Post-marketing vaccine safety surveillance is a shared responsibility between Health Canada, vaccine manufacturers, the Public Health Agency of Canada (PHAC), provinces and territories, as well as local public health authorities.[10] PHAC and Health Canada coordinate post-marketing surveillance nationally, while provinces and territories coordinate public health surveillance of AEFIs occurring within their jurisdiction in collaboration with local partners. AEFIs reported to provincial and territorial public health authorities are reported to the Canadian Adverse Event Following Immunization Surveillance System (CAEFISS), a national database maintained by PHAC for monitoring vaccine safety across Canada. AEFI reports received by vaccine manufacturers may also be voluntarily reported to CAEFISS. However, any

reports of serious adverse reactions received directly by the manufacturers are also required by law to be reported to Health Canada. As part of vaccine safety surveillance at the national level, the Advisory Committee on Causality Assessment (ACCA) reviews select reports of AEFIs to determine whether an event was likely to have been causally related to a given vaccine.[11] The National Advisory Committee on Immunization (NACI) independently reviews the available evidence on safety and efficacy of vaccines to make recommendations for the use of currently or newly approved vaccines in Canada.[12]

At the provincial level, the main objective of public health surveillance of AEFIs in Ontario is early detection and timely response to real or perceived vaccine safety signals or issues in order to help mitigate any impact on the health of individuals, as well as maintaining public confidence in vaccine programs. A robust vaccine safety surveillance system also provides important data to support provincial immunization program planning and evaluation.

In Ontario, passive vaccine safety surveillance relies on reporting of AEFIs by health care providers, vaccine recipients, or their caregivers to their local public health unit (PHU). The Health Protection and Promotion Act (HPPA), s. 38.3 mandates all health care providers who administer immunizations to report AEFIs for all vaccines authorized for use in Canada.[13] Once PHUs receive initial reports of AEFIs, reports are investigated, assessed, and documented according to provincial surveillance guidelines.[14] AEFIs are then reported in the integrated Public Health Information System (iPHIS), the provincial electronic reporting system for diseases of public health significance and AEFIs. The Public Health Case and Contact Management Solution (CCM) was used as the electronic reporting system for all AEFIs temporarily between December 2022 and May 2024. In June 2024, iPHIS returned as the reporting system for all AEFIs. AEFI reports are required to be reported in iPHIS/CCM within five business days of receipt of initial notification to a PHU.[15,16]

Public Health Ontario (PHO) conducts provincial surveillance of AEFIs using the AEFI data entered into iPHIS/CCM by the PHUs. Through routine data extraction and analysis, PHO monitors for potential signals and investigates any potential vaccine safety issues. PHO also provides advice and support for local PHUs in the investigation and management of AEFI reports. The Ministry of Health is responsible for public health legislation and standards, which enable the reporting and collection of information required for provincial surveillance. PHO also transmits AEFI data to PHAC on a monthly basis for inclusion in CAEFISS. For more detailed information on vaccine safety surveillance in Ontario, including previous annual reports (in PDF format), please see PHO's Vaccine Safety web page.

Data Sources and Analysis

Data Sources and Extraction

- **AEFI data:** AEFI data were extracted from iPHIS on August 1, 2023 for 2012–2022 data and extracted from CCM on June 28, 2024 for 2023 data.

- **Ontario population data:** Population estimates are sourced from Statistics Canada for years 2012–2023 on June 28, 2024.[17]

- **Doses distributed data:** Number of doses distributed are estimated using vaccine distribution data extracted on June 12, 2024 from the Digital Health Immunization Repository, which is the provincial information system for vaccine supply management. The number of net doses distributed are calculated by subtracting the number of wasted and reusable vaccines returned to the Ontario Government Pharmacy and Medical Supply Service (OGPMSS) from the gross number of vaccines distributed in a given year.

Data Analysis

The unit of analysis is an individual AEFI report. An AEFI report refers to a report received by the PHU, which pertains to one individual vaccine recipient who experiences one or more adverse events that occurs after administration of one or more vaccines and cannot be clearly attributed to other causes.

Only AEFI reports that meet the following criteria were included in the analysis:

- AEFI reports with a case classification of "confirmed" (i.e., meets the provincial AEFI surveillance definition).
- AEFI reports with a disposition other than "does not meet definition," "entered in error" or "closed- duplicate – do not use".
- AEFI reports associated with at least one Health Canada-approved active immunizing agent administered between 2012 and 2023. AEFI reports that are only associated with diagnostic agents (e.g., tuberculin skin test) and/or passive immunizing agents (e.g., immune globulin) with no active immunizing agents administered at the same time are not within the scope of provincial AEFI surveillance.
- AEFI reports with at least one adverse event.
- AEFI reports in those who were residents of Ontario at the time of adverse event.

Based on the provincial AEFI surveillance definitions described in Appendix 1 of the Ontario Infectious Diseases Protocol, a confirmed AEFI report is defined as: any untoward medical occurrence in a vaccine recipient which follows immunization that cannot be clearly attributed to other causes. The adverse event may be any unfavourable or unintended sign, abnormal laboratory finding, symptom or disease. A causal relationship with the administration of the vaccine does not need to be established in order to be reported as a confirmed case.[14] It is important to note that this tool describes adverse events that were temporally associated and not necessarily causally linked to vaccines.

Adverse events reported following COVID-19 vaccines are not currently included in this tool. However, the tool includes those AEFI reports that were associated with a COVID-19 vaccine and a non-COVID-19 vaccine administered at the same time; however, only the non-COVID-19 vaccine is presented in the vaccine-specific analysis. For more information on COVID-19 vaccine associated AEFIs, see AEFIs for COVID-19 in Ontario.

Serious AEFIs

Serious AEFIs are defined using the World Health Organization (WHO) standard definition: an AEFI that results in death, is life-threatening, requires in-patient hospitalization or prolongs an existing hospitalization, results in persistent or significant disability/incapacity, or in a congenital anomaly/birth defect.[18] Due to the data limitations of passive surveillance, serious AEFIs are operationally defined in Ontario as those with in-patient hospitalization or are reported to have died. In-patient hospitalization is defined as having a hospitalization record with a discharge date that is at least one day following the admission date. Persistent or significant disability/incapacity and congenital anomaly/birth defect are not systematically captured due to the relatively brief follow-up period of AEFIs reported in Ontario.

Calculation of AEFI Reporting Rates

AEFI reporting rates are calculated using either doses distributed or population-based denominators, depending on the purpose and the availability of information.

Doses distributed is used as a proxy for doses administered and enables a more accurate comparison of AEFI reporting rates across geographic areas by taking into account the differences in vaccine distribution. Dose-based reporting rates are calculated using the number of vaccine-specific AEFI reports by year within a geographic region (e.g., all of Ontario or within a PHU) divided by the annual net number of vaccine doses distributed within the specified geographic region. Reporting rates are expressed as the number of AEFI reports for every 100,000 vaccine doses distributed. In the tool, dose-based AEFI reporting rates are presented in the Geography section for the influenza vaccine and in the Vaccines section.

Since dose distribution data are not available within specific demographic groups (e.g., age groups, sex), population-based rates are used for calculating reporting rates within specific demographic groups. Population-based reporting rates are calculated using the number of AEFI reports by year of vaccine administration within a specific demographic group divided by the annual population of the same demographic group. Reporting rates are expressed as the number of AEFI reports for every 100,000 population. In the tool, population-based AEFI reporting rates are presented in the Trends, Age and Sex, and Geography sections.

See the section on Considerations for Interpretation of AEFI Surveillance Data for more information on denominators used to calculate reporting rates.

Data Notes

TRENDS

The number of AEFI reports during the COVID-19 pandemic (2020–2022) should be interpreted with caution due to its impact on the public health and health care sectors. The pandemic posed significant challenges to health care, including deferred routine immunization services, diminished health care seeking behaviours, decreased reporting of AEFIs from HCPs and diversion of public health resources to the pandemic response. All these factors had an impact on AEFI reporting, investigation, and data entry, resulting in lower AEFI reporting.

AGE AND SEX

AEFI reports with unknown age are excluded from age-specific analysis, but are included in the 'all ages' category.

Gender is completed in iPHIS by PHUs based on the reported gender of the client. For analysis purposes, gender is used as a proxy for biological sex for iPHIS data (2012–2022). For CCM data, sex and gender are captured separately; when sex was unknown or missing, gender was used as a proxy if available. AEFI reports with unknown or unspecified/other gender (including gender other than male or female) are excluded from sex-specific analysis, but are included in the 'all sexes' category.

GEOGRAPHY

In the map, reporting rates are grouped into four categories using quartiles (i.e., 0-24th, 25-49th, 50-74th and 75th and higher percentiles) specific to each year and vaccine category. Reporting rates are calculated per 100,000 population, except for the influenza vaccine where the reporting rate is calculated per 100,000 population and per 100,000 doses distributed.

ALL VACCINES (BY POPULATION)

The reporting rate includes AEFIs reported following any vaccine administered in a given year. The population includes people of all ages. COVID-19 vaccines are excluded from the tool.

EARLY CHILDHOOD VACCINES (BY POPULATION)

The reporting rate includes AEFIs reported following routine vaccines that are predominantly administered by primary health care providers to infants and young children. These vaccines include DTaP-IPV-Hib, Pneu-C-13, MMR, Men-C-C, Var, and Rot-1/Rot-5 (Rot-5 replaced Rot-1 in 2018 and then Rot-1 replaced Rot-5 in mid-2021). The population only includes children under four years of age.

INFLUENZA VACCINE (BY POPULATION AND BY DOSES DISTRIBUTED)

The reporting rate includes AEFIs reported following influenza vaccine administered in a given year. The reporting rate is calculated using both population (all ages) and doses distributed.

SCHOOL-BASED VACCINES (BY POPULATION)

The reporting rate includes AEFIs reported following vaccines that are routinely administered by PHUs to adolescents in school-based settings. These vaccines include Men-C-ACWY, HB, and HPV4/HPV-9 (HPV9 replaced HPV4 in 2017). The population only includes adolescents between 11 and 17 years of age.

VACCINES

The term "vaccine" refers to a generic active immunizing agent and may include one or more vaccine products (e.g., "influenza vaccine" refers to all influenza vaccine products). Additional information on vaccines presented in this tool can be found on Public Health Agency of Canada's list of approved vaccines in Canada and the National Vaccine Catalogue. The Canadian Immunization Guide is also a comprehensive resource on immunization and the diseases prevented by vaccines. Each AEFI report refers to an individual who received one or more vaccines that are temporally associated with the

reported adverse event. Therefore, the total number of vaccine-specific AEFI reports can exceed the number of individual AEFI reports reported in a given year. Vaccines are grouped into categories based on the recommended age to receive the vaccine according to the Publicly Funded Immunization Schedules for Ontario.[2] Infant and childhood vaccines include those that are routinely administered to children 10 years of age and younger; adolescent vaccines include those that are routinely administered to adolescents between 11 and 17 years of age in all settings; and adult vaccines include those that are routinely administered to adults 18 years of age and older.

Vaccine-specific reporting rates are calculated using doses distributed. For high-risk publicly funded, travel, and non-publicly funded vaccines, reporting rates are not calculated due to unknown vaccine distribution within the private market. Reporting rates are also not presented where the net doses distributed is zero or smaller (i.e., wastage is greater than doses distributed).

ADVERSE EVENTS

Adverse event refers to the specific event that was temporally associated with receipt of one or more vaccines and cannot be clearly attributed to other causes. An AEFI report may have one or more adverse event. The definition of each adverse event is outlined in Appendix 1 (Adverse Events Following Immunization) of the Ontario Infectious Diseases Protocol.[14]

Adverse events are presented both individually and within event categories, based on the provincial surveillance definitions and categories.[14] As an AEFI report may contain multiple adverse events, the total number of adverse events can exceed the number of individual AEFI reports reported in a given year. In addition, if an AEFI report contains more than one adverse event within the same event category, they are counted only once in the category total. Therefore, the total number of adverse events within a category may not equal to the category total. Percent of all AEFI reports is calculated by dividing the number of event or category- specific AEFI reports by the total number of individual AEFI reports reported in a given year.

Adverse events in the category of 'COVID-19 adverse events of special interest' that are presented in the tool likely represent those AEFI reports that are associated with a non-COVID-19 vaccine co-administered with a COVID-19 vaccine. Several adverse events of special interest (AESI) following administration of COVID-19 vaccine(s) have been identified by international health authorities based on a theoretical rationale for possible association with COVID-19 vaccines.

Considerations for Interpretation of AEFI Surveillance Data

General limitations of the AEFI surveillance data presented here are similar to other passive AEFI surveillance systems. These include inconsistent quality and completeness of AEFI reports, and reporting bias, including under-reporting, particularly for mild or common reportable events, as well as stimulated (elevated) reporting, which can occur in response to media coverage and subsequently increased public awareness. Additionally, the provincial AEFI surveillance system does not include an unimmunized group for comparison, therefore determining whether immunization is associated with an increased risk of a specific adverse event at a population level is not possible; further study would be required.

A further limitation of the analysis of AEFI surveillance data in Ontario is the lack of a population-based provincial immunization registry to estimate the number of individuals who were immunized or doses administered to individuals. This would enable estimation of AEFI incidence rates, including specific events, by vaccine type. In lieu of this, AEFI reporting rates are estimated using either the entire population irrespective of immunization status or vaccine doses distributed as the denominator. In this analysis, population-based denominators are used for overall system reporting rates (all vaccines combined) and for overall demographic analysis. This approach enables comparison of overall AEFI reporting trends over time and across geographic areas; however, population-based reporting rates have limitations as a proxy for true AEFI incidence where there are variations in vaccine uptake (i.e., coverage) over time or between geographic areas. Doses distributed are widely used in analyses of passive AEFI surveillance systems and can be a reasonable proxy for doses administered for established programs with known vaccine wastage.[19,20] When the amount of wastage is unknown and underestimated, this can result in underestimates of reporting rates. Additionally, in the context of new or discontinued vaccines/programs, the AEFI reporting rate using doses distributed as the denominator can be temporarily rendered invalid due to fluctuations in vaccine distribution caused by stockpiling, delayed vaccine use or large returns of unused/expired doses.

Changes to AEFI surveillance in the province (e.g., revised case definitions, updates to the iPHIS application) may impact comparability of AEFI surveillance data over time. In addition, trends in reported AEFIs can be influenced by changes to the publicly-funded program such as changes in vaccine products. Finally, the COVID-19 pandemic significantly reduced the number of AEFI reports received during 2020–2022. The number of AEFI reports during 2020–2022 should be interpreted with caution due to the potential impact on AEFI reporting, investigation and data entry arising from deferred routine immunization services, diminished health care seeking behaviours as a result of COVID-19 public health measures, decreased reporting from HCPs, as well as diversion of public health resources to the pandemic response. It is also important to note the changes in the provincial reporting system for AEFIs that occurred during the surveillance period: iPHIS was used in all years except between December 2022 and May 2024 where CCM was used. Changes in reporting system may impact comparability of AEFI surveillance data and analyses of trends over time.

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Appendix A: Immunizing Agent Abbreviations and Descriptions

Sources from Panorama

aP: Acellular pertussis

ap: Acellula pertussis (reduced)

ap-unspecified: Reduced acellular pertussis-containing agent (agent formulation unknown)

BCG vaccine: Bacillus Calmette-Guérin

D: Diphtheria toxoid

d: Diphtheria toxoid (reduced)

D-Hib: Diphtheria toxoid, *Haemophilus influenzae* type b

DPT: Diphtheria toxoid, tetanus toxoids, whole-cell pertussis

DPT-HB: Diphtheria toxoid, tetanus toxoid, whole-cell pertussis, hepatitis B

DPT-HB-Hib: Diphtheria toxoid, tetanus toxoid, whole-cell pertussis, hepatitis B, *Haemophilus influenzae* type b

DPT-Hib

DPT-IPV: Diphtheria toxoid, tetanus toxoid, whole-cell pertussis, inactivated poliomyelitis

DPTP: Diphtheria toxoid, tetanus toxoid, whole-cell pertussis, poliomyelitis

DPTP-Hib: Diphtheria toxoid, tetanus toxoid, whole-cell pertussis, poliomyelitis, *Haemophilus influenzae* type b

DT: Diphtheria, tetanus

DTaP: Diphtheria, tetanus, acellular pertussis

DTaP-HB-IPV: Diphtheria toxoid, tetanus toxoid, acellular pertussis, hepatitis B, inactivated poliomyelitis

DTaP-HB-IPV-Hib: Diphtheria toxoid, tetanus toxoid, acellular pertussis, hepatitis B, inactivated poliomyelitis, *Haemophilus influenzae* type b

DTaP-Hib: Diphtheria toxoid, tetanus toxoid, acellular pertussis, *Haemophilus influenzae* type b

DTaP-IPV: Diphtheria toxoid, tetanus toxoid, acellular pertussis, inactivated poliomyelitis

DTaP-IPV-Hib: Diphtheria toxoid, tetanus toxoid, acellular pertussis, inactivated poliomyelitis, *Haemophilus influenzae* type b

DT-IPV: Diphtheria toxoid, tetanus toxoid, inactivated poliomyelitis

DTwP-HB: Diphtheria toxoid, tetanus toxoid, whole-cell pertussis, hepatitis B

d-unspecified: Diphtheria toxoid-containing agent (agent formulation unknown)

HAHB: Hepatitis A, hepatitis B

HAHB-pediatric: Hepatitis A, hepatitis B (pediatric formation)

HAHB-unspecified: Hepatitis A, hepatitis B (agent formulation unknown)

HB: Hepatitis B

HB-dialysis: Hepatitis B (dialysis formulation)

HB-pediatric: Hepatitis B (pediatric formulation)

HB-unspecified: Hepatitis B-containing agent (agent formulation unknown)

Hib-HB: *Haemophilus influenzae* type b, hepatitis B

HPV-2: Bivalent human papillomavirus [types 16, 18]

HPV-4: Quadrivalent human papillomavirus [types 6, 11, 16, 18]

HPV-9: Nonavalent human papillomavirus [types 6, 11, 16, 18, 31, 33, 45, 52, 58]

hpv-unspecified: Human papillomavirus-containing agent (agent formulation unknown)

IPV: Inactivated poliomyelitis

M: Measles

men-AC-unspecified: Meningococcal groups A, C-containing agent (agent formulation unknown)

Men-ACYW-135 unspecified: Quadrivalent meningococcal-agent (agent formulation unknown)

Men-C-AC: Meningococcal conjugate bivalent (groups A, C)

Men-C-ACYW-135: Meningococcal conjugate, quadrivalent (groups A, C, Y, W-135)

Men-C-C: Meningococcal conjugate, monovalent (group C)

Men-C-CY: Meningococcal conjugate (groups C, Y)

Men-C-CY-Hib: Meningococcal conjugate (groups C, Y), *Haemophilus influenzae* type b

men-c-unspecified: Meningococcal conjugate agent (agent formulation unknown)

men-p-AC unspecified: Meningococcal polysaccharide, bivalent (groups A, C)

men-p-unspecified: Meningococcal polysaccharide agent (agent formulation unknown)

Men-P-ACYW-135: Meningococcal polysaccharide, quadrivalent (groups A, C, Y, W-135)

men-p-A unspecified: Meningococcal polysaccharide group A-containing agent (agent formulation unknown)

men-unspecified: Meningococcal agent (agent formulation unknown)

MMR: Measles, mumps, rubella

MMR-Var: Measles, mumps, rubella, varicella

MR: Measles, rubella

Mu: Mumps

OPV: Live attenuated oral poliomyelitis

p: Polio

pertussis-unspecified: Pertussis-containing agent (agent formulation unknown)

Pneu-C-10: Pneumococcal conjugate, 10-valent

Pneu-C-13: Pneumococcal conjugate, 13-valent

Pneu-C-15: Pneumococcal conjugate, 15-valent

Pneu-C-20: Pneumococcal conjugate, 20-valent

Pneu-C-7: Pneumococcal conjugate, 7-valent

pneu-c-unspecified: Pneumococcal conjugate agent (agent formulation unknown)

Pneu-P-23: Pneumococcal polysaccharide, 23-valent

pneu-p-unspecified: Pneumococcal polysaccharide agent (agent formulation unknown)

pneu-unspecified: Pneumococcal agent (agent formulation unknown)

p-unspecified: Poliomyelitis-containing agent (agent formulation unknown)

R: Rubella

Rota-1: Rotavirus monovalent

Rota-5: Rotavirus pentavalent

rota-unspecified: Rotavirus-containing agent (agent formulation unknown)

Sma: Smallpox

T: Tetanus

Td: Tetanus toxoid, reduced diphtheria toxoid

Tdap: Tetanus toxoid, reduced diphtheria toxoid, reduced acellular pertussis

Tdap-IPV: Tetanus toxoid, reduced diphtheria toxoid, reduced acellular pertussis, inactivated poliomyelitis

Td-IPV: Tetanus toxoid, reduced diphtheria toxoid, inactivated poliomyelitis

T-IPV: Tetanus toxoid, inactivated poliomyelitis

Var: Varicella

wP: Whole-cell pertussis

YF: Yellow Fever

Zos: Herpes zoster

Zos-Live: Live attenuated herpes zoster

Zos-unspecified: Herpes zoster (agent formulation unknown)

Sources from Coverage Assessment

HPV: Human papillomavirus

MCC: Meningococcal-C-conjugate

MCV4: Quadrivalent meningococcal conjugate

Source from Panorama and Coverage Assessment

Hib: *Haemophilus influenzae* type b

Appendix B: Definitions of Up-to-Date Coverage by Disease Antigen

Diphtheria

Age assessed: 7 and 17 years old

Up-to-date definition:

7-year-olds must satisfy one of the following criteria:

- ≥5 valid doses
- Four valid doses (only if received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old)

17-year-olds must satisfy one of the following criteria:

- ≥6 valid doses
- Five valid doses and only if satisfies one of the following:
    - Received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old
    - Received first valid dose at <7 years old AND received fifth valid dose at ≥4 years old AND <10 years between fifth valid dose and assessment date
- Four valid doses and only if satisfies one of the following:
    - Received first valid dose at <7 years old AND <10 years between fourth valid dose and assessment date
    - Received first valid dose at ≥7 years old (i.e., two primary and two booster doses)
- Three valid doses (only if received first valid dose ≥7 years old AND <10 years between third valid dose and assessment date)
    - Note: PHO considers receipt of two primary doses and one booster dose for individuals who start their series late (i.e., ≥7 years old) as the minimum requirement to be considered up-to-date, as long as less than 10 years have elapsed between the last (booster) dose and the date of assessment

Relevant immunizing agents:

- D
- d
- D-Hib
- DPT
- DPT-HB
- DPT-HB-Hib
- DPT-Hib
- DPT-IPV
- DPTP
- DPTP-Hib
- DT
- DTaP
- DTaP-HB-IPV
- DTaP-HB-IPV-Hib
- DTaP-Hib
- DTaP-IPV
- DTaP-IPV-Hib
- DT-IPV
- DTwP-HB
- d-unspecified
- Td
- Tdap
- Tdap-IPV
- Td-IPV

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Keep any one

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥42 days old
- Second valid dose — Received ≥28 days after first valid dose
- Third valid dose — One of the following:
    - Received first valid dose at <7 years old AND received ≥28 days after second valid dose
    - Received first valid dose at ≥7 years old AND received ≥168 days after second valid dose
- Fourth valid dose — One of the following:
    - Received first valid dose at <7 years old AND received ≥168 days after third valid dose AND ≥1 year old
    - Received first valid dose at ≥7 years old AND one of the following:
        - Received ≥10 years after third valid dose
        - Received ≥28 days after third valid dose AND ≥14 years old

- Fifth valid dose — One of the following:
    - Received first valid dose at <7 years old AND one of the following:
        - Received fourth valid dose at 1 to <4 years old AND received ≥28 days after fourth valid dose AND ≥4 years old
        - Received fourth valid dose at ≥4 years old AND received ≥10 years after fourth valid dose
        - Received fourth valid dose at ≥4 years old AND received ≥28 days after fourth valid dose AND ≥14 years old
    - Received first valid dose at ≥7 years old AND received ≥10 years after fourth valid dose
- Sixth valid dose — One of the following:
    - Received first valid dose at <7 years old AND received fourth valid dose at 1 to <4 years old AND one of the following:
        - Received ≥10 years after fifth valid dose
        - Received ≥28 days after fifth valid dose AND ≥14 years old
    - Received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old AND received ≥10 years after fifth valid dose
    - Received first valid dose at ≥7 years old AND received ≥10 years after fifth valid dose

Additional notes:

- All immunizing agents containing the respective antigens were considered valid (i.e., D or d) as long as they met the minimum age and minimum interval requirements
- Although an accelerated schedule is not specified in the *Canadian Immunization Guide* chapter on diphtheria for children who initiate the series when ≥7 years old[4], the minimum intervals outlined between doses of the primary series for infants were also applied to older children
- For the last (booster) dose, we used a 10-year interval instead of a five-year interval (as is used in the Panorama forecaster logic), in accordance with the *Canadian Immunization Guide*[4]

Exemption antigens:

- Diphtheria (D)
- Diphtheria (d)
- diphtheria (d-u)

Haemophilus influenza Type B (Hib)

Age assessed: 7 years old

Up-to-date definition: Must satisfy one of the following criteria:

- ≥4 valid doses
- Three valid doses (only if received first valid dose at 7 to <12 months old)
- Two valid doses (only if received first valid dose at 12 to <15 months old)
- One valid dose (only if received first valid dose at ≥15 months old)

Relevant immunizing agents:

- D-Hib
- DPT-HB-Hib
- DPT-Hib
- DPTP-Hib
- DTaP-HB-IPV-Hib
- DTaP-Hib
- DTaP-IPV-Hib
- Hib
- Hib-HB
- Men-C-CY-Hib

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Keep any one

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥42 days old
- Second valid dose — One of the following:
  - Received first valid dose at <12 months old AND received ≥28 days after first valid dose
  - Received first valid dose at 12 to <15 months old AND received ≥56 days after first valid dose
- Third valid dose — One of the following:
  - Received first valid dose at <7 months old AND received ≥28 days after second valid dose
  - Received first valid dose at 7 to <12 months old AND received ≥56 days after second valid dose AND ≥1 year old
- Fourth valid dose — Received first valid dose at <7 months old AND received ≥56 days after third valid dose AND ≥1 year old

Additional notes:

- Doses administered after the fifth birthday, but before the assessment date are considered valid for 7-year-olds if they satisfy the criteria for valid dose assessment
- An accelerated schedule (a 28-day interval between the first three doses) for those initiating a series at 2 to <7 months was accepted. This differs from the recommended schedule in the *Canadian Immunization Guide* for those initiating a series at 7 to <12 months, where a two-month interval is recommended.[4]
- Specific to Hib, a two-month interval between completion of the primary series and booster dose was applied

Exemption antigens: Not applicable

Hepatitis B

Age assessed: 12 and 17 years old

Up-to-date definition: Must satisfy one of the following criteria:

- Three valid doses in accordance with the three-dose schedule
- Two valid doses in accordance with the two-dose schedule
- Have a documented exemption for evidence of immunity

Relevant immunizing agents:

- DPT-HB
- DPT-HB-Hib
- DTaP-HB-IPV
- DTaP-HB-IPV-Hib
- DTwP-HB
- HAHB
- HAHB-pediatric
- HAHB-unspecified
- HB
- HB-dialysis
- HB-pediatric
- HB-unspecified
- Hib-HB

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Use the following hierarchies to keep only one record:

- DTaP-HB-IPV-Hib > DPT-HB-Hib
- DTaP-HB-IPV > DPT-HB
- DTwP-HB > Hib-HB > HAHB-pediatric > HAHB > HAHB-unspecified > HB-dialysis > HB-pediatric > HB > HB-unspecified

These hierarchies is guided by the inclusiveness of the agent (i.e., keep the agent that includes the largest number of antigens).

Evidence of immunity: Include evidence of immunity records for the following:

- Hepatitis B (HB)
- Hepatitis B (HB-dialysis)
- Hepatitis B (HB-pediatric)
- Hepatitis B (HB-unspecified)
- Hepatitis B (HB-regular)
- Hep B antibody
- Hepatitis B immunoglobulin

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

A student is assessed using both the two- and three-dose schedules and is considered up-to-date if at least one schedule is satisfied.

Two-dose schedule for Engerix®-B series (applied only if all doses received by the student are HB or HB-unspecified with an Engerix®-B trade name):

- First valid dose — HB, HB-unspecified or HB-pediatric received at 11 to <16 years old
- Second valid dose — HB, HB-unspecified or HB-pediatric received ≥168 days after first valid dose AND received at 11 to <16 years old

Two-dose schedule for non-Engerix®-B series (applied to those not assessed based on the two-dose schedule for Engerix®-B):

- First valid dose — HB, HB-unspecified, HB-pediatric, HAHB, HAHB-pediatric or HAHB-unspecified received at 11 to <16 years old
- Second valid dose — Received at 11 to <16 years old AND one of the following:
    - First valid dose was HB, HB-unspecified or HB-pediatric AND one of the following:
        - HB, HB-unspecified or HB-pediatric received ≥112 days after first valid dose
        - HAHB, HAHB-pediatric or HAHB-unspecified received ≥168 days after first valid dose
    - First valid dose was HAHB, HAHB-pediatric or HAHB-unspecified AND current dose is HB, HB-unspecified, HB-pediatric, HAHB, HAHB-pediatric or HAHB-unspecified received ≥168 days after first valid dose

Three-dose schedule (all students):

- First valid dose — One of the following:
    - HB, HB-dialysis, HB-unspecified or HB-pediatric received on or after birth
    - HAHB received at ≥1 years old
    - DTaP-HB-IPV-Hib, DPT-HB, DPT-HB-Hib, DTaP-HB-IPV, DTwP-HB or Hib-HB received at ≥42 days old
- Second valid dose — One of the following:
    - HB, HB-dialysis, HB-unspecified or HB-pediatric received ≥28 days after first valid dose
    - HAHB, HAHB-pediatric or HAHB-unspecified received ≥28 days after first valid dose AND ≥1 year old
    - DTaP-HB-IPV-Hib, DPT-HB, DPT-HB-Hib, DTaP-HB-IPV, DTwP-HB or Hib-HB received ≥28 days after first valid dose AND ≥42 days old

- Third valid dose — One of the following:
    - First valid dose was HB, HB-dialysis HB-unspecified, HB-pediatric, DTaP-HB-IPV-Hib, DPT-HB, DPT-HB-Hib, DTaP-HB-IPV, DTwP-HB or Hib-HB AND one of the following:
        - HB, HB-dialysis, HB-unspecified, HB-pediatric, DTaP-HB-IPV-Hib, DPT-HB, DPT-HB-Hib, DTaP-HB-IPV, DTwP-HB or Hib-HB received ≥112 days after first valid dose AND received ≥28 days after second valid dose
        - HAHB, HAHB-pediatric or HAHB-unspecified received ≥168 days after first valid dose AND received ≥28 days after second valid dose AND ≥1 year old
    - First valid dose was HAHB, HAHB-pediatric or HAHB-unspecified AND current dose is HB, HB-dialysis, HB-unspecified, HB-pediatric, HAHB, HAHB-pediatric, HAHB-unspecified, DTaP-HB-IPV-Hib, DPT-HB, DPT-HB-Hib, DTaP-HB-IPV, DTwP-HB or Hib-HB received ≥168 days after first valid dose AND received ≥28 days after 2nd valid dose

Additional notes:

- If a series involves at least two different immunizing agents, the validity of the current dose is assessed based on the logic corresponding to the first valid dose. An exception is for HAHB, HAHB-pediatric and HAHB-unspecified, where a 168-day interval is required between the first and last doses in the series whenever HAHB, HAHB-pediatric or HAHB-unspecified is administered as either the first valid dose or the last dose in the series.
- For the Engerix®-B two-dose schedule, all variations of 'Engerix-B' are considered since Trade Name is a free-text field for historical immunizations
- Trade name is not considered for validation of the three-dose schedule
- Since Twinrix® and Twinrix® Junior are not differentiated at the agent level, all HAHB doses are assumed to be Twinrix® for the two-dose schedule and assumed to be Twinrix® Junior for the three-dose schedule. A more conservative age requirement (11–16 years) is imposed for the two-dose schedule.
- For the two-dose schedules, doses given before 11 years of age do not affect the validity of doses given ≥11 years of age (e.g., doses administered before 11 years of age are not reviewed as part of valid dose assessment for HB two-dose coverage)
- The HB component of DTaP-HB-IPV-Hib is validated even if administered on or after the age of 7 years
- HB-dialysis is validated using the HB logic, but only under the three-dose schedule
- DPT-HB, DPT-HB-Hib, DTaP-HB-IPV, DTwP-HB and Hib-HB are validated using the logic for DTaP-HB-IPV-Hib

Exemption antigens: Not applicable

Human Papillomavirus (HPV)

Age assessed:

- 12 years old (all students)
- 17 years old (females only)

Up-to-date definition: Must satisfy one of the following criteria:

- Three valid doses in accordance with the three-dose schedule
- Two valid doses in accordance with the two-dose schedule

Relevant immunizing agents:

- HPV-2
- HPV-9
- hpv-unspecified
- HPV-4

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Use the following hierarchy to keep only one record: HPV-4 > hpv-unspecified > HPV-9 > HPV-2

The hierarchy is guided by giving preference to the publicly-funded vaccine used in Ontario in the 2018–19 school year (HPV-9) and then considering the vaccine offering protection against the greatest number of HPV genotypes. Unspecified HPV vaccines were assumed to be capturing the use of HPV-9 given the high prevalence of HPV-9 vaccines administered during this school year.

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

A student is assessed using both the two- and three-dose schedules and is considered up-to-date if at least one schedule is satisfied.

If gender is female:

- Two-dose schedule
    - First valid dose — HPV-2, HPV-4, HPV-9 or hpv-unspecified received at 9 to <15 years old
    - Second valid dose — HPV-2, HPV-4, HPV-9 or hpv-unspecified received ≥168 days after first valid dose

- Three-dose schedule
    - First valid dose — HPV-2, HPV-4, HPV-9 or hpv-unspecified received at ≥9 years old
    - Second valid dose — HPV-2, HPV-4, HPV-9 or hpv-unspecified received ≥28 days after first valid dose
    - Third valid dose — HPV-2, HPV-4, HPV-9 or hpv-unspecified AND received ≥84 days after second valid dose AND ≥168 days after first valid dose

If gender is male:

- Two-dose schedule
    - First valid dose — HPV-4, HPV-9 or hpv-unspecified received at 9 to <15 years old
    - Second valid dose — HPV-4, HPV-9 or hpv-unspecified received ≥168 days after first valid dose
- Three-dose schedule
    - First valid dose — HPV-4, HPV-9 or hpv-unspecified received at ≥9 years old
    - Second valid dose — HPV-4, HPV-9 or hpv-unspecified received ≥28 days after first valid dose
    - Third valid dose — HPV-4, HPV-9 or hpv-unspecified AND received ≥84 days after second valid dose AND ≥168 days after first valid dose

Additional notes:

- If a series involves more than two different immunizing agents, the current dose is validated based on the logic corresponding to the first valid dose
- Beginning in the 2016–17 school year, Ontario's HPV vaccination program switched from a program for Grade 8 girls to Grade 7 boys and girls
- Beginning September 5, 2017, HPV-9 replaced the HPV-4 vaccine in Ontario's HPV vaccination program
- HPV-2 is not incorporated into the valid dose parameters for coverage in males, as it is not authorized for use in males

Exemption antigens: Not applicable

Measles

Age assessed: 7 to 17 years old

Up-to-date definition: Must satisfy one of the following criteria:

- ≥2 valid doses
- Have a documented exemption for evidence of immunity

Relevant immunizing agents:

- M
- MMR
- MMR-Var
- MR

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: A minimum interval of 28 days between all live-virus vaccine combinations is required, unless they are administered on the same day. Additional immunizing agents used to assess for vaccine interactions:

- Mu
- R
- Var
- YF
- Sma
- Zos
- Zos-Live
- Zos-unspecified
- BCG vaccine

Multiple vaccines on the same day:

- If multiple measles-containing agents are received on the same day, keep any one
- If multiple non-measles containing live-virus vaccines are received on the same day, keep any one
- If a mix of measles and non-measles containing live-virus vaccines is received on the same day, keep one of each

Evidence of immunity: Include evidence of immunity records for: Measles (M)

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥1 year old AND both of the following:
  - Received ≥28 days after any preceding measles-containing vaccine
  - Received on the same day or ≥28 days after any preceding non-measles containing live-virus vaccine
- Second valid dose — Received ≥28 days after any preceding measles-containing vaccine AND received on the same day or ≥28 days after any preceding non-measles containing live-virus vaccine

Additional notes: None

Exemption antigens: Measles (M)

Meningococcal C Conjugate (MCC)

Age assessed: 7 years old

Up-to-date definition: ≥1 valid dose

Relevant immunizing agents:

- men-AC unspecified
- Men-ACYW-135-unspecified
- Men-C-AC
- Men-C-ACYW-135
- Men-C-C
- Men-C-CY
- Men-C-CY-Hib
- men-c-unspecified
- men-unspecified

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: A minimum interval of 168 days (or received on the same day) is required between a meningococcal polysaccharide vaccine followed by a meningococcal conjugate vaccine. Meningococcal polysaccharide C-containing agents:

- men-p-AC unspecified
- men-p-unspecified
- Men-P-ACYW-135

Doses of meningococcal polysaccharide agents administered <2 years of age are ignored as potential vaccine interactions due to the poor immune response generated by infants and toddlers to polysaccharide vaccines.

Multiple vaccines on the same day:

- If multiple MCC-containing vaccines (i.e., relevant immunizing agents) are received on the same day, keep any one
- If multiple meningococcal polysaccharide C-containing vaccines are received on the same day, keep any one
- If a mix of meningococcal conjugate and polysaccharide C-containing vaccines is received on the same day, keep one of each

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- Received at ≥1 year old AND received on the same day or ≥168 days after any previous meningococcal polysaccharide C-containing dose

Additional notes:

- Only doses administered ≥1 year of age are assessed as being valid. No minimum interval is imposed between dose(s) administered prior to the first birthday for valid dose assessment of the dose administered on/after 1 year of age (i.e., doses administered prior to the first birthday are not reviewed as part of valid dose assessment for MCC coverage).
- Due to the low completeness of the Trade Name field in Panorama, product-specific logic could not be developed for quadrivalent meningococcal conjugate (MCV4) records (as different MCV4 products have different dose recommendations and minimum interval requirements). Thus, one valid dose of MCV4 vaccine administered ≥1 year of age is assessed as being sufficient for being up-to-date for MCC at 7 years.

Exemption antigens:

- Men-C-AC
- Men-C-CY
- Meningitis (Men-C-GrC)
- meningitis (men-ACYW135)
- meningitis (men-C-ACYW135)
- meningitis (men-C-u)
- meningitis (men-GrC)
- meningitis (men-u)

Meningococcal Conjugate Quadrivalent (MCV4)

Age assessed: 12 and 17 years old

Up-to-date definition: ≥1 valid dose

Relevant immunizing agents:

- Men-C-ACYW-135
- Men-ACYW-135-unspecified

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: A minimum interval of 168 days (or received on the same day) is required between a meningococcal polysaccharide vaccine followed by a meningococcal conjugate vaccine. Meningococcal polysaccharide agents:

- Men-P-ACYW-135
- men-p-unspecified
- men-p-A unspecified
- men-p-AC unspecified

Doses of meningococcal polysaccharide agents administered <2 years of age are ignored as potential vaccine interactions due to the poor immune response generated by infants and toddlers to polysaccharide vaccines.

Multiple vaccines on the same day:

- If multiple MCV4 vaccines (i.e., relevant immunizing agents) are received on the same day, keep any one
- If multiple meningococcal polysaccharide vaccines are received on the same day, keep any one
- If a mix of MCV4 and polysaccharide vaccines is received on the same day, keep one of each

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- Received as early as September 1, five years prior to the end of the Grade 7 school year, based on the assumption that the student is 12 years old in Grade 7 (i.e., received on or after September 1, 2014 for the 2018–19 school year for a 12-year-old) AND received on the same day or ≥168 days after any previous meningococcal polysaccharide dose

Additional notes:

- Extrapolating from the booster dose intervals recommended for children with high risk medical conditions (*Canadian Immunization Guide* recommends a booster dose every five years for those vaccinated at 7 years of age and older[4]), PHO considers MCV4 doses administered in the five-year interval preceding eligibility at the end of Grade 7 as meeting the up-to-date criteria for adolescent MCV4 coverage

Exemption antigens:

- meningitis (men-ACYW135)
- meningitis (men-C-ACYW135)
- meningitis (men-C-u)
- meningitis (men-u)

Mumps

Age assessed: 7 and 17 years old

Up-to-date definition: Must satisfy one of the following criteria:

- ≥2 valid doses
- Have a documented exemption for evidence of immunity

Relevant immunizing agents:

- MMR
- MMR-Var
- Mu

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: A minimum interval of 28 days between all live virus vaccine combinations is required, unless they are administered on the same day. Additional immunizing agents used to assess for vaccine interactions:

- M
- MR
- R
- Var
- YF
- Sma
- Zos
- Zos-Live
- Zos-unspecified
- BCG vaccine

Multiple vaccines on the same day:

- If multiple mumps-containing agents are received on the same day, keep any one
- If multiple non-mumps containing live virus vaccines are received on the same day, keep any one
- If a mix of mumps- and non-mumps containing live virus vaccines is received on the same day, keep one of each

Evidence of immunity: Include evidence of immunity records for: Mumps (Mu)

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥1 year old AND both of the following:
  - Received ≥28 days after any preceding mumps-containing vaccine
  - Received on the same day or ≥28 days after any preceding non-mumps containing live virus vaccine
- Second valid dose — Received ≥28 days after any preceding mumps-containing vaccine AND received on the same day or ≥28 days after any preceding non-mumps containing live virus vaccine

Additional notes: None

Exemption antigens: Mumps (Mu)

Pertussis

Age assessed: 7 and 17 years old

Up-to-date definition:

7-year-olds must satisfy one of the following criteria:

- ≥5 valid doses
- Four valid doses (only if received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old)

17-year-olds must satisfy one of the following criteria:

- ≥6 valid doses
- Five valid doses and only if satisfies one of the following:
    - Received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old
    - Received first valid dose at <7 years old AND received fifth valid dose at ≥4 years old AND <10 years between fifth valid dose and assessment date
- Four valid doses and only if satisfies one of the following:
    - Received first valid dose at <7 years old AND <10 years between fourth valid dose and assessment date
    - Received first valid dose at ≥7 years old (i.e., two primary and two booster doses)
- Three valid doses (only if received first valid dose ≥7 years old AND <10 years between third valid dose and assessment date)
    - Note: PHO considers receipt of two primary doses and one 'booster' dose for individuals who start their series late (i.e., ≥7 years old) as the minimum requirement to be considered up-to-date, as long as less than 10 years have elapsed between the last (booster) dose and the date of assessment

Relevant immunizing agents:

- aP
- ap
- ap-unspecified
- DPT
- DPT-HB
- DPT-HB-Hib
- DPT-Hib
- DPT-IPV
- DPTP
- DPTP-Hib
- DTaP
- DTaP-HB-IPV
- DTaP-HB-IPV-Hib
- DTaP-Hib
- DTaP-IPV
- DTaP-IPV-Hib
- DTwP-HB
- pertussis-unspecified
- Tdap
- Tdap-IPV
- wP

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Keep any one

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥42 days old
- Second valid dose — Received ≥28 days after first valid dose
- Third valid dose — One of the following:
    - Received first valid dose at <7 years old AND received ≥28 days after second valid dose
    - Received first valid dose at ≥7 years old AND received ≥168 days after second valid dose
- Fourth valid dose — One of the following:
    - Received first valid dose at <7 years old AND received ≥168 days after third valid dose AND ≥1 year old
    - Received first valid dose at ≥7 years old AND one of the following:
        - Received ≥10 years after third valid dose
        - Received ≥28 days after third valid dose AND ≥14 years old
- Fifth valid dose — One of the following:
    - Received first valid dose at <7 years old AND one of the following:
        - Received fourth valid dose at 1 to <4 years old AND received ≥28 days after fourth valid dose AND ≥4 years old
        - Received fourth valid dose at ≥4 years old AND received ≥10 years after fourth valid dose
        - Received fourth valid dose at ≥4 years old AND received ≥28 days after fourth valid dose AND ≥14 years old
    - Received first valid dose at ≥7 years old AND received ≥10 years after fourth valid dose
- Sixth valid dose — One of the following:
    - Received first valid dose at <7 years old AND received fourth valid dose at 1 to <4 years old AND one of the following:
        - Received ≥10 years after fifth valid dose

- Received ≥28 days after fifth valid dose AND ≥14 years old

- Received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old AND received ≥10 years after fifth valid dose
- Received first valid dose at ≥7 years old AND received ≥10 years after fifth valid dose

Additional notes:

- All immunizing agents containing the respective antigens were considered valid (i.e., P or p) as long as they met the minimum age and minimum interval requirements
- Although an accelerated schedule is not specified in the *Canadian Immunization Guide* chapter on pertussis for children who initiate the series when ≥7 years old[4], the minimum intervals outlined between doses of the primary series for infants were also applied to older children
- For the last (booster) dose, we used a 10-year interval instead of a five-year interval (as is used in the Panorama forecaster logic), in accordance with the *Canadian Immunization Guide*[4]

Exemption antigens:

- Pertussis (aP)
- pertussis (ap)
- pertussis (pertussis-u)
- pertussis (P)
- pertussis (ap-u)
- Pertussis (wP)

Pneumococcal Conjugate

Age assessed: 7 years old

Up-to-date definition: Must satisfy one of the following criteria:

- Four valid doses in accordance with the 3+1 schedule
- Three valid doses in accordance with the 2+1 schedule
- Two valid doses in accordance with the two-dose schedule
- One valid dose in accordance with the one-dose schedule

Relevant immunizing agents:

- Pneu-C-7
- Pneu-C-10
- Pneu-C-13
- Pneu-C-15
- Pneu-C-20
- pneu-unspecified
- pneu-c-unspecified

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: A minimum interval of one year (or received on the same day) is required between a pneumococcal polysaccharide vaccine followed by a pneumococcal conjugate vaccine. Pneumococcal polysaccharide agents:

- Pneu-P-23
- pneu-p-unspecified

Doses of pneumococcal polysaccharide agents administered <2 years of age are ignored as potential vaccine interactions due to the poor immune response generated by infants and toddlers to polysaccharide vaccines.

Multiple vaccines on the same day:

- If multiple conjugate pneumococcal vaccines are received on the same day, keep any one
- If multiple polysaccharide pneumococcal vaccines are received on the same day, keep any one
- If a mix of conjugate and polysaccharide pneumococcal vaccines is received on the same day, keep one of each

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

A child is assessed according to multiple schedules and is considered up-to-date if at least one schedule is satisfied.

3+1 schedule:

- First valid dose — Received at ≥42 days to <7 months old AND received on the same day or ≥1 year after any preceding polysaccharide dose
- Second valid dose — Received ≥28 days after first valid dose AND received on the same day or ≥1 year after any preceding polysaccharide dose
- Third valid dose — Received ≥28 days after second valid dose AND received on the same day or ≥1 year after any preceding polysaccharide dose
- Fourth valid dose — Received ≥56 days after third valid dose AND ≥1 year old AND received on the same day or ≥1 year after any preceding polysaccharide dose

2+1 schedule:

- First valid dose — Received at ≥42 days to <1 year old AND received on the same day or ≥1 year after any preceding polysaccharide dose
- Second valid dose — Received ≥28 days after first valid dose AND received on the same day or ≥1 year after any preceding polysaccharide dose
- Third valid dose — Received ≥56 days after second valid dose AND ≥1 year old AND received on the same day or ≥1 year after any preceding polysaccharide dose

Two-dose schedule:

- First valid dose — Received at ≥1 year to <2 years old AND received on the same day or ≥1 year after any preceding polysaccharide dose
- Second valid dose — Received ≥56 days after first valid dose AND received on the same day or ≥1 year after any preceding polysaccharide dose

One-dose schedule:

- First valid dose — Received at ≥2 years old AND received on the same day or ≥1 year after any preceding polysaccharide dose

Additional notes:

- No distinction is made between serotype components of conjugate pneumococcal vaccine; any conjugate pneumococcal vaccine will be considered
- Several discrepancies were noted with respect to minimum ages and minimum intervals between the *Canadian Immunization Guide* chapter on pneumococcal vaccines and vaccine-specific product monographs.[4] In general, the interval that would allow for the greatest number of valid doses was selected when discrepancies were noted.

Exemption antigens: Not applicable

Polio

Age assessed: 7 and 17 years old

Up-to-date definition: Must satisfy one of the following criteria:

- Four valid doses
- Three valid doses (only if received third valid dose at ≥4 years old)

Relevant immunizing agents:

- DPT-IPV
- DPTP
- DPTP-Hib
- DTaP-HB-IPV
- DTaP-HB-IPV-Hib
- DTaP-IPV
- DTaP-IPV-Hib
- DT-IPV
- IPV
- OPV
- p-unspecified
- Tdap-IPV
- Td-IPV
- T-IPV

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Keep any one

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥42 days old
- Second valid dose — Received ≥28 days after first valid dose
- Third valid dose — Received ≥168 days after second valid dose AND ≥1 year old
- Fourth valid dose — Received third valid dose at <4 years old AND received ≥28 days after third valid dose AND ≥4 years old

Additional notes:

- IPV and OPV containing immunizing agents were considered interchangeable (while OPV is not used in Canada, it is still used elsewhere in the world)
- In contrast to *Canadian Immunization Guide*[4], the dose administered at ≥4 years old does not need to be IPV (i.e., can be either IPV or OPV)

Exemption antigens:

- Polio (IPV)
- polio (p-u)
- live poliovirus (OPV)

Rotavirus

Age assessed: 7 years old

Up-to-date definition: Must satisfy one of the following criteria:

- Three valid doses in accordance with the three-dose schedule
- Two valid doses in accordance with the two-dose schedule

Relevant immunizing agents:

- Rota-1
- Rota-5
- rota-unspecified

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Use the following hierarchy to keep only one record: Rota-1 > rota-unspecified > Rota-5

The hierarchy is guided by giving preference to the publicly-funded vaccine used in Ontario for infants born between 2012 and 2018 (Rota-1). Similarly, Rota-unspecified was assumed to be Rota-1 given the availability of Rota-1 vaccines between 2012 and 2018. This assumption may need to be revised in future years to accommodate the introduction of RotaTeq (Rota-5) between 2018 and 2021.

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

A child is assessed using both the two- and three-dose schedules and is considered up-to-date if at least one schedule is satisfied.

Three-dose schedule:

- First valid dose — Rota-5, Rota-1, rota-unspecified received at ≥42 days old
- Second valid dose — Rota-5, Rota-1, rota-unspecified received ≥28 days after first valid dose
- Third valid dose — Rota-5, Rota-1, rota-unspecified received ≥28 days after second valid dose

Two-dose schedule:

- First valid dose — Rota-1, rota-unspecified received at ≥42 days old
- Second valid dose — Rota-1, rota-unspecified received ≥28 days after first valid dose

Additional notes:

- Beginning August 8, 2011, Ontario introduced a publicly-funded RV vaccine program using Rota-1 vaccine
- Beginning September 1, 2018, Rota-5 replaced the Rota-1 vaccine in Ontario's RV vaccination program
- Beginning August 1, 2021, Rota-1 replaced Rota-5 vaccine in Ontario's RV vaccination program
- As per the *Canadian Immunization Guide*[4] and Ministry of Health, if any dose in the series was Rota-5, then a total of 3 doses is needed

Exemption antigens: Not applicable

Rubella

Age assessed: 7 and 17 years old

Up-to-date definition: Must satisfy one of the following criteria:

- ≥1 valid dose
- Have a documented exemption for evidence of immunity

Relevant immunizing agents:

- MMR
- MR
- R
- MMR-Var

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: A minimum interval of 28 days between all live virus vaccine combinations is required, unless they are administered on the same day. Additional immunizing agents used to assess for vaccine interactions:

- M
- YF
- Zos-Live
- Mu
- Sma
- Zos-unspecified
- Var
- Zos
- BCG vaccine

Multiple vaccines on the same day:

- If multiple rubella-containing agents are received on the same day, keep any one
- If multiple non-rubella containing live virus vaccines are received on the same day, keep any one
- If a mix of rubella- and non-rubella containing live virus vaccines is received on the same day, keep one of each

Evidence of immunity: Include evidence of immunity records for: Rubella (R)

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥1 year old AND both of the following:
    - Received ≥28 days after any preceding rubella-containing vaccine
    - Received on the same day or ≥28 days after any preceding non-rubella containing live virus vaccine

Additional notes: None

Exemption antigens: Rubella (R)

Tetanus

Age assessed: 7 and 17 years old

Up-to-date definition:

7-year-olds must satisfy one of the following criteria:

- ≥5 valid doses
- Four valid doses (only if received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old)

17-year-olds must satisfy one of the following criteria:

- ≥6 valid doses
- Five valid doses and only if satisfies one of the following:
    - Received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old
    - Received first valid dose at <7 years old AND received fifth valid dose at ≥4 years old AND <10 years between fifth valid dose and assessment date
- Four valid doses and only if satisfies one of the following:
    - Received first valid dose at <7 years old AND <10 years between fourth valid dose and assessment date
    - Received first valid dose at ≥7 years old (i.e., two primary and two booster doses)
- Three valid doses (only if received first valid dose ≥7 years old AND <10 years between third valid dose and assessment date)
    - Note: PHO considers receipt of two primary doses and one 'booster' dose for individuals who start their series late (i.e., ≥7 years old) as the minimum requirement to be considered up-to-date, as long as less than 10 years have elapsed between the last (booster) dose and the date of assessment

Relevant immunizing agents:

- DPT
- DPT-HB
- DPT-HB-Hib
- DPT-Hib
- DPT-IPV
- DPTP
- DPTP-Hib
- DT
- DTaP
- DTaP-HB-IPV
- DTaP-HB-IPV-Hib
- DTaP-Hib
- DTaP-IPV
- DTaP-IPV-Hib
- DT-IPV
- DTwP-HB
- T
- Td

- Tdap
- Td-IPV
- Tdap-IPV
- T-IPV

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: None

Multiple vaccines on the same day: Keep any one

Evidence of immunity: Not applicable

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥42 days old
- Second valid dose — Received ≥28 days after first valid dose
- Third valid dose — One of the following:
    - Received first valid dose at <7 years old AND received ≥28 days after second valid dose
    - Received first valid dose at ≥7 years old AND received ≥168 days after second valid dose
- Fourth valid dose — One of the following:
    - Received first valid dose at <7 years old AND received ≥168 days after third valid dose AND ≥1 year old
    - Received first valid dose at ≥7 years old AND one of the following:
        - Received ≥10 years after third valid dose
        - Received ≥28 days after third valid dose AND ≥14 years old
- Fifth valid dose — One of the following:
    - Received first valid dose at <7 years old AND one of the following:
        - Received fourth valid dose at 1 to <4 years old AND received ≥28 days after fourth valid dose AND ≥4 years old
        - Received fourth valid dose at ≥4 years old AND received ≥10 years after fourth valid dose
        - Received fourth valid dose at ≥4 years old AND received ≥28 days after fourth valid dose AND ≥14 years old
    - Received first valid dose at ≥7 years old AND received ≥10 years after fourth valid dose

- Sixth valid dose — One of the following:
    - Received first valid dose at <7 years old AND received fourth valid dose at 1 to <4 years old AND one of the following:
        - Received ≥10 years after fifth valid dose
        - Received ≥28 days after fifth valid dose AND ≥14 years old
    - Received first valid dose at <7 years old AND received fourth valid dose at ≥4 years old AND received ≥10 years after fifth valid dose
    - Received first valid dose at ≥7 years old AND received ≥10 years after fifth valid dose

Additional notes:

- Although an accelerated schedule is not specified in the *Canadian Immunization Guide* chapter for tetanus for children who initiate the series when ≥7 years old[4], the minimum intervals outlined between doses of the primary series for infants were also applied to older children
- For the last (booster) dose, we used a 10-year interval instead of a five-year interval (as is used in the Panorama forecaster logic), in accordance with the *Canadian Immunization Guide*[4]

Exemption antigens:

- Tetanus (T)
- Tetanus antibody

Varicella

Age assessed: 7 years old

Up-to-date definition: Must satisfy one of the following criteria:

- ≥2 valid doses
- Have a documented exemption for evidence of immunity

Relevant immunizing agents:

- MMR-Var
- Var

See Appendix A for immunizing agent abbreviations and descriptions.

Vaccine interactions: A minimum interval of 28 days between all live-virus vaccine combinations is required, unless they are administered on the same day. Additional immunizing agents used to assess for vaccine interactions:

- M
- MMR
- MR
- Mu
- R
- YF
- Sma
- Zos
- Zos-Live
- Zos-unspecified
- BCG vaccine

Multiple vaccines on the same day:

- If multiple varicella-containing agents are received on the same day, keep any one
- If multiple non-varicella containing live-virus vaccines are received on the same day, keep any one
- If a mix of varicella- and non-varicella containing live-virus vaccines is received on the same day, keep one of each

Evidence of immunity: Include evidence of immunity records for the following:

- Varicella (Var)
- Varicella-zoster antibody
- Zoster (Zos

Valid dose definitions: Relevant immunizing agents must be received in accordance with the following criteria to be considered a valid dose:

- First valid dose — Received at ≥1 year old AND both of the following:
    - Received ≥28 days after any preceding varicella-containing vaccine
    - Received on the same day or ≥28 days after any preceding non-varicella containing live virus vaccine
- Second valid dose — Received ≥28 days after any preceding varicella-containing vaccine AND received on the same day or ≥28 days after any preceding non-varicella containing live virus vaccine

Additional notes: None

Exemption antigens: Not applicable

Appendix C: Changes to the Publicly-Funded Immunization Programs in Ontario

2023: Ontario introduced a publicly-funded RSV vaccine program using the AREXVY vaccine targeting adults aged 60 years and older at higher of severe disease and those in higher risk settings.

2022: Use of smallpox/mpox vaccine (Imvamune) for the purposes of pre-exposure prophylaxis to specific populations meeting the eligibility criteria and also for the purposes of post-exposure prophylaxis to those who have been assessed by their local PHU to be a high risk contact to mpox.

2021: Replacement of Rot-5 with Rot-1 for the routine immunization program, which resulted in the decrease from three to two doses of rotavirus vaccine.

2018:

- High-dose trivalent influenza vaccine (High-dose TIV) introduced for persons 65 years of age and older. Trivalent influenza vaccines (TIV) no longer publicly funded. Quadrivalent influenza vaccines (QIV) for all those aged six months and older (previously QIV was only for those 6 months to 17 years of age).
- Replacement of Rot-1 with Rot-5, which resulted in the increase from two to three doses of rotavirus vaccine for the routine immunization program.

2017:

- Replacement of HPV-4 with HPV-9 for the school-based immunization program: two-dose HPV9 school-based program offered to Grade 7 students. HPV-9 vaccine eligibility until the end of Grade 12 for Grade 7 students who did not receive or complete the HPV-9 immunization series in Grade 7.
- Replacement of HPV-4 with HPV-9 for high-risk males 9 to 26 years of age who have not initiated their HPV4 immunization series. DTaP-IPV discontinued and DTaP-IPV-Hib eligibility is expanded to all children five to six years of age who have not completed their primary immunization vaccine series with diphtheria, tetanus, pertussis and polo. As a result of DTaP-IPV discontinuation, Hib routine eligibility is expanded to children five to six years of age.
- Trivalent influenza vaccine adjuvanted no longer publicly-funded.

2016:

- Two-dose HPV-4 school-based program moved to Grade 7 (from Grade 8) for 2016–17 school year and expanded to males, as well as females (previously only girls in Grade 8 were eligible); program also offered to Grade 8 females during same school year. Vaccine series publicly-funded for high-risk males nine to 26 years old.
- Zoster vaccine for individuals 65 to 70 years of age and one time catch-up in 2016 for individuals born in 1945.

2015:

- Addition of quadrivalent influenza vaccine (inactivated and live attenuated) to the Universal Influenza Immunization Program (UIIP) for children ages six months to 17 years and two to 17 years, respectively.
- HPV4 program for Grade 8 girls switched from a three-dose to a two-dose schedule.

2014:

- Meningococcal B vaccine for high-risk children aged two months to 17 years.
- Meningococcal Conjugate-ACYW vaccine; for high risk individuals nine months to 55 years of age (previously two to 55 years); booster doses and expanded high risk criteria.
- One dose of pertussis (Tdap) vaccine for all adults ≥18 years of age, regardless of whether Tdap was received in adolescence.
- Pneumococcal conjugate 13 vaccine for high-risk individuals ≥50 years of age.

2012:

- Extended HPV4 vaccine eligibility until the end of Grade 12 for girls who did not receive or complete the three-dose HPV immunization series in Grade 8. One-time HPV 4 catch-up from Sept. 2012 to June 30, 2014 for females who were in Grade 8 during 2007–08 school year who have received at least one dose by June 30, 2013; could complete the series by June 30, 2014.
- Replacement of DTaP-IPV with Tdap-IPV for the four- to six-year-old booster dose.

Appendix D: Adverse Events and Categories

Adverse event category: Allergic events

- **Adverse events:**
    - Allergic reaction - skin
    - Event managed as anaphylaxis
    - Oculorespiratory syndrome (ORS)
    - Allergic reaction – other (discontinued as of January 1, 2013)

Adverse event category: Injection site reactions

- **Adverse events:**
    - Infected abscess
    - Sterile abscess
    - Cellulitis
    - Nodule
    - Pain/redness/swelling

Adverse event category: Neurologic events

- **Adverse events:**
    - Acute disseminated encephalomyelitis (ADEM)
    - Anaesthesia/paraesthesia
    - Bell's palsy
    - Convulsions/seizure
    - Encephalopathy/encephalitis
    - Guillain-Barré syndrome (GBS)
    - Meningitis
    - Myelitis/Transverse Myelitis
    - Paralysis

Adverse event category: Other events of interest

- **Adverse events:**
    - Arthritis/arthralgia
    - Intussusception
    - Kawasaki disease
    - Syncope (fainting) with injury
    - Thrombocytopenia
    - Other sever or unusual events

Adverse event category: Systemic events

- **Adverse events:**
    - Adenopathy/lymphadenopathy
    - Fever in conjunction with another reportable event
    - Hypotonic-hyporesponsive episode (HHE)
    - Parotitis
    - Persistent crying/screaming
    - Rash
    - Severe vomiting/diarrhea

Adverse event category: COVID-19 adverse events of special interest

- **Adverse events:**
    - Acute cardiovascular injury
    - Acute kidney injury
    - Acute liver injury
    - Acute pancreatitis
    - Acute respiratory distress syndrome
    - Anosmia, ageusia

- Chilblain like lesions
- Coagulation disorder (including thrombotic events)
- Erythema multiforme
- Multisystem inflammatory syndrome in children/adults
- Myocarditis/pericarditis
- Rhabdomyolysis
- Single organ cutaneous vasculitis
- Subactute thyroiditis
- Vaccine-associated enhanced disease
- Thrombosis with Thrombocytopenia Syndrome/Vaccine-Induced Immune Thrombotic Thrombocytopenia

Public Health Ontario
661 University Avenue, Suite 1701
Toronto, Ontario
M5G 1M1
416.235.6556
communications@oahpp.ca
publichealthontario.ca

Ontario