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Impact of a large measles outbreak associated with transmission in the Americas and Canada's loss of measles elimination status: descriptive cohort study

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ABSTRACT

OBJECTIVE

To describe the epidemiological characteristics, public health response, and evidence of international spread of a large measles outbreak that contributed to the loss of Canada's measles elimination status.

DESIGN

Descriptive analysis of the cohort of measles outbreak cases reported to Ontario's public health surveillance system during the outbreak period: epidemiological week of 28 October 2024 to 6 October 2025.

SETTING

Ontario, Canada.

PARTICIPANTS

Individuals meeting the outbreak case definition for confirmed or probable measles infection during the outbreak period.

EXPOSURE

Exposure to measles virus associated with the Ontario outbreak and related transmission chains.

MAIN OUTCOME MEASURES

Demographic characteristics, vaccination status, admission to hospital, complications, pregnancy associated outcomes, mortality, and evidence of international spread based on measles virus genotyping and sequencing. Cases were identified using an outbreak-specific case definition incorporating epidemiological, clinical, laboratory, and viral sequencing criteria. Phylogenetic analysis of measles virus sequences was used to assess evidence of onwards spread to other countries.

RESULTS

The outbreak consisted of 2377 cases (2064 confirmed and 313 probable) over 49 weeks and contributed to the loss of Canada's measles elimination status. Most cases (2146/2377, 90.3%) occurred among members of historically under-vaccinated communities, with limited spillover into the broader population. Among the 2377 cases, approximately three quarters of cases (n=1736, 73.0%) occurred in individuals aged 19 years or younger, 2121 (89.2%) were unvaccinated, and 97 (4.1%) had unknown vaccination status. The outbreak was associated with 166 (7%) admissions to hospital, 13 (<1%) admissions to intensive care unit, 51 (2.1%) infections during pregnancy, 10 (<1%) congenital measles infections, one (<1%) case of encephalitis, and one (<1%) infant death. Sequencing identified a novel N450 distinct sequence identifier that was subsequently detected in countries including the United States of America, Mexico, and the Netherlands. The outbreak strain was designated a World Health Organization named strain (MVs/Ontario.CAN/47.24).

CONCLUSIONS

These findings highlight the risk of measles re-establishment in countries that have attained elimination and underscore the importance of culturally appropriate community engagement to build trust in immunisation and prevent future outbreaks. This outbreak shows the fragility of measles elimination in the presence of long standing immunity gaps within interconnected communities across the Americas and the population-level protection that limited broader community transmission.

Introduction

Measles is a highly infectious respiratory virus. Its high transmissibility reflects short and long range transmission of infectious respiratory particles through the air and a period of communicability extending from four days before until four days after rash onset.[1] Consequently, susceptible contacts are frequently exposed to the virus before cases are recognised and public health control measures, including case isolation and post-exposure prophylaxis, can be effectively implemented. Measles can cause severe complications, admission to hospital, and death, particularly among infants, pregnant individuals, and people who are immunocompromised.[1] Beyond its direct health effects, measles is associated with substantial social and economic burdens on individuals and families. In a patient-based survey, acute measles infection was associated with a mean illness duration of 13.8 days, 9.6 days away from school or work, and substantial reductions in health related quality of life.[2] Despite the availability of a safe and highly effective vaccine, measles outbreaks have re-emerged in several countries that had previously achieved elimination.[3]

Canada attained measles elimination status in 1998 after the introduction of a second dose of measles-containing vaccine and a national catch-up programme for school-aged children.[4,5] High uptake of the two dose schedule led to a marked decline in measles incidence. In the province of Ontario, more than 5000 cases were reported in 1991,[6] compared with 101 cases reported between 2013 and 2023.[7] In November 2025, the Pan American Health Organization (PAHO) determined that Canada lost its measles elimination status due to ongoing

domestic transmission associated with a multijurisdictional measles outbreak.[8] The outbreak began in October 2024, after exposure to measles at a wedding in New Brunswick, Canada, followed by secondary cases among attendees in the provinces of New Brunswick and Ontario.[7] Ontario is home to several diverse ethno-religious and cultural groups with vaccine coverage that has historically been low due to a combination of structural barriers, historical experience with health systems, and community specific perspectives on vaccination. These groups, which include some Mennonite, Amish, and Netherlands Reformed communities, have close social networks spanning Canada, the United States of America (USA), Mexico, and other countries that create opportunities for cross-border transmission.[9-11]

We describe the epidemiological and genomic characteristics of the Ontario measles outbreak, which formed part of a broader multijurisdictional outbreak involving other Canadian provinces,[12] the US, Mexico and several other countries across the Americas.[13,14] We also summarise the public health response and some of the unique challenges posed by this outbreak, and their implications for re-establishing measles elimination, which are relevant for other countries at risk of losing elimination status.

Methods

Measles case identification

Measles is reportable in Ontario under the Health Protection and Promotion Act[15] with routine surveillance, case definitions, and a provincial protocol for case and contact management.[16] Measles is classically characterised by fever, cough, coryza, conjunctivitis, and rash, although the rash may be absent or atypical in people with immunocompromising conditions, some neonates with congenital infection, and in breakthrough cases in previously vaccinated individuals. To support case finding activities, an outbreak-specific case definition was established,[17] allowing inclusion of clinically compatible cases with relevant epidemiological linkages. On 10 June 2025, the outbreak case definition was updated to incorporate sequencing information, classifying laboratory-confirmed cases as outbreak-related if viral sequences matched defined distinct sequence IDs (DSId),[18] even in the absence of direct epidemiological linkage; this change was also applied retrospectively.

Laboratory diagnosis of measles and virus sequencing

Measles virus RNA was detected using a real-time reverse transcription polymerase chain reaction (RT-PCR) assay. Diagnostic testing was conducted at Public Health Ontario regional laboratories with RT-PCR testing introduced at one non-Public Health Ontario laboratory on 16 June 2025. All specimens positive for measles underwent secondary RT-PCR testing to differentiate wild-type virus from vaccine strain and all wild-type virus detections were referred to the National Microbiology Laboratory for genotyping and sequencing (further details outlined in the eMethods in the supplementary appendix).[19-21] To increase the uptake of laboratory testing, patient self-collection of specimens was accepted, facilitated by local public health agencies, and evaluated as part of quality assurance activities.

Public health case investigation

All reported cases were investigated by local public health agencies, with demographic, clinical, exposure, vaccination, and laboratory data entered into Ontario's public health surveillance system. Vaccination status was determined using doses of measles-containing vaccine administered at least 14 days before symptom onset. Local public health agency staff also determined if suspect cases were members of historically under-vaccinated communities. For cases in pregnant women, additional information was collected, including pregnancy and infant outcomes. Confirmed congenital measles cases were identified using a case definition provided by the Public Health Agency of Canada.[12] For the one report of death, a case conference approach, with clinicians involved in direct patient care, determined the extent to which measles contributed to the cause of death.

Data source for vaccine coverage and doses administered

We used Panorama, Ontario's public health immunisation repository, to calculate two dose measles-containing vaccine coverage for the school year preceding the outbreak. We also used the repository to determine the number of doses administered directly by local public health agency staff through the outbreak vaccination strategy. Although Panorama captures vaccines administered by local public health staff during outbreak responses, most vaccines are administered in primary care and are added retrospectively based on records collected by local public health agencies under the Immunization of School Pupils Act. The completeness of these data is known to have been affected by a pause in record-collection processes during the covid-19 pandemic, particularly for younger children, and by incomplete capture of vaccinations among children attending private religious schools.[22,23] Recent trends in coverage of measles-containing vaccine at the provincial and local public health agency levels were obtained from Public Health Ontario's immunisation data tool,[24] which uses Panorama as its data source and is subject to the same limitations.

Analysis and reporting

The cohort of measles outbreak cases was analysed descriptively using SAS Enterprise Guide 8.2. We calculated two dose coverage of measles-containing vaccine among 17 year olds, a group less likely to have been affected by pandemic-related disruptions in vaccine record collection and measles outbreak incidence rate (for all ages) at the small area level. We calculated and mapped these measures by forward sortation area using the 2021 Canadian Census. Phylogenetic analysis of N450 sequences was performed to describe the Ontario outbreak strain and assess the extent to which it has been implicated in measles activity outside of Canada (further details outlined in the eMethods in the supplementary appendix).

Patient and public involvement

Local community members and faith leaders were engaged in the outbreak response, including in the development of public health messaging.

Results

Measles outbreak size and duration

The Ontario measles outbreak resulted in a total of 2377 reported (2064 confirmed and 313 probable) cases (table 1, figure 1). The outbreak began during the epidemiological week of 28 October 2024, and was declared over on 6 October 2025, in accordance with the Public Health Agency of Canada's criteria for measles outbreak closure.[1] During the same 49 week period, 50 measles cases not associated with the outbreak were reported in Ontario. Measles cases imported from travel have occurred sporadically in Ontario since elimination in 1998, typically in urban or suburban areas.[25] By contrast, among the five local public health agencies with the highest outbreak case incidence, four had not reported a case of measles in over 25 years (eTable 1, supplementary appendix). All five local public health agencies are located in rural and semi-rural communities in the province and four of the five share geographical

boundaries in southwestern Ontario. Prior to the onset of the outbreak, recorded two dose measles vaccine coverage in Ontario was 76.8% among 7 year olds and 91.8% among 17 year olds, based on local public health agency vaccination records.[24] Figure 2 presents maps of measles vaccine coverage at the onset of the outbreak and measles outbreak incidence at the conclusion of the outbreak.

Table 1 | Characteristics of measles outbreak cases

Outbreak case characteristics	No (%)
Total cases	2377 (100)
Case classification	
Confirmed	2064 (86.8)
Probable	313 (13.2)
Member of a historically under-vaccinated community	
Yes	2146 (90.3)
No	231 (9.7)
Gender	
Female	1140 (48.0)
Male	1236 (52.0)
Unknown	1 (<1%)
Age, years	
<1	145 (6.1)
1-4	438 (18.4)
5-9	543 (22.8)
10-19	610 (25.7)
20-39	486 (20.4)
≥40	142 (6.0)
Unknown	13 (0.5)
Cases born in or after 1970*	2333 (98.1)
Immunisation status	
Not immunised	2121 (89.2)
One dose	47 (2.0)
Two or more doses	112 (4.7)
Unknown/no proof of immunisation	97 (4.1)
Cases admitted to hospital†	166 (7.0)
ICU admissions‡	13 (0.5)
Deaths	1 (<1%)

ICU=intensive care unit.

* In Canada, individuals born before 1970 are presumed to have measles immunity from prior infection due to trends in measles circulation and the timing of the vaccine programme introduction.1

† Median length of stay for people admitted to hospital was 3 days (mean 4.9 days, range 1-54).

‡ Median length of stay for ICU admissions was 3 days (mean 10.2 days, range 1-54).

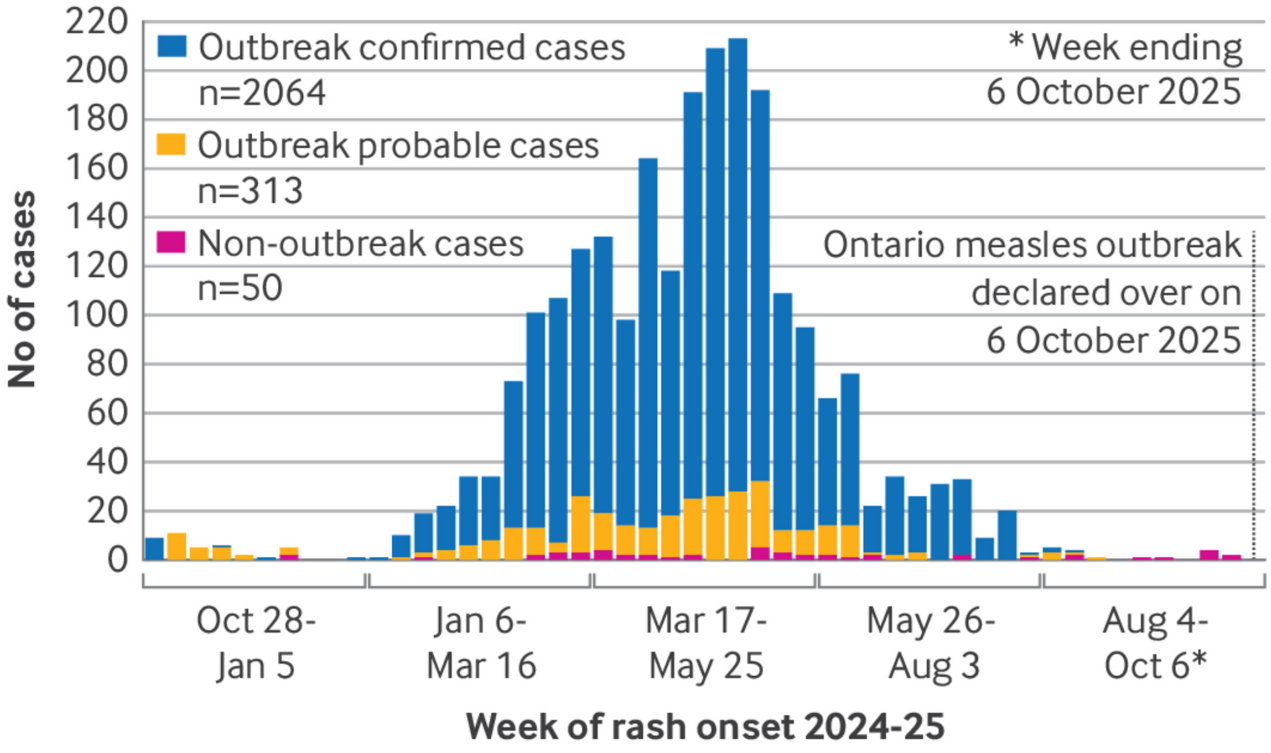


Fig 1 | Outbreak and non-outbreak measles cases in Ontario, Canada: 28 October 2024 to 6 October 2025

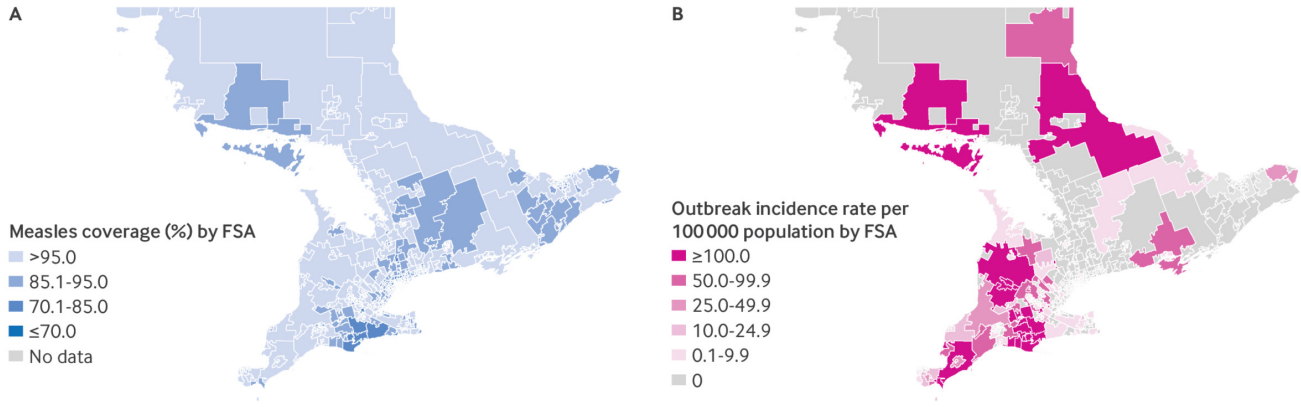


Fig 2 | Two dose measles vaccine coverage among 17-year-olds in 2023-24 (A) and 2024-25 measles outbreak incidence (B), by forward sortation area in Ontario, Canada. Forward sortation areas are geographical areas defined by the first three characters of Canadian postal codes. Because forward sortation area boundaries reflect population distribution, they are substantially larger in sparsely populated regions of Northern Ontario than in Southern Ontario. Consequently, maps based on forward sortation areas may not accurately represent the geographical extent of measles transmission risk or areas of low vaccination coverage

The Ontario outbreak began following the exposure of several Ontario residents to a guest from Thailand,[26] during a wedding in New Brunswick in October 2024.[7] Public Health Ontario was notified by New Brunswick public health officials and alerted six local public health agencies in southwestern Ontario to initiate contact tracing and follow-up investigations. Secondary cases were identified among wedding attendees and later among household contacts who had not attended the event.

Between 28 October 2024 and 1 January 2025, 37 measles outbreak cases were reported to three local public health agencies in southwestern Ontario (figure 1) but only one case was confirmed by laboratory testing. Limited uptake of diagnostic testing during this period reflected both community members' reluctance to be tested and, to a lesser extent, concerns among primary care providers regarding transmission risk during specimen collection.

Source of measles acquisition

After a period of minimal case reporting in December 2024, which was likely indicative of ongoing but undetected transmission, new cases began to rapidly emerge in January 2025. Multiple cases were associated with exposures in community and healthcare settings, resulting in well documented chains of transmission. In one instance, a single case was linked to 20 subsequent cases (eight secondary and 12 tertiary cases) over five weeks. Case investigations also identified transmission during social gatherings within under-vaccinated communities with close social ties across the province. Over time, the outbreak expanded to involve additional historically under-vaccinated communities across the province (eFigure 1, supplementary appendix), with reported cases peaking in the week of 28 April 2025 (figure 1). Overall, 2146 (90.3%) of 2377 outbreak cases occurred among members of historically under-vaccinated communities including Mennonite, Amish, and Netherlands Reformed communities (table 1).

As the outbreak progressed, identifying specific sources of exposure became increasingly difficult due to widespread transmission within the most affected communities. Among all 2377 outbreak cases, 74.4% (n=1768) were associated with a household with more than one case; among households with multiple cases, the median was five cases per household (range 2-11). Schools, including school buses, (14.9% (n=355)) and community gatherings (8.1% (n=192)) were reported as likely sources of acquisition. Eight cases occurred among migrant agricultural workers (referred to as international agricultural workers in Ontario) or their household members in southwestern Ontario. Over time, related measles outbreaks emerged in other regions of Canada, the USA, and Mexico,[13 14] frequent travel and social connections between affected communities meant that some cases had multiple plausible exposures across jurisdictions, complicating efforts to determine where transmission had occurred.

Outbreak case characteristics

Among the 2377 outbreak cases, 73.0% occurred in individuals 19 years or younger, including 583 (24.5%) cases in children under 5 years old (table 1). The median age was 10 years (range birth to 76 years). More than 98% (n=2333) of cases occurred in individuals born in 1970 or later, the birth year used in Canada to presume immunity from natural infection in the pre-vaccine era.[1]

Overall, 93.3% of outbreak cases were either unvaccinated (89.2%) or had unknown vaccination status (4.1%) (table 1). Fewer than 5% (n=122) of cases had a documented history of two doses of a measles-containing vaccine, with variation by age group. Among cases, 0.9% (5/543) of children aged 5-9 years had received two doses compared with 15.6% (76/486) of adults aged 20-39 years (eFigure 2, supplementary appendix). Among cases who had received at least two doses, the median interval between doses was 4.0 years (range 77 days to 49.3 years) and the median time since the last dose was 21.5 years (range 36 days to 47.2 years).

The outbreak was associated with substantial morbidity with 166 cases requiring admission to hospital (length of stay was 1-54 days, median 3.0 days) and 13 people with measles received treatment in an intensive care unit. The proportion of people with measles that were admitted to hospital was highest among unvaccinated individuals (158/2121, 7.4%) and lowest among the smaller number of cases who were vaccinated with at least two doses (2/112, 1.8%) (eFigure 3). The hospitalized cases who had previously received two vaccine doses were a pregnant adult and an immunocompromised adult. Reported complications among measles cases included pneumonia or acute respiratory distress (n=85), seizure (n=4), hearing loss with referral to specialist consultation (n=2), meningitis (n=1), and encephalitis (n=1).

Fifty one cases of measles occurred during pregnancy (44 confirmed, seven probable) (table 2). Rash onset occurred in the first trimester (n=11), second trimester (n=20), and third trimester (n=20). Most pregnant women were not immunised (n=42, 82.4%) or had an unknown immunisation history (n=1, 2.0%) and about a quarter (n=13, 25.5%) were admitted to hospital during their measles infection. Complications included pre-term labour and delivery (n=7), emergency C-section (n=1), and congenital measles infection diagnosed in the neonate (n=10). Among the ten infants with congenital measles infection, one infant was reported to have fever and five were reported to have a rash. All ten infants were born to mothers who were not immunised prior to measles infection in pregnancy. The outbreak was associated with one death in an infant with congenital measles infection who was born prematurely as a complication of measles during pregnancy in an unvaccinated mother.[27] Although measles was felt to be a contributing factor in both the premature birth and death, the infant also had several complex medical comorbidities unrelated to the virus.[27]

Table 2 | Characteristics of measles outbreak cases infected during pregnancy. Data are number (%), unless otherwise specified

Pregnant outbreak case characteristics	No. (%)
Total number of pregnant cases	51 (100)
Case classification	
Confirmed	44 (86.3)
Probable	7 (13.7)
Median age, years (range)	25 (19-39)
Immunisation status	
Not immunised	42 (82.4)
One dose	2 (3.9)
Two or more doses	6 (11.8)
Unknown/no proof of immunisation	1 (2.0)
Gestation at time of infection	
1st trimester (1-13 weeks)	11 (21.6)
2nd trimester (14-27 weeks)	20 (39.2)
3rd trimester (28-40 weeks)	20 (39.2)
Complications	
Hospital admissions	13 (25.5)
Preterm labour or delivery	7 (13.7)
Emergency caesarean section	1 (2.0)
Infants with congenital measles infection	10 (19.6)

Laboratory findings

During the outbreak period, 10 182 specimens were collected for measles RT-PCR testing, of which 347 (3.4%) were self-collected. Among specimens where measles was detected, a total of 604 N450 sequences were generated, including 30 from non-outbreak cases that were genetically distinct from the outbreak (eFigure 4, supplementary appendix). The first specimen that was sequenced as part of the outbreak, collected on 24 November 2024, had a novel DSId that deviated by a single nucleotide from DSId 8717, a strain named by World Health Organization (WHO) that was first detected in Thailand (MVs/Songkhla.THA/3.24), consistent with the travel history of the outbreak's source case.[26] DSId 9171 was detected in 531 (92.5%) of the 574 sequenced outbreak cases and was identified throughout the entire outbreak period (figure 3). This DSId was subsequently detected in multiple Canadian provinces (data not shown) and internationally (figure 3), including in multiple US states and the Netherlands. It was designated a WHO named strain (MVs/Ontario.CAN/47.24), reflecting its first global detection in Ontario, Canada, during this outbreak. Given the duration and number of cases associated with this outbreak, 22 additional distinct sequence IDs emerged among the 42 cases, representing sequences that differed from DSId 9171 by one or two nucleotides. Some of these distinct sequence IDs were detected also in the USA (figure 3).

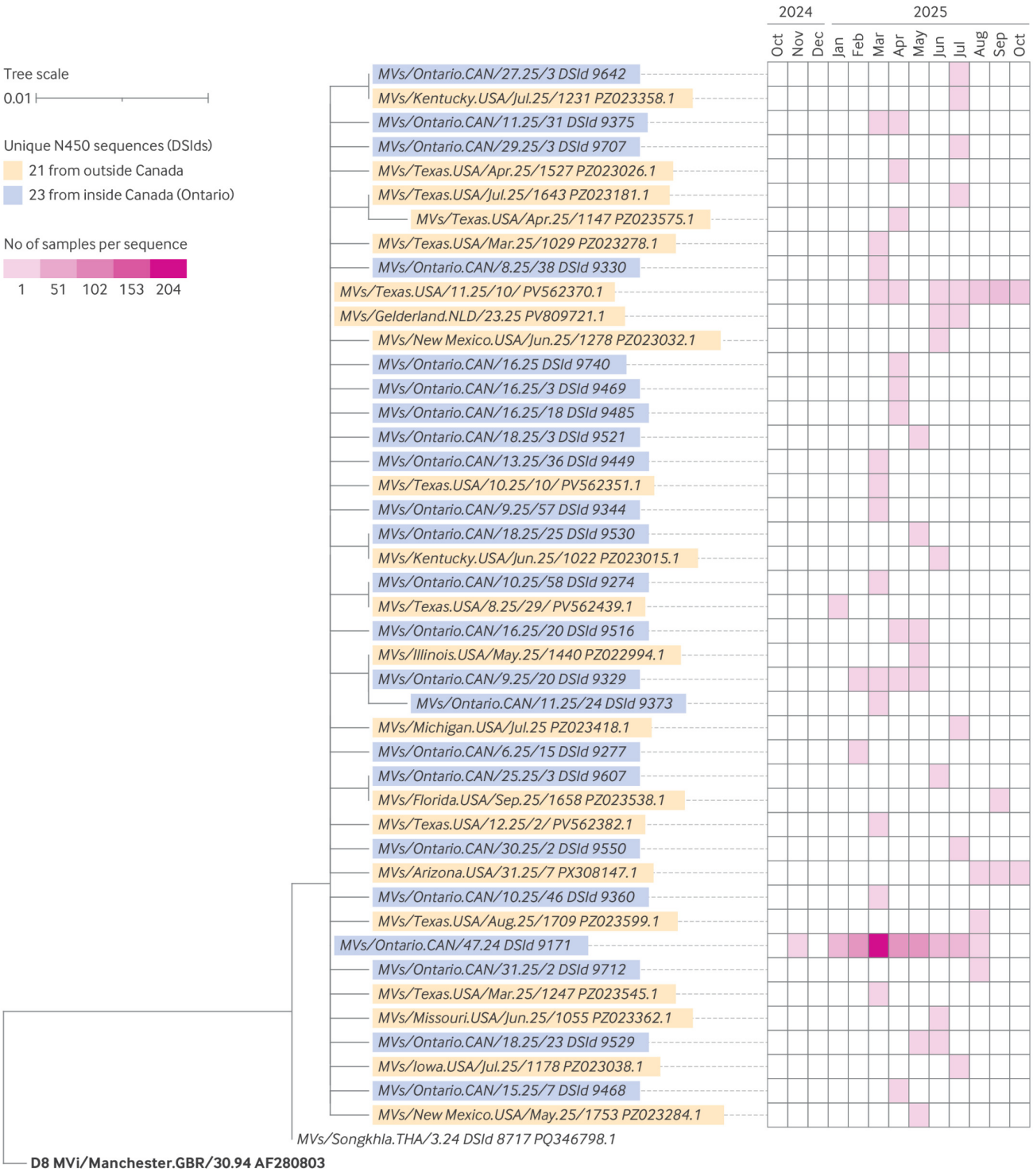


Fig 3 | Maximum likelihood phylogenetic analysis of N450 sequences from Ontario outbreak cases and international sequences from the outbreak period. The analysis was performed with unique N450 sequences (distinct sequence IDs) from a single country (23 from Ontario, Canada in blue; 21 from outside Canada, in yellow). Tips are labelled with the WHO sequence designation for the first detection and either the distinct sequence ID (internally generated Ontario sequences) or the GenBank accession number (international). The number of samples for which the sequence was detected is provided by month in the heat map to the right of the tree with scale given at the top left. The total number of samples represented is 677 (574 from Ontario and 103 international). Bold font denotes WHO genotype D8 reference sequence. Italics denotes WHO named strain most similar to the outbreak sequences

Public health response

The response to the Ontario measles outbreak included a range of activities led primarily by local local public health agencies, with support from provincial and national partners (table 3). The response evolved over time from case and contact based interventions, outlined in the provincial measles protocol,[16] to broader population level strategies as transmission intensified and stretched public health resources. People who were identified as cases were instructed to self-isolate for the duration of their period of communicability. Contacts who were susceptible to measles were instructed to refrain from attending high risk settings including childcare, schools, and health care settings for 21 days, the maximum incubation period of measles. Given the demands on public health resources, local public health agencies were unable to assess individual compliance with these measures. In addition, many cases had passed their period of communicability by the time they were reported to public health.

Table 3 | Public health and health system response to the measles outbreak

Response category	Standard measles response protocol	Additional measures implemented during outbreak
Measles case investigation and contact follow-up	• Case interviews to identify transmission links and exposure locations, and instructions to cases to self-isolate; • Contact follow-up activities, including directing susceptible contacts to exclude themselves from high risk settings; • Referral of contacts residing outside the province to the relevant public health agency, including those outside of Canada	• Measles assessment clinics at local hospitals in high incidence communities • Backwards contact tracing to identify source of measles acquisition among cases • Use of online tools for reporting of cases and contacts to LPHAs • LPHA led post-exposure prophylaxis clinics • Development of a surveillance case definition for congenital measles infection
Laboratory testing	• Use of a vaccine specific PCR assay to rapidly differentiate wild-type infection from measles vaccine virus; • Collaboration with NML for genotyping and sequencing	• Expanded measles PCR testing capacity across regional Public Health Ontario laboratories to reduce turnaround time • Deployment of multiplex PCR testing to concurrently identify positive specimens and differentiate wild-type virus from vaccine strain and accommodate higher throughput testing • Self-collection of measles specimens through a pilot initiative • Incorporation of measles direct sequence ID information into outbreak case definition
Vaccination and post-exposure prophylaxis	• Promotion of routine immunisation schedule for measles; • Arrangements for time sensitive, post-exposure prophylaxis (vaccine or immunoglobulin) for susceptible contacts	• Deployment of an outbreak specific vaccination strategy • Targeted and flexible vaccination initiatives (eg, migrant agricultural workers, pop-up clinics, home visits) and additional MMR vaccine procurement • Enhanced school based assessment and enforcement activities under the Immunization of School Pupils Act
Surveillance and reporting	• Weekly reporting of cases to Public Health Agency of Canada	• Regular (weekly during peak outbreak period) updating of public facing outbreak reports • Public reporting of community exposure locations on a centralised webpage
Infection, prevention, and control measures	• Support given to acute care hospitals through infection, prevention, and control networks; • Promotion of measles guidance to healthcare providers	• Centralised electronic alerts to prompt measles risk assessment at hospital triage • Individualised consultations for support measures for infants with congenital measles in NICU settings
Communications and community engagement	• Local (LPHA-led) communications for the general public	• Engagement with community leaders and partners • Culturally appropriate, translated messaging in affected communities • Webinars and other models of measles knowledge exchange for healthcare providers • Local (LPHA-led) and provincially issued public communications for the public
Outbreak coordination activities	• Health system communication on outbreak status, measles, and immunisation recommendations	• Regular outbreak coordination calls: within province and with national partners (Public Health Agency of Canada and NML) and other provinces • Cross border communication and information sharing on the measles outbreak with US public health officials

LPHA=local public health agency; MMR vaccine=measles, mumps, and rubella vaccine; NICU=neonatal intensive care unit; NML=National Microbiology Laboratory; PCR=polymerase chain reaction.

Several outbreak strategies were tailored to communities at risk. Examples included reducing barriers to laboratory testing through patient self-collection, culturally appropriate health communications, and flexible approaches to vaccine administration (eg, pop-up clinics and home visits). Communications were translated into the Low German language (Plautdietsch) and disseminated using trusted, community-specific channels, such as radio, newspaper, and WhatsApp groups. Local public health agencies led community-level communications, supplemented by national-level engagement with faith leaders facilitated by the Public Health Agency of Canada. Co-developed messaging emphasised personal autonomy, protecting the vulnerable by preventing onward transmission (eg, avoiding travel while ill), increasing awareness of measles symptoms and complications to promote timely presentation to health care and providing reasons to choose immunization.

Under Ontario's routine immunisation schedule, the measles-mumps-rubella (MMR) vaccine is administered at 12 months of age, followed by a measles-mumps-rubella-varicella (MMRV) vaccine at 4-6 years of age. These vaccines are typically delivered by primary care providers alongside other routine childhood immunisations. As part of the outbreak immunisation response, eligibility for measles-containing vaccines was expanded in southwestern Ontario to include infants aged 6-11 months, and the second measles-containing vaccine dose was offered earlier than the routine schedule of age 4-6 years. These measures were in addition to general messaging on the importance on being up to date with the measles vaccine. Initially implemented in February and March 2025 in four local public health agencies with the highest measles incidence, the strategy was subsequently expanded to individuals who lived, worked, travelled, worshipped, or spent time in ten southwestern Ontario local public health agencies. The strategy was communicated to healthcare providers, schools, childcare settings, and affected communities. Vaccines were delivered through primary care providers and through initiatives led by local public health agencies, including community based clinics and home visits. Between 1 February 2025 and the end of the outbreak on 6 October 2025, 7828 infants aged 6 months to less than 12 months and 37 784 children aged 1-3 years were recorded in Panorama as having received a measles-containing vaccine. These figures do not include all doses administered by primary care providers because they are not recorded in Panorama in real-time and are typically only collected at the time of school-entry and data were also unavailable to determine how many doses were administered to members of historically under-vaccinated communities because these details are not recorded in the system.

Health system and community impacts

The measles outbreak was associated with increased demands on the healthcare system, particularly in the communities where incidence was highest. Primary care services and emergency departments had increased volumes of patients requiring assessment and management for suspected or confirmed measles infections and associated complications. Limited availability of airborne infection isolation rooms created additional operational challenges. In response, some hospitals converted existing clinical spaces to airborne infection isolation rooms, including areas within emergency departments and labour and delivery units. Special arrangements were made with local hospitals to ensure that costs of hospital admission and administration of intravenous immunoglobulin for post-exposure prophylaxis did not create barriers to care for community members who were not covered by Ontario's publicly funded health insurance programme.

In publicly reported accounts, members of the Mennonite communities in southwestern Ontario and community based health workers described several challenges during the outbreak including language barriers and misunderstandings during healthcare encounters, concerns about stigma and stereotyping, limited recognition of the heterogeneity within and between Mennonite communities, and mistrust of government institutions.[28-30] These accounts also highlighted the value of trusted community intermediaries, including Low German-speaking community health workers, in facilitating communication, access to care, and informed decision making on vaccination.

Discussion

This measles outbreak was the largest in Ontario, Canada in almost 30 years, with over 2300 reported cases. More than 90% (2146/2377) of cases occurred among members of historically under-vaccinated communities, with limited spillover into the broader population, reflecting the population level protection provided by long standing, high immunisation coverage, despite immunisation coverage measurement challenges, and strong local responses.[22] However, close social ties within and between under-vaccinated communities, combined with the high transmissibility of measles, facilitated spread across Ontario and beyond, to other regions of Canada, the USA, Mexico, several other countries in the Americas, and to the Netherlands. The multijurisdictional outbreak led to the loss of Canada's measles elimination status in November 2025,[8] five weeks after Ontario's outbreak was declared over.

The size of Ontario's outbreak, and the related multijurisdictional outbreak in Canada, are unprecedented. The largest prior outbreak in Canada after elimination was attained in 1998 occurred in Quebec in 2011, involving 725 cases over 33 weeks.[31] Despite its duration, transmission remained largely limited to Quebec. A subsequent outbreak in British Columbia in 2014, involving 433 cases over 15 weeks, shares several features with this outbreak, including transmission within a Netherlands Reformed community who had low vaccine coverage.[32] The British Columbia outbreak was successfully controlled by use of a high degree of community cooperation with infection control measures and restriction of movement; the outbreak did not extend to other under-vaccinated communities.[32]

In endemic settings, periodic outbreaks reduce the likelihood of remaining susceptible into adulthood, while high vaccine coverage in elimination settings limits susceptibility in reproductive age populations. [1] By contrast, in under-immunised communities in Ontario, longstanding low immunisation uptake combined with the absence of measles circulation since the pre-elimination period of the mid-1990s, resulted in a large and highly susceptible cohort. These conditions, together with large household sizes in some at-risk communities, contributed to a substantial burden of measles among pregnant individuals with associated morbidity and mortality. The outbreak was associated with one infant death after premature labour and delivery in a pregnant individual with measles and one case of encephalitis in a young infant. Longer term health outcomes for infants born with congenital measles infection are uncertain and require future study. However, some evidence suggests that these infants are at risk of delayed neurological complications, including subacute sclerosing panencephalitis, for which the risk is highest among children infected during the first year of life.[33] Continued clinical follow up is advised as part of routine primary care, as is a low threshold for specialist referral in the presence of neurological signs or symptoms, including seizures or regression in developmental milestones.[34]

This outbreak represents the first routine, prospective application of measles N450 Distinct sequence ID nomenclature during a multijurisdictional measles outbreak in Canada. DSIds were critical for identifying outbreak-associated cases that did not have epidemiological linkages and for documenting international spread of the Ontario outbreak strain. Although sequences from Mexico and South America were unavailable in the National Center for Biotechnology Information GenBank, case reports and PAHO updates have confirmed the presence of MVs/Ontario.CAN/47.24 (DSId 9171) in measles outbreaks in Mexico, Brazil, Peru, Argentina, and Guatemala.[13 14 35] In June 2026, PAHO indicated that DSId 9171 had been identified across multiple countries in the Americas and remains the main measles strain circulating in the region.[36] The emergence of DSId 9171 as the dominant measles strain in the Americas has important implications for measles elimination efforts. Once the multijurisdictional measles outbreak in Canada is declared

over, distinguishing imported cases from unrecognised domestic transmission may become increasingly challenging because the strain has become established across the Americas. This could complicate verification and re-establishment of measles elimination in Canada and other countries in the region of the Americas who are at risk of losing elimination status. The measles elimination status of the countries in the Region will be reviewed at the November 2026 meeting of the Pan American Health Organization Regional Verification Committee.

Our analysis is subject to limitations inherent to public health surveillance data. The true size of the outbreak was likely underestimated, despite the use of a sensitive outbreak case definition and enhanced public health surveillance, as not all cases will have been reported to the public health system. Complications may also have been under-ascertained if they were not evident at the time of case investigation. The multifaceted public health response, the prolonged duration of the outbreak, the uncertainty in the size of case under-ascertainment, and the absence of a comprehensive immunisation registry in Ontario limited our ability to assess the effectiveness of individual outbreak interventions or their contribution to the outbreak's resolution. The absence of a comprehensive immunisation registry also affected the ability to proactively identify communities at risk during the outbreak. Finally, the proportion of cases occurring in under-vaccinated communities is likely conservative, reflecting challenges in data collection for a variety of reasons, including mistrust among some community members and concerns from public health staff about the risk of stigmatisation of affected groups during the outbreak.

Conclusions

This measles outbreak illustrates the fragility of measles elimination in the presence of substantial immunity gaps within domestically and globally interconnected communities. These immunity gaps reflect long standing, low vaccine uptake, rather than newfound hesitancy following the covid-19 pandemic. Limited spillover beyond these communities highlights a high degree of vaccine acceptance in the population at large and the success of local partners in closing immunity gaps as part of the outbreak response. Strengthening of immunisation systems, improving vaccine coverage, and sustaining culturally appropriate engagement to continue to build trust in immunisation will be essential to prevent future vaccine preventable disease outbreaks and to support re-establishing measles elimination.

What is already known on this topic

Canada lost measles elimination status, which was gained in 1998, in November 2025, after a large and prolonged multijurisdictional outbreak

Many historically under-vaccinated communities in Canada have close social networks spanning Canada, the United States of Ameria, Mexico, and beyond creating opportunities for cross-border transmission

Limited evidence is available describing the public health responses to large, prolonged outbreaks that threaten measles elimination in the Americas

What this study adds

A prolonged measles outbreak involving 2377 cases in Ontario and a novel sequence identifier was concentrated within historically under-vaccinated communities and contributed to Canada's loss of measles elimination status

Community engagement, culturally tailored communication, and low barrier testing approaches were incorporated into the public health response and may inform future outbreak control efforts

Susceptibility among reproductive aged women contributed to important maternal and infant morbidity, with 51 infections in pregnancy, 10 congenital measles infections and one infant death.

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Transparency: The lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the outbreak investigation being reported; that no important aspects have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: Key findings from this outbreak have been disseminated through public health communication channels. A summary of the outbreak and its key epidemiological findings was made publicly available through the Public Health Ontario website and shared through presentations to public health and healthcare audiences. In addition, local Medical Officers of Health communicated information about the outbreak and its conclusion to affected communities through local public health communications and media engagement.

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Ethical approval: This project did not require research ethics committee approval as the activities described in this manuscript were conducted in fulfillment of Public Health Ontario's legislated mandate under the Ontario Agency for Health Protection and Promotion Act, SO 2007, c10 and are therefore considered public health practice, not research.

Data sharing: Data sharing statement: The epidemiological data reported in this article were collected under public health legislation and, as such, individual level data cannot be shared. Requests for aggregate data can be sent to the authors who will bring the request forward for further discussion with the Privacy Office of Public Health Ontario. Alternatively, requests can be sent directly to data@oahpp.ca. Laboratory (measles sequence) data have been submitted to public sequence repositories (Pathoplexus SeqSet PP_SS_1519.6). Individual National Center for Biotechnology Information GenBank accession numbers are provided in the additional Methods found in the Supplementary appendix.

1 Public Health Agency of Canada. Guidance for the public health management of measles cases, contacts and outbreaks in Canada [online]. 2025. https://www.canada.ca/en/public-health/services/diseases/measles/health-professionals-measles/guidance-management-measles-cases-contacts-outbreaks-canada.html (05 May 2026).

2 Thorrington D, Ramsay M, van Hoek AJ, etal. The effect of measles on health-related quality of life: a patient-based survey. *PLoS One* 2014;9:e105153. pmid: 25202905. doi: 10.1371/journal.pone.0105153

3 Measles cases dropped in Europe and Central Asia in 2025 compared to the previous year, but the risk of outbreaks remains - UNICEF and WHO [online]. 2026. https://www.who.int/europe/news/item/11-02-2026-measles-cases-dropped-in-europe-and-central-asia-in-2025-compared-to-the-previous-year--but-the-risk-of-outbreaks-remains---unicef-and-who (23 September 2026).

4 Public Health Agency of Canada. Measles: for health professionals [online]. 2026. https://www.canada.ca/en/public-health/services/diseases/measles/health-professionals-measles.html (05 May 2026).

5 Betsi-Enchill A. Update on implementation of a routine two-dose measles vaccination schedule and supplementary catch-up programs. *Measles Update* . 1996;4:. https://publications.gc.ca/collections/collection_2018/sc-hc/H12-28-1-4-4-eng.pdf.

6 Duclos P. Progress towards measles elimination. *Measles Update* . 1996;4:-3. https://publications.gc.ca/collections/collection_2018/sc-hc/H12-28-1-4-4-eng.pdf.

7 Ontario Agency for Health Protection and Promotion (Public Health Ontario). Measles in Ontario (January 8, 2026) [online]. 2026. https://www.publichealthontario.ca/-/media/Documents/Surveillance-Reports/Measles/26/measles-ontario-epi-2026-01-08.pdf?rev=9c3a6ab4d8a347398aa5712d7f531690&sc_lang=en (05 May 2026).

8 PAHO calls for regional action as the Americas lose measles elimination status [online]. 2025. https://www.paho.org/en/news/10-11-2025-paho-calls-regional-action-americas-lose-measles-elimination-status (05 May 2026).

9 Who are the Mennonites [online]? 2026. https://uwaterloo.ca/grebel/about-grebel/who-are-mennonites (05 May 2026).

10 le Polain de Waroux Y, Neumann J, O'Driscoll A, etal. Pious pioneers: the expansion of Mennonite colonies in Latin America. *J Land Use Sci* 2020;16:-17. doi: 10.1080/1747423X.2020.1855266

11 Hahné S, Macey J, Tipples G, etal. Rubella outbreak in an unvaccinated religious community in the Netherlands spreads to Canada. *Euro Surveill* . 2005;10:E050519.1. doi: 10.2807/esw.10.20.02704-en

12 Health Infobase. Measles and rubella weekly monitoring report: epiemiological week 36 (September 6-12, 2026) [online]. 2026. https://health-infobase.canada.ca/measles-rubella/ (27 September 2026).

13 Epidemiological alert: measles in the Americas region, 3 February 2026 [online]. 2026. https://www.paho.org/en/documents/epidemiological-alert-measles-americas-region-3-february-2026 (05 May 2026).

14 Epidemiological update: measles in the Americas region, 2 May 2025 [online]. 2025. https://www.paho.org/en/documents/epidemiological-update-measles-americas-region-2-may-2025 (05 May 2026).

15 Health Protection and Promotion Act. , RSO 1990, cH.7.

16 Ontario. Ministry of Health. Ontario public health standards: requirements for programs, services and accountability. Infectious disease protocol. Appendix 1: case definitions and disease-specific information. Disease: measles. Effective: March 2024 [online]. 2024. https://www.ontario.ca/files/2024-03/moh-measles-appendix-en-2024-03-19.pdf (05 May 2026).

17 WHO outbreak toolkit: stages of an outbreak investigation [online]. c2026. https://www.who.int/emergencies/outbreak-toolkit/investigating-outbreak-of-unknown-disease (05 May 2026).

18 Brown KE, Rota PA, Goodson JL, etal. Genetic Characterization of Measles and Rubella Viruses Detected Through Global Measles and Rubella Elimination Surveillance, 2016-2018. *MMWR Morb Mortal Wkly Rep* 2019;68:-91. pmid: 31269012. doi: 10.15585/mmwr.mm6826a3

19 Hiebert J, Zubach V, Schulz H, etal. Genomic tools for post-elimination measles molecular epidemiology using Canadian surveillance data from 2018-2020. *Front Microbiol* 2024;15:. pmid: 39629208. doi: 10.3389/fmicb.2024.1475144

20 World Health Organization (WHO). Genetic diversity of wild-type measles viruses and the global measles nucleotide surveillance database (MeaNS). *Wkly Epidemiol Rec* . 2015;30:-80. https://iris.who.int/server/api/core/bitstreams/3f701046-8f6a-4e17-869f-4541ce86db41/content.

21 Williams D, Penedos A, Bankamp B, etal. Update: circulation of active genotypes of measles virus and recommendations for use of sequence analysis to monitor viral transmission. *Wkly Epidemiol Rec* . 2022;97:-92. https://iris.who.int/server/api/core/bitstreams/69e3b7d2-25c5-4dc5-b0b3-464e8dc4bf57/content.

22 Ontario Agency for Health Protection and Promotion (Public Health Ontario). Increasing routine immunization coverage following the COVID-19 pandemic: perspectives from Ontario's public health units [online]. 2025. https://www.publichealthontario.ca/-/media/Documents/C/25/covid-19-pandemic-increasing-routine-immunization-coverage.pdf (13 september 2026).

23 Chambers C, Sarmiento J, Nguyen-Orlando M, etal. Public health unit perspectives on challenges, barriers, and lessons learned from Ontario's 2024-2025 measles outbreak: a mixed-methods survey. *Can J Public Health* [Epub ahead of print]. September 09, 2026 . doi: 10.17269/s41997-026-01253-3.

24 Ontario Agency for Health Protection and Promotion (Public Health Ontario). Immunization data tool [online]. 2026. https://www.publichealthontario.ca/en/Data-and-Analysis/Infectious-Disease/Immunization-Tool (13 september 2026).

25 Ontario Agency for Health Protection and Promotion (Public Health Ontario). Infectious disease trends in Ontario Tool [online]. 2025. https://www.publichealthontario.ca/en/data-and-analysis/infectious-disease/reportable-disease-trends-annually (05 May 2026).

26 VanderKlippe N. Behind the measles investigation story. Globe and Mail [online], 2025. https://www.theglobeandmail.com/world/article-behind-the-measles-investigation-story/ (05 May 2026).

27 Ontario. Ministry of Health. Statement from the Chief Medical Officer of Health [online]. 2025. https://news.ontario.ca/en/statement/1006004/statement-from-the-chief-medical-officer-of-health (05 May 2026).

28 How Mennonite women are building bridges between public health and community amid measles outbreak. Canadian Press [online], 2025. https://globalnews.ca/news/11214661/ont-measles-mennonite/ (12 September 2026).

29 Friesen C. Behind the scenes of Ontario's Mennonite measles outbreak. Maclean's [online], 2025. https://macleans.ca/society/behind-the-scenes-of-ontarios-mennonite-measles-outbreak/ (12 September 2026).

30 Canadian Broadcasting Corporation. Inside a Mennonite community where measles is spreading. The Current [audio recording], 2025. https://www.youtube.com/watch?v=v3xBZGaxBOk (12 september 2026).

31 De Serres G, Markowski F, Toth E, etal. Largest measles epidemic in North America in a decade--Quebec, Canada, 2011: contribution of susceptibility, serendipity, and superspreading events. *J Infect Dis* 2013;207:-8. pmid: 23264672. doi: 10.1093/infdis/jis923

32 Naus M, Puddicombe D, Murti M, etal. Outbreak of measles in an unvaccinated population, British Columbia, 2014. *Can Commun Dis Rep* 2015;41:-74. pmid: 29769948. doi: 10.14745/ccdr.v41i07a02

33 Wendorf KA, Winter K, Zipprich J, etal. Subacute Sclerosing Panencephalitis: The Devastating Measles Complication That Might Be More Common Than Previously Estimated. *Clin Infect Dis* 2017;65:-32. pmid: 28387784. doi: 10.1093/cid/cix302

34 American Academy of Pediatrics, Committee on Infectious Diseases. Congenital measles: frequently asked questions. Red Book Online [online]. 2026. https://publications.aap.org/redbook/resources/35976/Congenital-Measles-Frequently-Asked-Questions (21 September 2026).

35 Ruiz González IL de J, Morales Marin R. Reintroduction of measles in Chihuahua, Mexico, February-August 2025. *Am J Field Epidemiol* . 2025;3:-4. doi: 10.59273/ajfe.v3i1.15717

36 Situation report #4: measles in the Americas region, 4 June 2026 [online]. 2026. https://www.paho.org/en/documents/situation-report-4-measles-americas-region-4-june-2026 (02 August 2026).

Supplementary material supporting the paper

Analysis data

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