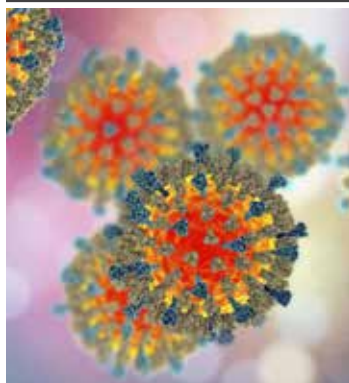


# MEASLES SURVEILLANCE IN CANADA

2016



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## INTRODUCTION

Measles is one of the most highly contagious respiratory infectious diseases. Before vaccination became available, measles was responsible for millions of deaths in the world. No animal reservoir maintains measles virus transmission and no latent or persistent measles virus infections result in prolonged contagiousness, making elimination possible (1). Measles elimination is defined as the absence of endemic measles transmission in a defined geographic area for 12 months or more, in the presence of a well-performing surveillance system (2). Enhanced surveillance of measles provides evidence for measles elimination. In Canada, measles has been a nationally notifiable disease between 1924 and 1959, and since 1968. Enhanced, case-based surveillance of measles is coordinated by the Public Health Agency of Canada (PHAC), through the Canadian Measles and Rubella Surveillance System (CMRSS). Measles elimination in Canada has been described as an important and attainable public health objective since 1980 (3). Moreover, Canada set the goal of achieving measles elimination by 2005 during the 1992 Consensus Conference on Measles (4). This was revised at the 1994 XXIV Pan American Sanitary Conference, where Canada and other member states agreed to eliminate measles in the Americas by 2000 (5). A two-dose routine vaccination program against measles and rubella was implemented in all provinces and territories in 1996–1997. As the last endemic case of measles was reported in 1997, measles elimination status in Canada was achieved in 1998 and reconfirmed in 2016 (6,7,8,9). However, Canada's elimination status remains a challenge due to importations of measles from other countries, where the disease is still endemic. In order to verify measles elimination status on an ongoing basis, Canada submits surveillance data to the Pan American Health Organization (PAHO). The objective of this report is to provide an epidemiologic summary of measles activity reported in Canada for the 2016 epidemiologic year.

## METHODS

**Surveillance data:** Measles cases meeting the national case definition (7) were reported weekly to PHAC by provinces and territories through CMRSS, including zero-reporting. Surveillance data were extracted and non-identifying case data were submitted to PAHO. Confirmed measles cases included in this report had rash onset during the 2016 epidemiologic year (January 3<sup>rd</sup>, 2016 to December 31<sup>st</sup>, 2016).

**Genotyping:** All measles virus genotyping was performed at the PHAC's National Microbiology Laboratory. World Health Organization (WHO) standardized genotyping: sequencing of 450 nucleotides of the nucleoprotein (N) gene (the N-450), with the addition of the full length haemagglutinin (H) gene (10) was attempted on all reverse transcription-polymerase chain reaction (RT-PCR) confirmed measles cases. The clinical specimens (respiratory and/or urine) were referred to the NML by provincial laboratories and were RT-PCR-confirmed in the provincial laboratories or at the NML. Genotypes were assigned by maximum homology of the N-450 sequences to the WHO genotype reference sequences (11,12). Sequences were also deposited in the WHO Measles Nucleotide Surveillance database (MeaNS, [www.who-measles.org](http://www.who-measles.org)) and compared to so called "named strains" as well as sequences deposited by other members of the global measles laboratory network (11,13).

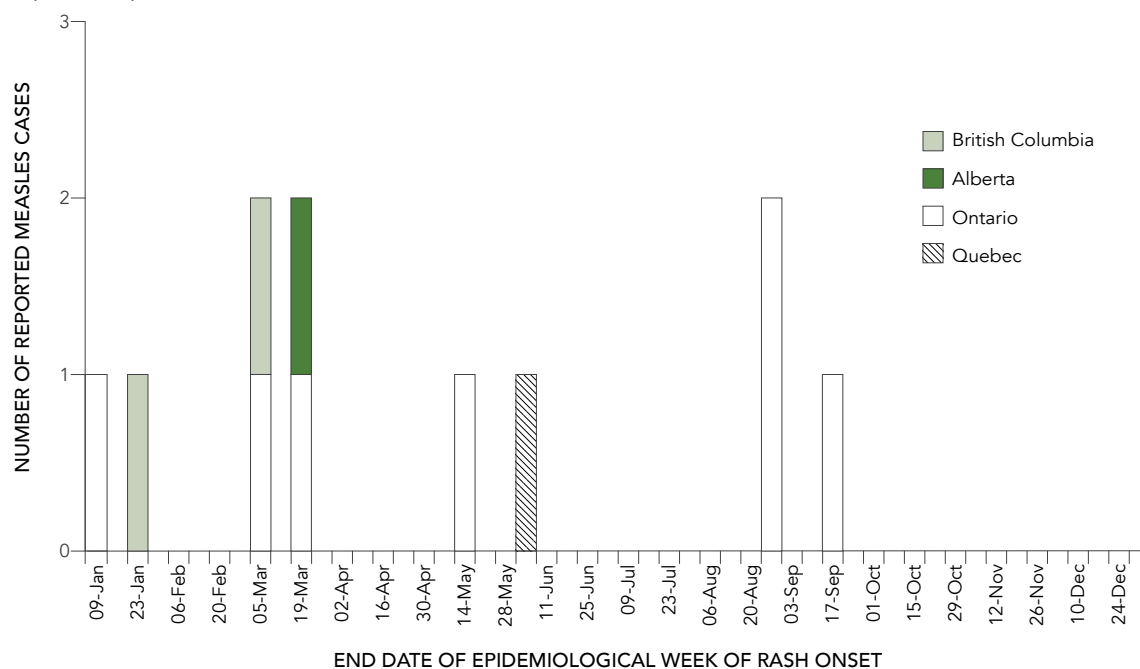
**Data management and validation:** Measles surveillance data were managed using Microsoft Access 2010. A data validation process was conducted in March 2017, with all provinces/territories. This included querying for blank fields, identifying illogical field entries and confirming values with reporting jurisdictions.

**Analysis:** Microsoft Excel 2010 and SAS Enterprise Guide v.5.1 were used to perform descriptive epidemiologic analyses, for categorical variables (counts, proportions) and continuous values (medians, ranges). Incidence rates were calculated using Statistics Canada July 1, 2016 population estimates by provinces and territories. Measles cases were assessed by demographics (e.g., age, sex, and location), risk characteristics (e.g., vaccination status, hospitalization, and source of exposure) and genotype. Event characteristics were summarized and surveillance data were evaluated against the essential criteria for the maintenance of measles elimination status, as described by PAHO (14). This routine public health surveillance activity was exempt from research ethics board approval.

## RESULTS

In 2016, the incidence of measles in Canada was 0.3 cases per 1,000,000 population, with a total of 11 reported cases. All cases were laboratory-confirmed. The majority of cases were reported in March (epidemiologic weeks 9–11,  $n=4$ , 36%) and August–September (weeks 34–37,  $n=3$ , 27%). A maximum of two cases (18%) were reported during a single week (weeks 9, 11, and 34) (Figure 1).

**FIGURE 1:** Number of reported measles cases, by epidemiological week of rash onset and reporting province or territory, Canada, 2016



## AGE, SEX AND LOCATION

Information on age, sex and reporting province or territory was available for every case reported in 2016. Cases ranged from four months to 40 years, with a median age of 10 months. The most frequently reported age group was less than one year (64%, n=7), followed by those aged one to four years (18%, n=2). Incidence rates were also highest for these groups, at 17.9 and 1.3 cases per 1,000,000 population respectively (Table 1). There were no cases reported among those aged five to 19 years, 25 to 39 years, and 60 years and older. Approximately half of the reported cases (54%, n=6) were male. Four Canadian provinces reported measles cases in 2016: British Columbia, Alberta, Ontario and Quebec. Incidence was highest in Ontario, followed by British Columbia, Alberta and Quebec (0.5, 0.4, 0.2 and 0.1 cases per 1,000,000 population respectively).

**TABLE 1:** Confirmed measles cases and incidence rates (per 1,000,000 population) by age group, sex, and reporting province or territory\*, Canada, 2016

AGE GROUP	SEX		PROVINCES				CA	OVERALL INCIDENCE RATE
	M	F	BC	AB	ON	QC		
<1 year	4	3	1	1	4	1	7	17.9
1 to 4 years	1	1	0	0	2	0	2	1.3
5 to 9 years	0	0	0	0	0	0	0	0.0
10 to 14 years	0	0	0	0	0	0	0	0.0
15 to 19 years	0	0	0	0	0	0	0	0.0
20 to 24 years	0	1	0	0	1	0	1	0.4
25 to 29 years	0	0	0	0	0	0	0	0.0
30 to 39 years	0	0	0	0	0	0	0	0.0
40 to 59 years	1	0	1	0	0	0	1	0.1
60 years or more	0	0	0	0	0	0	0	0.0
<b>Total</b>	<b>6</b>	<b>5</b>	<b>2</b>	<b>1</b>	<b>7</b>	<b>1</b>	<b>11</b>	
<b>Incidence rate:</b>	<b>0.3</b>	<b>0.3</b>	<b>0.4</b>	<b>0.2</b>	<b>0.5</b>	<b>0.1</b>	<b>0.3</b>	<b>0.3</b>

Abbreviations: M: Male, F: Female, BC: British Columbia, AB: Alberta, ON: Ontario, QC: Quebec, CA: Canada

\* Only provinces and territories with confirmed cases were included. No cases of measles were reported in Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Nunavut, Prince Edward Island, Saskatchewan and Yukon.

## VACCINATION

In 2016, nine of 11 cases were not vaccinated, and two had unknown vaccination status (Table 2). Of the nine unvaccinated cases, seven were age ineligible according to the routine immunization schedule. Two cases were adults with unknown vaccination history. None of the reported cases were born before 1970, the cut off used for presumed natural immunity to measles in Canada (15).

**TABLE 2:** Vaccination status of confirmed measles cases reported in Canada in 2016 by age group

AGE GROUP	UNVACCINATED	VACCINATED	UNKNOWN	TOTAL
<1 year	7	0	0	7
1 to 4 years	2	0	0	2
5 to 9 years	0	0	0	0
10 to 14 years	0	0	0	0
15 to 19 years	0	0	0	0
20 to 24 years	0	0	1	1
25 to 29 years	0	0	0	0
30 to 39 years	0	0	0	0
40 to 59 years	0	0	1	1
60 years or more	0	0	0	0
<b>Total</b>	<b>9</b>	<b>0</b>	<b>2</b>	<b>11</b>



## HOSPITALIZATION

In 2016, five cases were hospitalized (45%) (Table 3). All hospitalizations occurred among children zero to four years of age.

**TABLE 3:** Hospitalization status of confirmed measles cases by age group, Canada, 2016

AGE GROUP	TOTAL	NOT HOSPITALIZED	HOSPITALIZED
		N	N
<1 year	7	4	3
1 to 4 years	2	0	2
5 to 9 years	0	0	0
10 to 14 years	0	0	0
15 to 19 years	0	0	0
20 to 24 years	1	1	0
25 to 29 years	0	0	0
30 to 39 years	0	0	0
40 to 59 years	1	1	0
60 years or more	0	0	0
<b>Total</b>	<b>11</b>	<b>6</b>	<b>5</b>

Abbreviation: N = Number

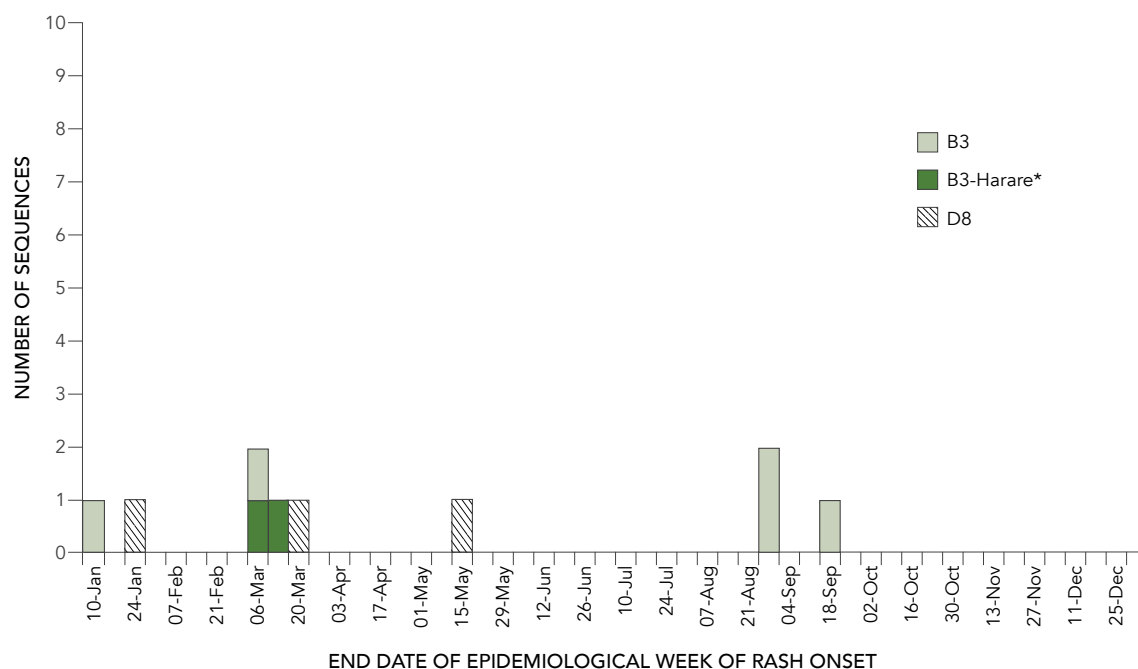
## CANADIAN MEASLES IN THE GLOBAL CONTEXT

Importations accounted for 91% (n=10) of cases in 2016; only one case had an unknown source of exposure. Seven cases were infants under one year old, which is too young to be immunized according to the routine schedule. However, measles, mumps and rubella (MMR) vaccine may be given as early as six months of age to children travelling to countries outside of North America, thus six cases were eligible for vaccine as per the previously stated travel recommendations (16). These children also represent missed opportunities for vaccination. One case was under six months of age, which is too young to be vaccinated even in a travel context. Imported cases were exposed to measles during travel within four of the six WHO regions: Eastern Mediterranean (n=6; Pakistan and Afghanistan), South-East Asian (n=2; China and/or Malaysia, India), African (n=1, Gabon) and European (n=1, Italy and/or Montenegro) regions. There was one event with two co-index cases where the source of exposure was Afghanistan (Appendix).

## MOLECULAR EPIDEMIOLOGY

Of the 11 measles cases in 2016, 10 had specimens available for genotyping (91%). Two of the 11 cases were epidemiologically linked while remaining nine were individual cases with no secondary spread. Of the measles events 91% were genotyped. The genotypes detected were B3 (n=7) and D8 (n=3) (Figure 2). Globally, these were two of the most frequently detected genotypes, outside of China, based on submissions to the MeaNS.

**FIGURE 2:** Distribution of measles genotypes detected in 2016 (n=10) by week of rash onset†<sup>1</sup>



Six of the seven cases with genotype B3 detected were imported from the Eastern Mediterranean Region (4 from Pakistan and 2 from Afghanistan), where genotype B3 is endemic (17). Two of these were identical to the MVi/Harare.ZWE/38.09 named strain (GenBank accession number JF973033.1) while a third was identical to the MVs/Dublin. IRL/8.16 named strain (GenBank accession number KY013331.1). The seventh genotype B3 case was associated with travel in the European region and was identical to the MVs/Iasi. ROU/19.15 named strain (GenBank accession number KX372739.1).

† Epidemiological weeks are assigned in accordance with the CDC guidelines (10) with week 1 beginning on the first Sunday of the year.

\* Genotype B3 sequences identical to sequence variant MVi/Harare.ZWE/38.09 (GenBank accession number JF973033).

Genotype D8 was detected in three cases and each case had a distinct viral sequence. One case, associated with travel to the Western Pacific Region, had a viral sequence identical to the MVi/Hulu Langat.MYS/26.11 named strain (GenBank accession number JX486001.1) while the remaining two viruses weren't identical to any named strains. One genotype D8 case was imported from India where this genotype is endemic (17).

## MAINTENANCE OF MEASLES ELIMINATION

There are four criteria set out by PAHO, for the ongoing verification of measles elimination (Table 4). As per the detail described earlier, Canada met or partially met three indicators.

**TABLE 4:** Pan American Health Organization essential criteria for the verification of measles elimination

CRITERION	INDICATOR	DESCRIPTION
Verify the interruption of endemic measles cases for a period of at least three years from the last known endemic case, in the presence of high-quality surveillance.	Zero cases of endemic transmission.	Criterion met. Canada achieved measles elimination status in 1998 and this was recertified in 2016. Molecular and epidemiological data continue to demonstrate that no viral strain has circulated for a period of one year or more in Canada (6,9,18,19).
Maintain high-quality surveillance sensitive enough to detect imported and import-related cases.	>2 suspect cases per 100,000 population adequately investigated.	Criterion partially met. CMRSS allows identifying imported and import-related cases, but suspected cases are not nationally notifiable.
Verify the absence of endemic measles virus strains through viral surveillance.	Measles genotype assessed in 80% of outbreaks.	Criterion met. No outbreak occurred in Canada in 2016. However, there was one event with co-index cases exposed outside of Canada. Genotype was assessed in 9/10 events (90%).
Verify adequate immunization in the population	95% of population cohorts aged 1 to 40 years have received a measles-containing vaccine	Criterion not met. Canada currently measures (biannually) measles vaccination coverage rates at 2 and 7 years of age, and therefore is unable to assess measles vaccination coverage for all ages 1 through 40 years. The 2013 estimates for measles-containing vaccine age 2 and 7 years are 89.6% and 85.5% respectively, below the indicator of 95% (20,21).

## DISCUSSION

Eleven confirmed cases of measles, in 10 unique events, were reported in Canada in 2016. Almost all cases were imported (91%); one had an unknown source of exposure. This is the lowest number of cases reported annually since 2012 (n=9) (8). No cases had a documented history of vaccination, nine were unvaccinated and two had an unknown vaccination history. The burden was highest among children, especially those aged less than one year. All hospitalized cases were in children less than five years of age. Ten cases had genotype information available: seven were B3, and three were D8 genotype, which reflected the genotypes circulating globally. Two cases had the same source of exposure outside of Canada but no outbreaks occurred in Canada in 2016.

Canada meets or partially meets three of the four PAHO essential indicators for maintenance of measles elimination. Canada has a high performing surveillance system for measles, which is able to detect imported and import-related cases as well as the infrequent cases with unknown source of exposure. Molecular epidemiologic laboratory data confirms the absence of a circulating endemic measles virus genotype in Canada.

Canada falls short of the criterion regarding measles containing vaccination coverage. Canada currently measures (biannually) measles vaccination coverage rates at 2 and 7 years of age, and therefore is unable to assess measles vaccination coverage for all ages 1 through 40 years as is set out in the PAHO elimination criterion indicator. The 2013 estimates for measles-containing vaccine age 2 and 7 years are 89.6% and 85.5% respectively, below the PAHO indicator of 95% (20). Despite this, endemic transmission of the measles virus has not been re-established. Therefore, based on a combination of the epidemiologic, laboratory and vaccination coverage data, Canada's National Certification Committee recertified Canada's measles elimination status in 2016 (9).

The *Global Vaccine Action Plan* adopted by the World Health Assembly in 2012 set a goal of eliminating measles in four regions by 2015. Failure to close vaccination coverage gaps has resulted in a failure to meet the goal (22). Globally, measles elimination continues to be a public health priority, with all six WHO regions now aiming to achieve measles elimination by 2020 (23).

Measles continues to be an important public health issue globally. Although only 92 cases of measles were reported in the Region of the Americas in 2016, worldwide over 174,000 cases of measles were reported to the WHO (24).

## LIMITATIONS

These data have limitations that merit consideration. The indicators of a well-performing surveillance system established by PAHO are based on investigation of measles-like illness (i.e., suspected cases), whereas only confirmed cases are nationally notifiable in Canada. As such, these data can only indirectly address the PAHO criteria. Moreover, information on mortality and detailed information on morbidity (e.g., length of hospitalization, sequelae) are not currently captured by CMRSS, limiting the ability to completely describe the burden of illness due to measles in Canada.

## CONCLUSION

Both in Canada and abroad, maintaining high vaccination coverage with measles-containing vaccine remains a significant public health effort, as well as an essential component of a strategy for achieving and maintaining measles elimination. Although importations and suboptimal vaccination coverage continue to challenge Canada's elimination status, surveillance data provided strong evidence that measles elimination has been maintained.

## ACKNOWLEDGEMENTS

PHAC gratefully acknowledge the continued cooperation and efforts of provincial and territorial surveillance and laboratory partners for providing and validating data captured by CMRSS, for referring specimens for molecular surveillance (genotyping) and for their review of the report content. PHAC wants to acknowledge the contribution of the National certifying committee in support of Canada continuous elimination status.

## APPENDIX: SUMMARY OF MEASLES EVENTS IN CANADA, ORDERED BY EARLIEST DATE OF RASH ONSET, 2016

EVENT	PROVINCE	NUMBER OF CASES	GENOTYPE	INDEX CASE
1	ON	1	B3 (Not identical to named strain)	Imported (Pakistan) <1 year old
2	BC	1	D8 (Mvi/Hulu Langat.MYS/26.11)	Imported (South East Asia — Hong Kong, Singapore) 40–45 yr old
3	BC	1	B3 (Not identical to named strain)	Imported (Pakistan) < 1 year old
4	ON	1	B3 (Mvi/Harare.ZWE/38.09)	Imported (Pakistan) < 1 year old
5	AB	1	B3 (Mvi/Harare.ZWE/38.09)	Imported (Pakistan) < 1 year old
6	ON	1	D8 (Not identical to named strain)	Imported (India) 1–4 year old
7	ON	1	D8 (Not identical to named strain)	Unknown Source < 1 year old
8	QC	1	N/A	Imported (Gabon) < 1 year old
9	ON	2	B3 (Not identical to named strain)	Imported (x2) (Afghanistan) 1–4 year old & 20–24 year old
10	ON	1	B3 (Not identical to named strain)	Imported (Italy and Montenegro) <1 year old

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