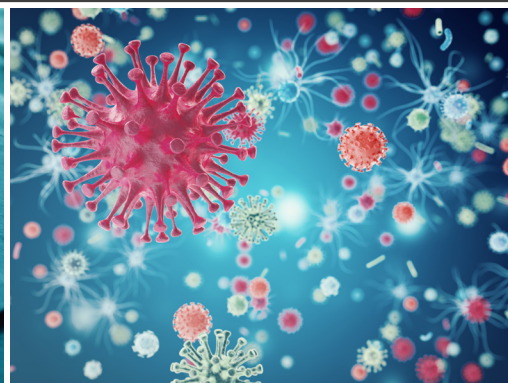


VACCINE PREVENTABLE DISEASE

SURVEILLANCE REPORT TO DECEMBER 31, 2015



Public Health
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**TO PROMOTE AND PROTECT THE HEALTH OF CANADIANS THROUGH LEADERSHIP, PARTNERSHIP,
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ABBREVIATIONS

AFP	Acute flaccid paralysis
aNICS	Adult National Immunization Coverage Survey
CAFPSS	Canadian Acute Flaccid Paralysis Surveillance System
CANSIM	Canadian Socio-Economic Information Management System
CIRID	Centre for Immunization and Respiratory Infectious Diseases
CMRSS	Canadian Measles and Rubella Surveillance System
cNICS	Childhood National Immunization Coverage Survey
CNDSS	Canadian Notifiable Disease Surveillance System
CPS	Canadian Pediatric Society
CRI	Congenital rubella infection
CRS	Congenital rubella syndrome
eIMDSS	Enhanced Invasive Meningococcal Disease Surveillance System
Hib	<i>Haemophilus influenzae</i> type b
HPV	Human papillomavirus
IMD	Invasive meningococcal disease
IMPACT	Immunization Monitoring Program ACTive
IPD	Invasive pneumococcal disease
NACI	National Advisory Committee on Immunization
NML	National Microbiology Laboratory
PAHO	Pan-American Health Organization
PHAC	Public Health Agency of Canada
VPDs	Vaccine preventable diseases
WHO	World Health Organization
WPV	Wild-type poliovirus

EXECUTIVE SUMMARY

Disease prevention is a core function of public health. Many common infectious diseases that were once a major cause of morbidity and mortality in Canada are now preventable with vaccines. Nevertheless, as this report clearly outlines, vaccine-preventable diseases (VPDs) are still a public health concern in Canada and it is important to achieve the highest possible levels of vaccination. The Vaccine Preventable Disease in Canada: Surveillance Report to December 31, 2015 summarizes the epidemiology of 12 nationally notifiable VPDs for which publicly-funded routine vaccination programs are in place in all provinces and territories. It serves the following purposes:

- Summarize the epidemiology of 12 VPDs and associated vaccination coverage in Canada.
- Provide a baseline against which progress in disease reduction can be measured.
- Support the Government of Canada's international commitments to report on disease elimination and eradication initiatives.
- Provide evidence to inform vaccination programs and policy.

This report uses data from a variety of national surveillance systems including the Canadian Notifiable Diseases Surveillance System, the Canadian Measles and Rubella Surveillance System, the Enhanced Invasive Meningococcal Disease Surveillance System, the Canadian Acute Flaccid Paralysis Surveillance System, and the Canada's Immunization Monitoring Program, ACTive. Vaccination coverage estimates obtained from the 2015 Childhood National Immunization Coverage Survey and the 2014 Adult National Immunization Coverage Survey were also included to provide context. Each VPD was placed into one of three categories: VPDs under elimination in Canada, VPDs with low level incidence, and VPDs with moderate level incidence. The findings for each of these categories are summarized below.

HOW ARE WE DOING?

VPDs under elimination¹

Canada's elimination status was maintained for measles, rubella, congenital rubella syndrome/congenital rubella infection, and polio. While vaccination coverage rates for two year olds were high for measles (89%), rubella (89%), and polio (91%), they remain below national vaccination coverage goals. Reported measles outbreaks due to imported cases in 2011, 2014, and 2015 did not result in the re-establishment of endemic transmission but illustrate the need to remain vigilant in maintaining national vaccine coverage levels until worldwide eradication has been achieved.

¹ This includes measles, rubella, congenital rubella syndrome/congenital rubella infection, and polio.

VPDs with low level incidence²

Among the described VPDs not under elimination, diphtheria and tetanus accounted for the fewest cases with five or less cases reported per year between 2011 and 2015. Similarly, the incidence of invasive disease due to *Haemophilus influenzae* (Hib) has declined by 99% among those under five years of age since the introduction of vaccines, with fewer than 35 cases reported in all age groups annually. Reported IMD cases continue to decrease with less than 200 cases reported each year, of which thirteen or fewer are due to IMD serogroup C. IMD serogroup B, for which no routine vaccination programs currently exist, accounted for the majority (63%) of IMD cases reported between 2011 and 2015. While mumps incidence rates have declined by over 99% since the introduction of routine vaccination programs, outbreaks continue to occur every two to five years, with incidence rates highest among young adults.

Despite these low disease incidence rates, vaccine coverage rates can be improved. Rates for diphtheria and tetanus were considerably below national goals with approximately 77% of two year olds receiving the recommended number of doses and only 53% of adults reporting a tetanus vaccine as an adult. Coverage among two year olds was slightly better for meningococcal C (88%) and mumps (89%), but worse for Hib (72%).

VPDs with moderate level incidence³

From 2011 to 2015, pertussis and invasive pneumococcal disease (IPD) accounted for the greatest proportion of reported VPD cases in Canada. Although pertussis incidence has declined by 96% since the pre-vaccine era, pertussis continues to be an endemic, cyclical disease in Canada with an increase in annual incidence rates since a low in 2011. Numerous outbreaks were reported in Canada in 2012 and 2015. Pertussis incidence rates were particularly high among infants less than one year of age, a concerning statistic given they are at highest risk for associated complications. Only approximately 77% and 75% of children had received the recommended doses of pertussis-containing vaccine by two and seven years of age, respectively.

In Canada, IPD incidence rates are highest among adults 65 years of age and older followed by infants less than one year of age. While incidence rates have declined among infants less than two years of age since the mid-1990s, they have remained mostly unchanged among adults 65 years of age and older. Of note, vaccine coverage among adults in this age group remains low at 37% while approximately 80% of children had received the recommended doses of pneumococcal vaccine by two years of age.

Finally, the nation-wide burden of varicella is difficult to assess as varicella is not reportable in all provinces and territories and cases may not be seen by a physician. However, since the introduction of vaccine programs there has been a 99% reduction in reported cases as well as a decline in the number of hospitalizations for serious varicella infections in the paediatric population.

² This includes diphtheria, tetanus, invasive disease due *Haemophilus influenzae* serotype b, invasive meningococcal disease, and mumps.

³ This includes pertussis, IPD, and varicella.

TABLE 1: Average annual reported cases and range of select vaccine preventable diseases in Canada by age group, 2011 to 2015.

AGE GROUP (YEARS)	MEASLES	RUBELLA	CRS/CRI	POLIO	TETANUS	DIPHTHERIA
< 1	10.0 (1-26)	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)	0 (0-0)
1 to 4	25.0 (2-63)	0 (0-0)		0 (0-0)	0.2 (0-1)	0.4 (0-1)
5 to 9	46.4 (2-125)	0 (0-0)		0 (0-0)	0.2 (0-1)	0 (0-0)
10 to 14	87.6 (0-260)	0 (0-0)		0 (0-0)	0.2 (0-1)	0 (0-0)
15 to 19	70.0 (1-227)	0 (0-0)		0 (0-0)	0.0 (0-0)	0 (0-0)
20 to 24	16.4 (2-27)	0.2 (0-1)		0 (0-0)	0.4 (0-2)	0 (0-0)
25 to 29	7.2 (0-13)	0.2 (0-1)		0 (0-0)	0.20 (0-1)	0.0 (0-1)
30 to 39	20.6 (2-57)	0.4 (0-1)		0 (0-0)	0.6 (0-2)	0 (0-0)
40 to 59	8.6 (0-18)	0.2 (0-1)		0 (0-0)	0.20 (0-1)	0.4 (0-1)
≥ 60	0 (0-0.0)	0 (0-0)		0 (0-0)	1.4 (0-3)	0 (0-0)
Unspecified	0 (0-0.0)	0 (0-0)		0 (0-0)	0 (0-0)	0 (0-0)
All ages	291.8 (10-752)	1.0 (0-2)	0 (0-0)	3.4 (2-5)	0.8 (0-2)	

TABLE 1: continued

AGE GROUP (YEARS)	HIB	MUMPS	IMD	VARICELLA	IPD	PERTUSSIS	OVERALL
< 1	5.0 (3-7)	0.8 (0-2)	16.8 (11-27)	24.4 (17-31)	67.8 (55-78)	246.4 (148-453)	371.6 (291-560)
1 to 4	3.2 (1-5)	1.8 (0-3)	19.8 (14-34)	64.0 (53-76)	187.6 (152-236)	352.8 (148-676)	654.8 (446-963)
5 to 9	1.0 (0-2)	3.0 (0-6)	4.0 (1-8)	160.0 (65-265)	77.4 (65-95)	404.8 (108-801)	696.8 (418-958)
10 to 14	0.2 (0-1)	7.8 (2-19)	5.8 (2-13)	109.2 (43-165)	33.0 (20-47)	511.0 (105-1176)	754.8 (372-1285)
15 to 19	0.4 (0-2)	15.0 (3-29)	19.6 (14-26)	45.8 (23-67)	29.6 (18-37)	156.2 (39-308)	336.6 (187-414)
20 to 24	0.2 (0-1)	21.0 (3-67)	8.4 (4-12)	32.6 (25-50)	42.0 (33-60)	68.4 (18-130)	189.6 (140-259)
25 to 29	0.8 (0-2)	12.6 (3-43)	4.8 (3-6)	28.8 (23-33)	72.2 (60-95)	67.4 (14-139)	194.2 (147-277)
30 to 39	1.8 (1-3)	20.4 (5-52)	5.6 (3-7)	51.6 (41-63)	223.8 (202-246)	172.6 (44-341)	497.4 (390-640)
40 to 59	7.8 (5-11)	18.0 (7-48)	21.2 (16-32)	46.4 (35-61)	896.2 (848-934)	261.2 (50-482)	1260.2 (1101-1503)
≥ 60	7.0 (3-15)	2.4 (0-4)	25.8 (17-35)	19.4 (12-37)	1606.8 (1529-1651)	88.4 (17-181)	1751.2 (1628-1872)
Unspecified	0 (0-0)	0.00 (0-0)	0.0 (0-0)	0.4 (0-1)	22.8 (0-112)	2.8 (0-6)	26.0 (1-112)
All ages	27.4 (24-33)	102.8 (40-273)	131.8 (101-175)	582.6 (355-720)	3259.2 (3178-3418)	2332.0 (694-4655)	6733.2 (5249-8670)

TABLE 2: Average annual incidence rate (cases per 100,000 population) and range of select vaccine preventable diseases in Canada by age group, 2011 to 2015.

AGE GROUP (YEARS)	MEASLES	RUBELLA	CRS/CRI	POLIO	TETANUS	DIPHTHERIA
< 1	2.6 (0.3-6.9)	0 (0.0-0.0)	0 (0.0-0.5)	0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
1 to 4	1.6 (0.1-4.1)	0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.1)	0.0 (0.0-0.1)
5 to 9	2.5 (0.1-6.5)	0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.1)	0.0 (0.0-0.0)
10 to 14	4.6 (0.0-13.6)	0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.1)	0.0 (0.0-0.0)
15 to 19	3.2 (0.0-10.1)	0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
20 to 24	0.7 (0.1-1.1)	0.0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.1)	0.0 (0.0-0.0)
25 to 29	0.3 (0.0-0.5)	0.0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
30 to 39	0.4 (0.0-1.2)	0.0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
40 to 59	0.1 (0.0-0.2)	0.0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
≥ 60	0.0 (0.0-0.0)	0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Unspecified	0.0 (0.0-0.0)	0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
All ages	0.8 (0.0-2.2)	0.0 (0.0-0.0)		0 (0-0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)

TABLE 2: continued

AGE GROUP (YEARS)	HIB	MUMPS	IMD	VARICELLA	IPD	PERTUSSIS	OVERALL
< 1	1.3 (0.8-1.9)	0.2 (0.0-0.5)	4.4 (2.8-7.2)	11.6 (8.2-14.5)	17.8 (14.2-20.7)	64.5 (39.3-120.0)	97.3 (76.0-148.3)
1 to 4	0.2 (0.1-0.3)	0.1 (0.0-0.2)	1.3 (0.9-2.2)	7.6 (6.3-9.1)	12.2 (9.8-15.5)	22.9 (9.7-44.0)	42.6 (29.0-62.7)
5 to 9	0.1 (0.0-0.1)	0.2 (0.0-0.3)	0.2 (0.1-0.4)	15.3 (6.3-26.1)	4.1 (3.4-5.2)	21.4 (6.0-43.5)	37.0 (22.2-52.0)
10 to 14	0.0 (0.0-0.1)	0.4 (0.1-1.0)	0.3 (0.1-0.7)	10.4 (4.1-15.9)	1.7 (1.1-2.5)	27.2 (5.5-62.3)	40.1 (19.9-68.1)
15 to 19	0.0 (0.0-0.1)	0.7 (0.1-1.3)	0.9 (0.7-1.2)	3.8 (1.9-5.8)	1.4 (0.8-1.7)	7.2 (1.7-13.9)	15.5 (8.6-18.3)
20 to 24	0.0 (0.0-0.0)	0.9 (0.1-2.8)	0.3 (0.2-0.5)	2.4 (1.8-3.7)	1.7 (1.4-2.5)	2.8 (0.8-5.3)	7.8 (5.7-8.4)
25 to 29	0.0 (0.0-0.1)	0.5 (0.1-1.8)	0.2 (0.1-0.3)	2.15 (1.76-2.42)	3.0 (2.5-4.0)	2.8 (0.6-5.8)	8.0 (6.1-11.6)
30 to 39	0.0 (0.0-0.1)	0.4 (0.1-1.1)	0.1 (0.1-0.1)	2.0 (1.6-2.4)	4.7 (4.2-5.3)	3.6 (1.0-7.3)	10.5 (8.2-13.7)
40 to 59	0.1 (0.0-0.1)	0.2 (0.1-0.5)	0.2 (0.2-0.3)	0.8 (0.6-1.1)	8.8 (8.3-9.2)	2.6 (0.5-4.7)	12.4 (10.8-14.8)
≥ 60	0.1 (0.0-0.2)	0.0 (0.0-0.1)	0.3 (0.2-0.5)	0.5 (0.3-1.0)	21.5 (20.4-22.8)	1.2 (0.2-2.5)	23.4 (21.8-25.9)
Unspecified	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.1 (0.0-0.3)	0.0 (0.0-0.0)	0.1 (0.0-0.3)
All ages	0.1 (0.1-0.1)	0.3 (0.1-0.8)	0.4 (0.3-0.5)	3.1 (1.9-3.7)	9.3 (8.9-9.8)	6.6 (2.0-13.4)	19.2 (14.9-24.9)

INTRODUCTION

Vaccines are one of the greatest achievements in public health and are considered to have saved more lives in the past 50 years in Canada than any other health intervention (1-3). While infectious diseases were the leading cause of death both in Canada and worldwide in the 1900s, they are now responsible for less than 5% of all deaths in Canada, thanks in part to publicly funded vaccination programs (1,4,5). Furthermore, Canada has contributed to the global eradication of smallpox as well as the elimination of endemically transmitted poliomyelitis (1994), measles (1998), rubella (2005) and congenital rubella syndrome/infection (CRS/CRI) (2000) in the Americas through strong public health initiatives, including surveillance activities and routine publicly-funded vaccination programs (4-6).

Despite these successes, VPDs remain a public health concern in Canada. While vaccination coverage rates are good, Canada has yet to meet any of the 2005 national vaccination coverage goals. Despite low rates of disease, VPDs still constitute a considerable health burden to the population, with infections causing a variety of serious complications such as pneumonia, meningitis, encephalitis, amputations, and death. Infections due to VPDs also have substantial economic and societal costs related to missed school and work days, health care provider visits, hospitalisation and rehabilitation (2,3). Finally, despite attaining elimination status for several VPDs, the risk of an importation and possible resurgence of any of the VPDs under elimination exists so long as these diseases continue to occur in countries outside of the Americas and vaccination coverage remains suboptimal.

In Canada, the prevention and control of VPDs is a shared responsibility. At the federal level, the Public Health Agency of Canada (PHAC) conducts surveillance of VPDs at the national level; provides leadership and coordination for the National Immunization Strategy; delivers public and professional education and outreach to promote vaccination acceptance and uptake; and ensures the security of vaccine supply. Recommendations for the use of vaccines in Canada are made by the National Advisory Committee on Immunization. Provinces and territories are responsible for vaccination program decisions and implementing programs that meet their goals, policies, and strategies in light of their specific epidemiologic and financial circumstances.

Objectives

This report provides a concise summary of the epidemiology of 12 nationally notifiable VPDs for which publicly-funded routine vaccination programs exist in all provinces and territories. This report is intended to serve the following purposes:

- Summarize the epidemiology of 12 VPDs and associated vaccination coverage in Canada.
- Provide a baseline against which progress in disease reduction can be measured.
- Support the Government of Canada's international commitments to report on disease elimination and eradication initiatives.
- Provide evidence to inform vaccination programs and policy.

FORMAT AND CONTENT

The 12 VPDs included in this report are grouped into categories according to their incidence levels in Canada as follows:

ELIMINATION	LOW-LEVEL INCIDENCE	MODERATE-LEVEL INCIDENCE
<p>VPDs that have domestic and international programs to reduce their disease-specific incidence to zero</p> <ul style="list-style-type: none"> • Measles • Rubella • CRS/CRI • Polio 	<p>VPDs that generally have an annual incidence rate of less than one case per 100,000 population</p> <ul style="list-style-type: none"> • Tetanus • Diphtheria • Invasive disease due to Hib • IMD • Mumps 	<p>VPDs that consistently have an annual incidence rate equal to or greater than one case per 100,000 population</p> <ul style="list-style-type: none"> • Varicella • IPD • Pertussis

VPDs such as zoster, rotavirus gastroenteritis, and human papillomavirus infection are not currently nationally notifiable and as such, are not included in this report. Information on the national epidemiology of influenza and hepatitis are covered in separate surveillance reports.

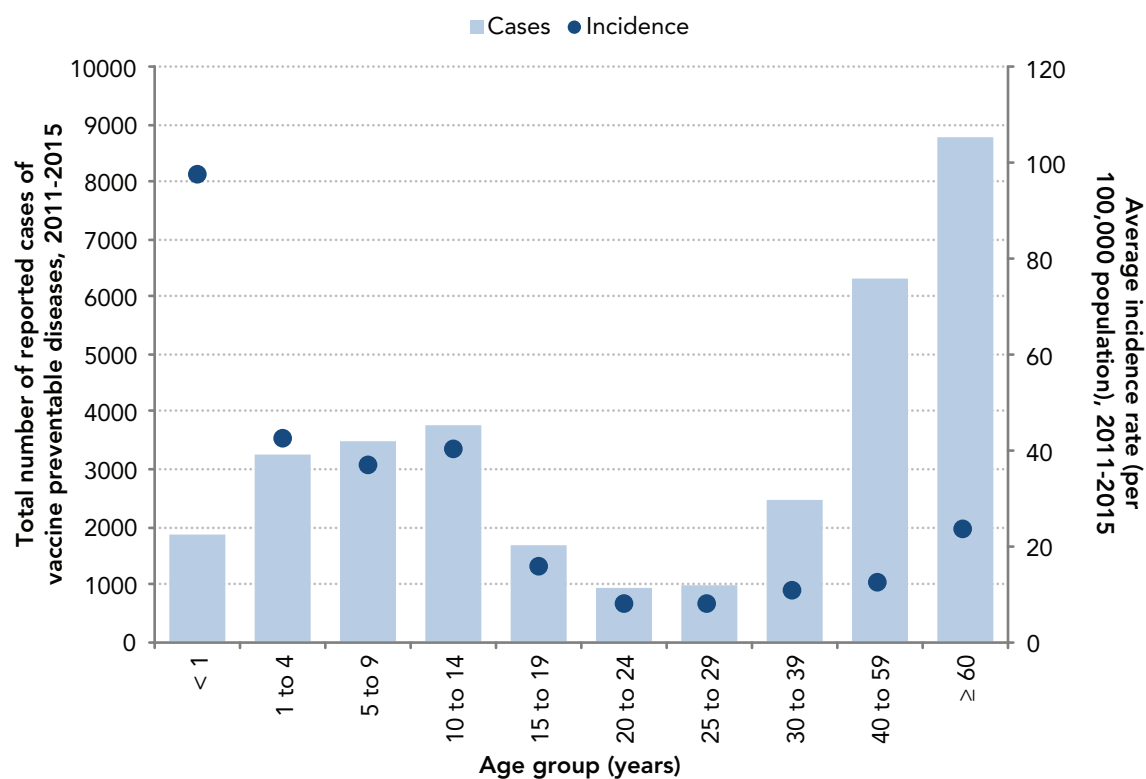
While this report presents an overview of VPDs in Canada, routine surveillance reports for many of the diseases included here are published on a regular basis and are referenced throughout this report. Readers interested in more detailed data are encouraged to consult these publications.

The epidemiology of VPDs contained in this report should be interpreted with an awareness of available vaccination programs, populations eligible for vaccination, rates of vaccine uptake by the population, and vaccine effectiveness. Details pertaining to specific vaccines can be found in the [Canadian Immunization Guide](#) and [National Advisory Committee on Immunization statements](#).

HOW ARE WE DOING?

National surveillance data indicate that from 2011 to 2015, an average of 6,733 VPD cases were reported annually (Table 1), representing an average annual crude incidence rate of 18.8 cases per 100,000 population (Table 2). The VPDs that accounted for the largest proportion of reported cases were IPD (48%) and pertussis (35%). Age groups most affected by VPDs included children less than one year of age (97.3 cases per 100,000 population), children one to four years of age (42.6 cases per 100,000 population), and children ten to fourteen years of age (40.1 cases per 100,000 population) (Figure 1). Case counts were highest among those aged 60 years and older (n=8,756 cases) and 40 to 59 year olds (n=6,301 cases). The most-affected age groups varied by disease, with some diseases having a greater incidence in the elderly (e.g. IPD) and others having a greater incidence in young children (e.g. pertussis).

FIGURE 1: Total number and overall incidence rate (per 100,000 population) of reported vaccine preventable disease⁴ cases in Canada by age group, 2011 to 2015 (n=33,666)



⁴ Vaccine preventable diseases included in this figure include measles, rubella, congenital rubella syndrome/infection, polio, diphtheria, tetanus, IMD, mumps, invasive disease due to Hib, pertussis, IPD, and varicella.

VACCINE PREVENTABLE DISEASES UNDER ELIMINATION IN CANADA

Measles

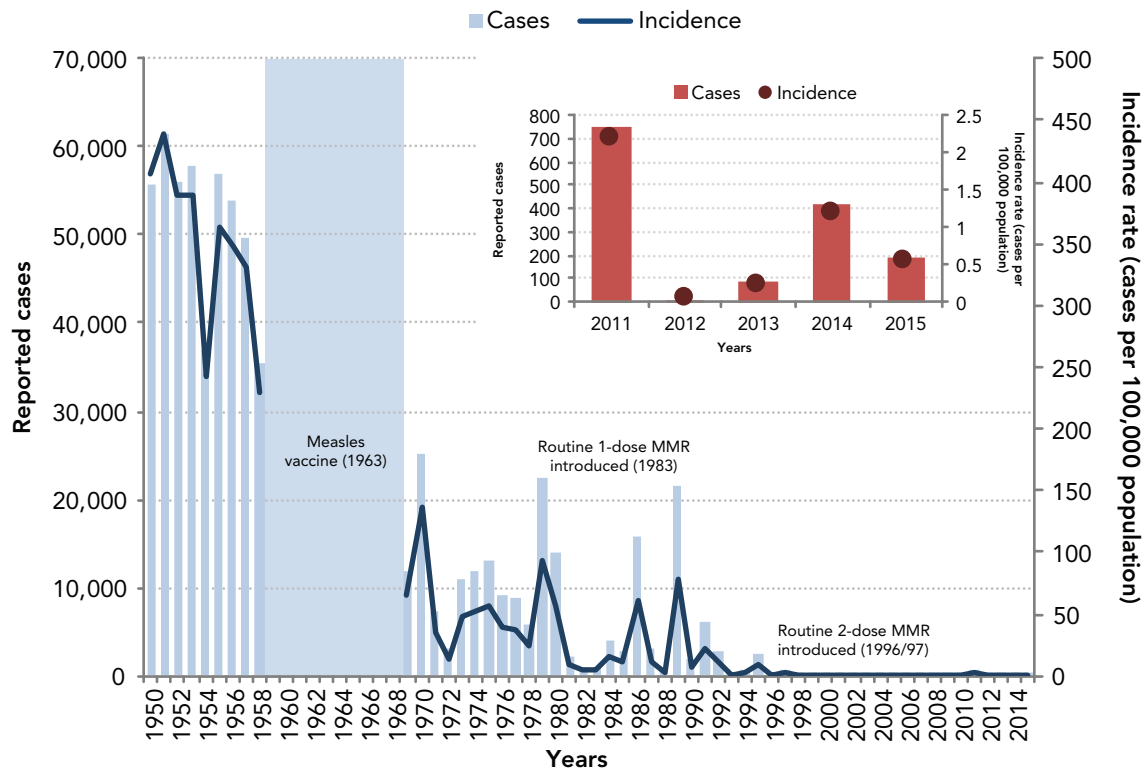
Key points:

- With routine vaccination, the incidence of measles in Canada has declined by over 99% from an average incidence rate of 373.3 cases per 100,000 population in the pre-vaccine era to 0.8 cases per 100,000 population from 2011 to 2015.
- Canada continues to maintain its measles elimination status; however, reported outbreaks of measles due to imported cases continue to occur, illustrating the need to remain vigilant until measles is eradicated worldwide.
- Vaccination rates should be improved. Based on the 2015 cNICS, 89% of children in Canada had received the recommended dose of measles-containing vaccine by two years of age and 86% had received the recommended doses by seven years of age.

A measles-containing vaccine was made available in Canada in 1963 and routine vaccination programs were in place in all provinces and territories by 1970 (7,8). In 1996/97 all provinces and territories added a second dose of measles-containing vaccine to their routine schedules (9). Before measles-containing vaccine became available, many thousands of measles cases were reported annually, and outbreaks occurred in two to five year cycles. With routine vaccination, the incidence of measles has declined by over 99% from an average incidence rate of 373.3 cases per 100,000 population in the pre-vaccine era (1950 to 1954)⁵ to 0.8 cases per 100,000 population from 2011 to 2015 (Figure 2). Nonetheless, imported cases continue to occur, resulting in secondary spread.

⁵ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For measles, this was 1950 to 1954. The measles live vaccine was authorized in Canada in 1963 and all provinces and territories had a measles vaccine program by 1983. Measles was taken off the notifiable disease list from 1959 to 1968 with decreased physician reporting in the years leading up to 1959, thus 1954 was chosen as the last year with reliable data that could be used in comparisons.

FIGURE 2: Number and incidence rate (per 100,000 population) of reported measles cases in Canada by year, 1950 to 2015⁶



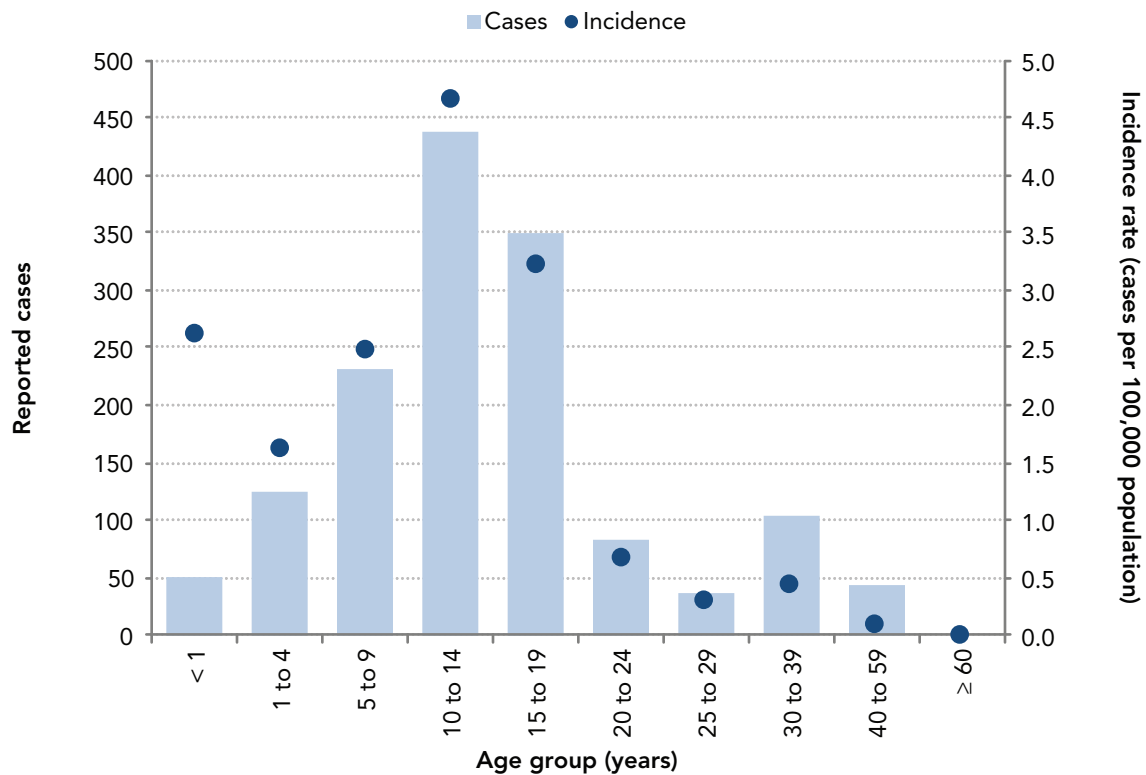
Epidemiology between 2011 and 2015

From 2011 to 2015, a total of 1,459 measles cases were reported in Canada. The annual number of reported cases ranged from ten to 752, with a median of 196 cases. Of these cases, 82 were imported into Canada and an additional 174 cases were of unknown source of infection. Annual incidence rates ranged from 0.03 to 2.2 cases per 100,000 population (Figure 2). Cases were reported in every age group except among those aged 60 years or older. The most-affected age group varied from year to year depending on the outbreak context, but for the time period as a whole, the highest incidence rates were reported in ten to 14 year olds (4.7 cases per 100,000 population), followed by 15 to 19 year olds (3.2 cases per 100,000 population), and infants less than one year old (2.6 cases per 100,000 population, Figure 3). Cases were relatively evenly distributed across the sexes.

In 2015, 196 measles cases were reported (9 imported cases and an additional 14 with an unknown source of infection). The incidence rate was 0.6 cases per 100,000 population. Both age-specific incidence rates and case counts were highest among ten to 14 year olds (3.0 cases per 100,000 population, 55 cases).

⁶ Measles was removed from the list of national notifiable diseases for the years 1959 to 1968(30).

FIGURE 3: Total number and overall incidence rate (per 100,000 population) of reported measles cases in Canada by age group, 2011 to 2015 (n=1,459)



Measles vaccination coverage

Based on the 2015 cNICS, only 89% of children in Canada had received the recommended doses of measles-containing vaccine by two years of age and 86% had received the recommended doses by seven years of age (10).

Further reading

- [PHAC measles webpage](#)
- [Canadian Immunization Guide measles vaccine chapter](#)
- [National Advisory Committee on Immunization measles vaccine guidance](#)
- [Measles annual reports: 2015, 2014, 2013](#)
- [Measles weekly reports](#)

Rubella

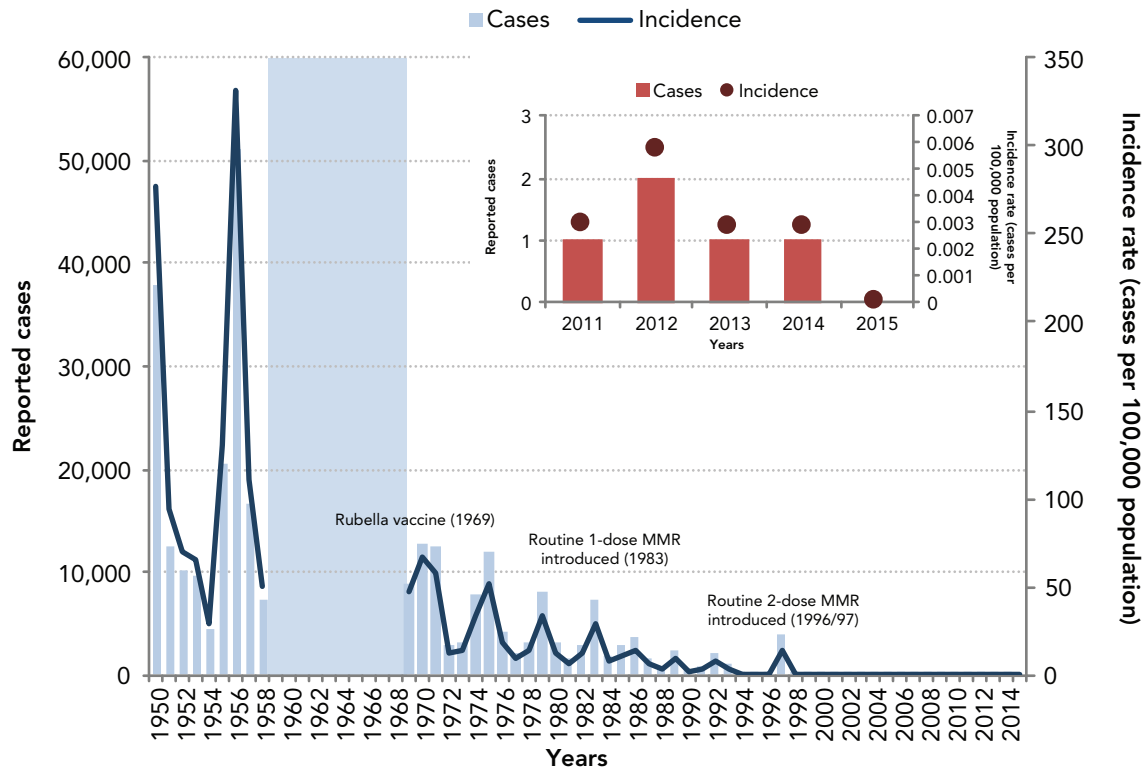
Key points:

- With routine vaccination, the incidence of rubella in Canada has declined by over 99% from an average incidence rate of 107.2 cases per 100,000 population in the pre-vaccine era to less than 0.01 cases per 100,000 population from 2011 to 2015.
- While no cases of rubella were reported in 2015, imported cases leading to secondary transmission did occur in 2012, indicating a need for ongoing vigilance until rubella is eradicated worldwide.
- Vaccination rates should be improved. Based on the 2015 cNICS, 89% of children in Canada received the recommended dose of rubella-containing vaccine by two years of age and 94% had received the recommended doses by seven years of age.

A rubella-containing vaccine was made available in Canada in 1969 and routine vaccination programs were in place across all provinces and territories by 1983 (9,11). Before rubella-containing vaccine became available, many thousands of rubella cases were reported annually and outbreaks occurred in three to six year cycles. With routine vaccination, the incidence of rubella has declined by over 99% from an average incidence rate of 107.2 cases per 100,000 population in the pre-vaccine era (1950 to 1954)⁷ to less than 0.01 cases per 100,000 population from 2011 to 2015 (Figure 4). While imported cases continue to occur, secondary spread tends to be extremely limited, involving Canadians who are still vulnerable due to inadequate vaccination. Ongoing vigilance is required as a result.

⁷ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For rubella, this was 1950 to 1954. The rubella vaccine was authorized in Canada in 1969 and all provinces and territories had a rubella vaccine program by 1983. Rubella was taken off the notifiable disease list from 1959 to 1968 with decreased physician reporting in the years leading up to 1959, thus 1954 was chosen as the last year with reliable data that could be used in comparisons.

FIGURE 4: Number and incidence rate (per 100,000 population) of reported rubella cases in Canada by year, 1950 to 2015⁸



Epidemiology between 2011 and 2015

As rubella has been eliminated in Canada, disease activity generally results from infrequent imported cases. From 2011 to 2015 a total of five rubella cases were reported, ranging between zero and two cases annually (Figure 4). Annual incidence rates were less than 0.01 cases per 100,000 population across this time period. Four cases were imported and one case had an unknown source of exposure. All cases were adults 20 to 59 years of age. No cases of rubella were reported in Canada in 2015.

Rubella vaccination coverage

Based on the 2015 cNICS, 89% of children in Canada received the recommended one dose of rubella-containing vaccine by two years of age and 94% had received the recommended doses by seven years of age (10). In recent seroprevalence studies of cohorts of pregnant women in Canada, the percentage of study participants immune to rubella ranged from 84% to 92% (12-14).

⁸ Rubella was removed from the list of national notifiable diseases for the years 1959 to 1968(30).

Further reading

- PHAC rubella and CRS webpage
- Canadian Immunization Guide rubella vaccine chapter
- National Advisory Committee on Immunization rubella vaccine guidance
- Rubella weekly reports

Congenital rubella syndrome and congenital rubella infection

Key points:

- With routine vaccination, the incidence of CRS/CRI in Canada has declined by 97% from an average incidence rate of 3.0 cases per 100,000 live births in the pre-vaccine era to 0.10 cases per 100,000 live births from 2011 to 2015.
- There have been no reported cases of CRS/CRI due to a rubella exposure in Canada since 2000.

While symptoms from a rubella infection can sometimes be considered relatively mild, infection during pregnancy can result in CRS/CRI, miscarriage, or stillbirth. Babies with CRS/CRI can suffer from major birth defects, as well as other lifelong mental and physical disabilities. With routine rubella vaccination, CRS/CRI has declined by 97%. The average incidence rate of CRS/CRI decreased from 3.0 cases per 100,000 live births in the pre-vaccine era (1950 to 1954)⁹ to 0.10 cases per 100,000 live births from 2011 to 2015.

Epidemiology between 2011 and 2015

From 2011 to 2015, two cases of CRS/CRI were reported in Canada: one in 2011 and one in 2015, resulting in an incidence rate of 0.3 cases per 100,000 live births for each of those years. Both cases resulted from maternal exposure to rubella outside of Canada; there have been no reported cases of CRS/CRI due to rubella exposure within Canada since 2000.

Rubella vaccination coverage

Congenital rubella syndrome/infection is prevented by ensuring that women of childbearing age are vaccinated against rubella. Currently, no vaccine coverage estimates are available for this group. In recent seroprevalence studies of cohorts of pregnant women in Canada, the percentage of study participants immune to rubella ranged from 84% to 92% (12-14).

Further reading

- PHAC rubella and CRS webpage
- Canadian Immunization Guide rubella vaccine chapter
- National Advisory Committee on Immunization rubella and CRS guidance

⁹ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For rubella, this was 1950 to 1954. The rubella vaccine was authorized in Canada in 1969 and all provinces and territories had a rubella vaccine program by 1983. Rubella was taken off the notifiable disease list from 1959 to 1968 with decreased physician reporting in the years leading up to 1959, thus 1954 was chosen as the last year with reliable data that could be used in comparisons.

Polio and acute flaccid paralysis

Key points:

- With routine vaccination, endemic polio has been eliminated in Canada. Incidence has declined from an average incidence rate of 17.5 cases per 100,000 population in the pre-vaccine era to zero cases reported from 2011 to 2015.
- Until polio eradication has been achieved globally, active surveillance of acute flaccid paralysis (AFP) remains critical given the continued risk of polio importation.
- Vaccination rates should be improved. Based on the 2015 cNICS, 91% of children in Canada had received the recommended doses of polio-containing vaccine by two years of age.

The incidence of polio in Canada was dramatically reduced with the introduction of vaccination programs across Canada in the 1950s (15). The average incidence rate of polio decreased from 17.5 cases per 100,000 population in the pre-vaccine era (1950 to 1954)¹⁰ to zero from 2011 to 2015. Despite the elimination of endemic wild poliovirus transmission in Canada, the risk of polio importation remains until polio eradication has been achieved globally. As recommended by the WHO, Canada conducts AFP surveillance in children and youth less than 15 years of age to monitor for polio.

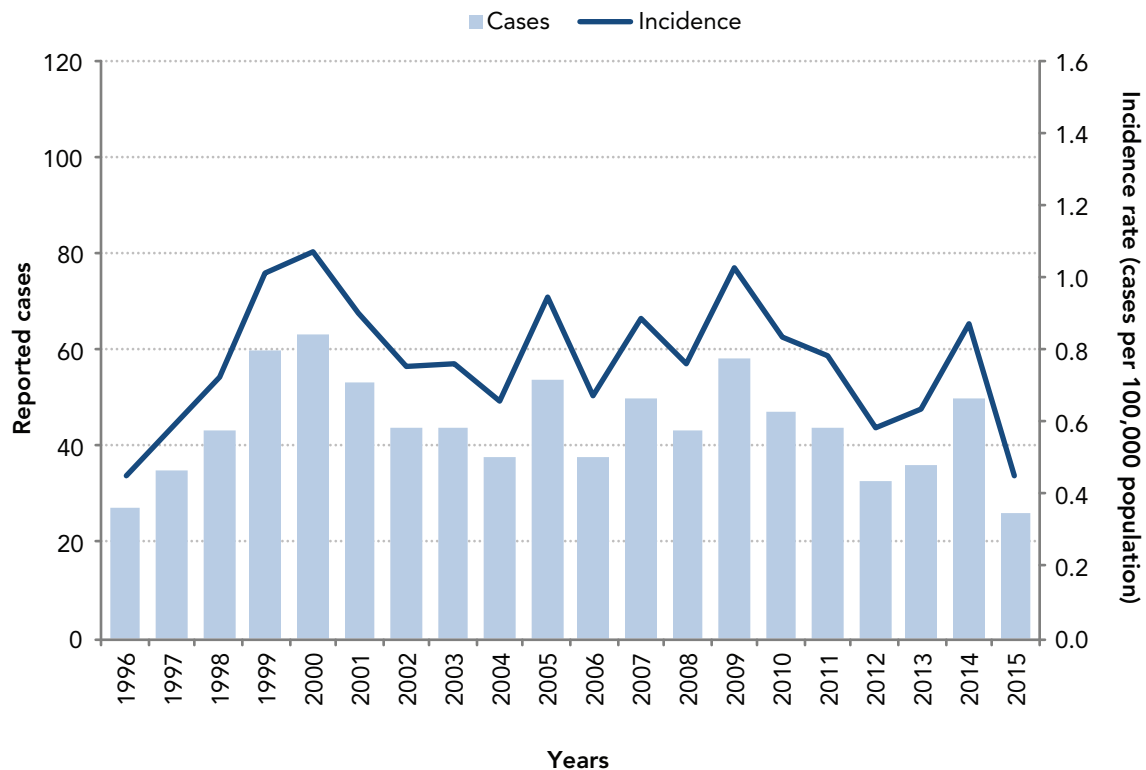
AFP epidemiology between 2011 and 2015

From 2011 to 2015, a total of 189 AFP cases were reported in Canada in individuals less than 15 years of age. The annual number of reported cases ranged from 26 to 50, with a median of 36 cases per year. Annual incidence rates ranged from 0.5 to 0.9 cases per 100,000 in the under 15 population (Figure 5). Distribution varied by year across the sexes, with males accounting for 51% of cases overall, ranging from 33% to 65% annually. All cases were adjudicated against the polio case definition, and none were assessed to be polio. The majority of reported cases were diagnosed with either Guillain-Barré syndrome (64%) or transverse myelitis (15%).

In 2015, 26 AFP cases were reported in Canada in individuals less than 15 years old, for an incidence rate of 0.5 cases per 100,000 population. All cases were adjudicated against the polio case definition, and none were assessed to be polio. The cases ranged in age from less than one to 14 years old with a mean of 7.8 years and a median of 8.6 years.

¹⁰ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For polio, this was 1950 to 1954 as the inactivated polio vaccine was authorized in Canada in 1955.

FIGURE 5: Number and incidence rate (per 100,000 population) of reported acute flaccid paralysis cases in Canada by year, 1996 to 2015¹¹



Polio vaccination coverage

Based on the 2015 cNICS, 91% of children in Canada had received the recommended doses of polio-containing vaccine by two years of age (10).

Further reading

- PHAC polio website
- Canadian Immunization Guide polio vaccine chapter
- National Advisory Committee on Immunization polio guidance
- Annual CPSP report: AFP in Canada
- The polio eradication endgame: Why immunization and continued surveillance is critical

¹¹ AFP has been nationally notifiable in Canada since 1996.

VACCINE PREVENTABLE DISEASES WITH LOW LEVEL INCIDENCE IN CANADA

Diphtheria

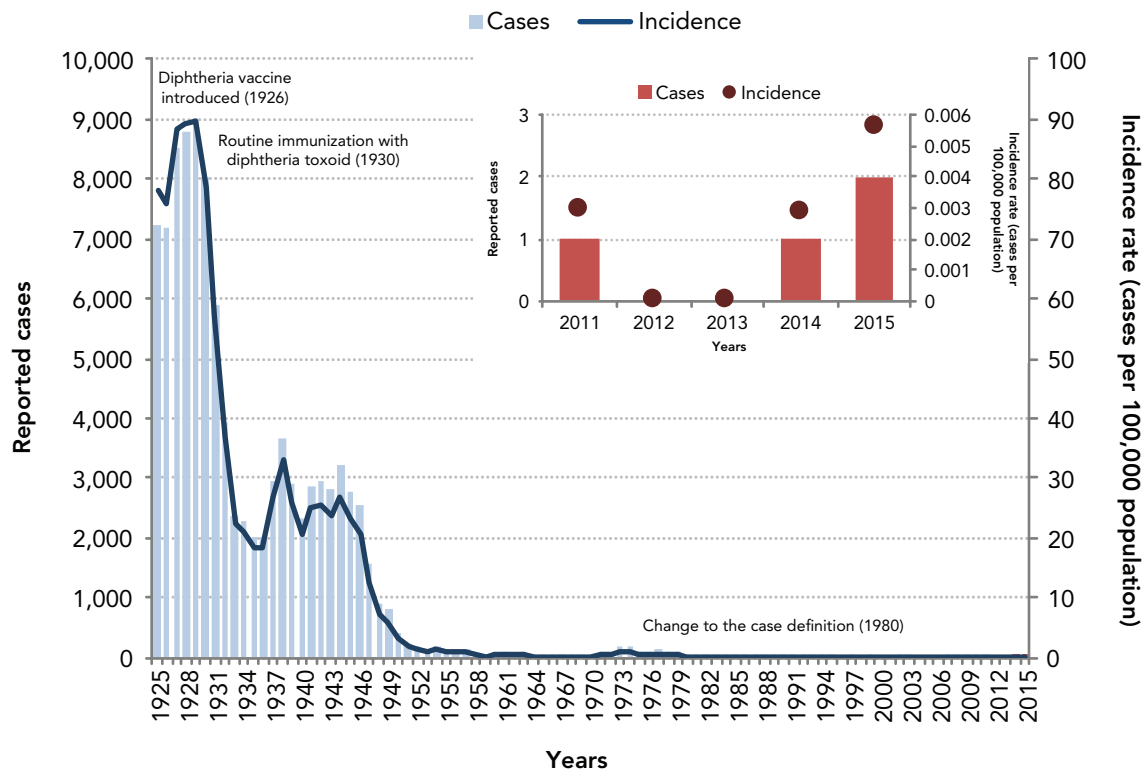
Key points:

- Routine vaccination has had a profound effect in reducing the incidence of diphtheria in Canada. The average incidence rate has declined by over 99% from 84.2 cases per 100,000 population in the pre-vaccine era to an average incidence rate of less than 0.01 cases per 100,000 population from 2011 to 2015.
- Despite the success of vaccination in reducing diphtheria disease burden, vaccination coverage rates remain low. Based on the 2015 cNICS, only 77% of children in Canada had received the recommended doses of diphtheria-containing vaccine by two years of age and 75% had received the recommended doses by seven years of age.

Previously, diphtheria was one of the most common causes of death in children under five years of age (16,17). The diphtheria vaccine was introduced in 1926, and since 1930 routine vaccination in infancy and childhood has been widely provided in Canada (9,18). With routine vaccination, the incidence of diphtheria has declined by over 99% from an average incidence rate of 84.2 cases per 100,000 population in the pre-vaccine era (1925 to 1929)¹² to less than 0.01 cases per 100,000 population from 2011 to 2015 (Figure 6).

¹² The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For diphtheria, this was 1925 to 1929. Although the diphtheria toxoid was introduced in 1926, routine immunization began in 1930.

FIGURE 6: Number and incidence rate (per 100,000 population) of reported diphtheria cases in Canada by year, 1925 to 2015



Epidemiology between 2011 and 2015

From 2011 to 2015, a total of four diphtheria cases were reported in Canada; of these, two were reported in 2015 (Figure 6). Accordingly, the overall incidence rate during this time period was less than 0.01 cases per 100,000 population. Of the two cases reported in 2015, one was a child and the other was an adult.

Diphtheria vaccination coverage

Based on the 2015 cNICS, 77% of children in Canada had received the recommended doses of diphtheria-containing vaccine by two years of age and 75% had received the recommended doses by seven years of age (10).

Further reading:

- PHAC diphtheria website
- Canadian Immunization Guide diphtheria vaccine chapter
- National Advisory Committee on Immunization diphtheria vaccine guidance
- National goals and objectives for the control of vaccine-preventable diseases of infants and children

Tetanus

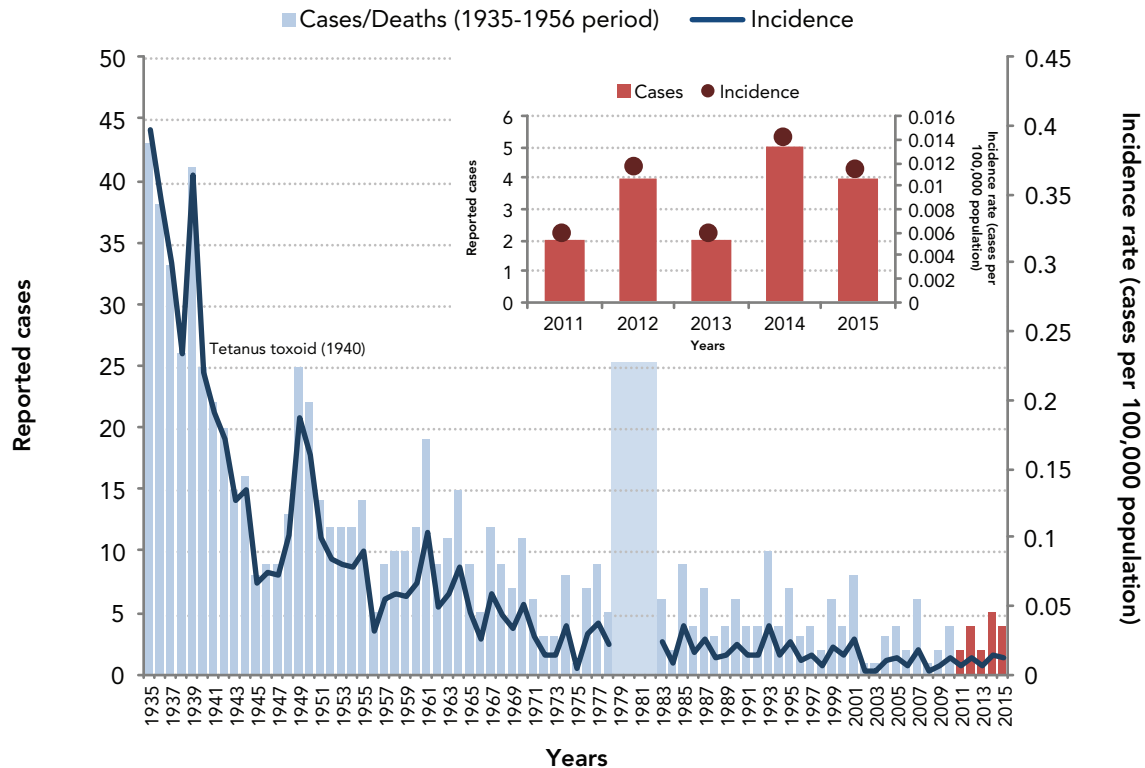
Key points:

- With routine vaccination, the incidence of tetanus declined by 95% from an average incidence rate of 0.21 cases per 100,000 population in the pre-vaccine era to less than 0.01 cases per 100,000 population from 2011 to 2015.
- Vaccination rates should be improved. Based on the 2015 cNICS, 77% of children in Canada had received the recommended doses of tetanus-containing vaccine by two years of age and 75% had received the recommended doses by seven years of age. Based on the 2014 aNICS, only 53% of respondents had received a tetanus-containing vaccine as an adult.

Unlike other VPDs, tetanus is not transmitted from person to person and while cases have always been relatively rare in Canada, they are generally severe. As tetanus is not communicable, vaccination programs were introduced with a focus on individual protection instead of herd immunity and all provinces and territories had routine tetanus vaccination programs by the 1940s (9). With routine vaccination, the incidence of tetanus has declined by 95% from an average incidence rate of 0.2 cases per 100,000 population in the pre-vaccine era (1935 to 1939)¹³ to less than 0.01 cases per 100,000 population from 2011 to 2015 (Figure 7).

¹³ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For tetanus, this was 1935 to 1939. Tetanus toxoid was introduced in Canada in 1940 but national reporting began in 1957. Thus reported tetanus deaths were used instead of cases for the years preceding vaccine introduction.

FIGURE 7: Number and incidence rate (per 100,000 population) of reported tetanus cases¹⁴ in Canada by year, 1935 to 2015¹⁵



Epidemiology between 2011 and 2015

From 2011 to 2015, a total of 17 cases of tetanus were reported in Canada (Figure 12). The annual number of reported cases ranged from two to five, with a median for four. The overall incidence rate during this time period was less than 0.01 cases per 100,000 population. No cases were reported in infants less than one year of age. Three cases (18%) were reported among children one to 14 years old and 14 cases were reported among adults 20 year olds and older.

Only four tetanus cases were reported in 2015. Among these cases, one was a child and the remaining three were adults.

¹⁴ Tetanus was added to the list of nationally notifiable diseases in 1957. Reported tetanus deaths were used instead of cases for the years 1935 to 1956.

¹⁵ Tetanus was removed from the list of national notifiable diseases for the years 1979 to 1982 (30).

Tetanus vaccination coverage

Based on the 2015 cNICS, only 76% of children in Canada had received the recommended four doses of tetanus-containing vaccine by two years of age and only 75% had received the recommended five doses by seven years of age (10). Based on the 2014 aNICS, only 53% of Canadians had received a tetanus-containing vaccine as an adult (10).

Further reading

- [PHAC tetanus webpage](#)
- [Canadian Immunization Guide tetanus vaccine chapter](#)
- [National Advisory Committee on Immunization tetanus vaccine guidance](#)

Invasive disease due to *Haemophilus influenzae* serotype b

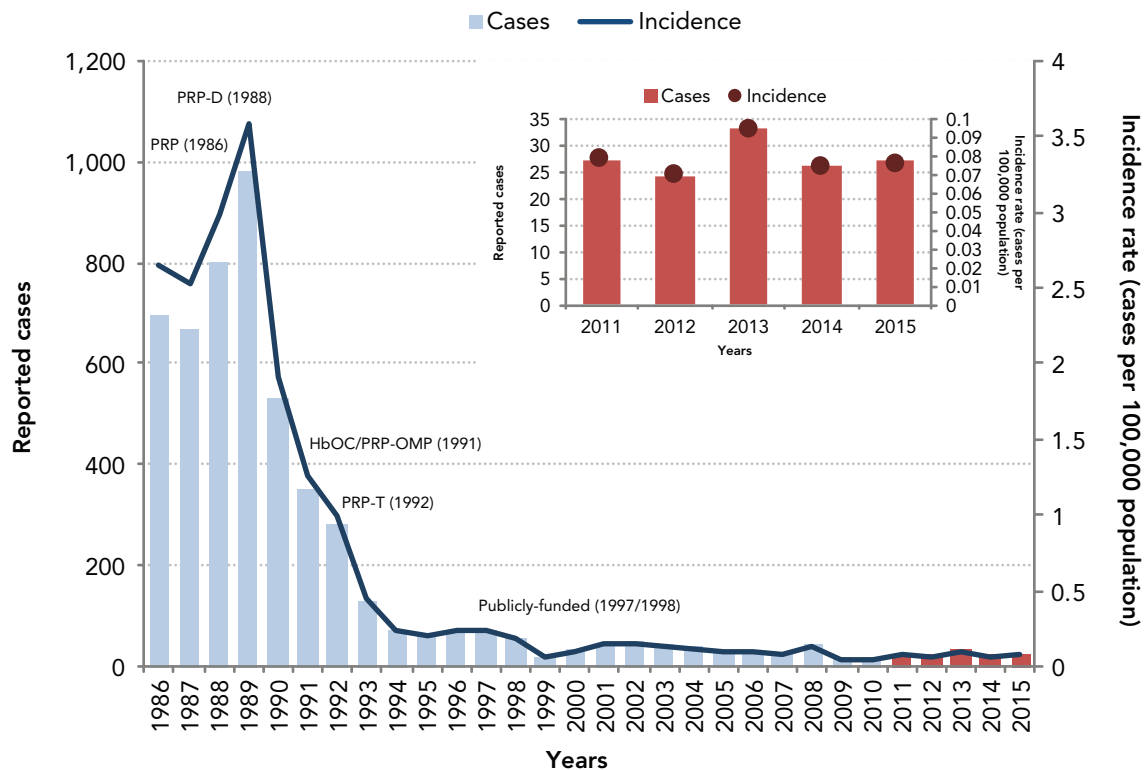
Key points:

- With routine vaccination, the incidence of invasive disease due to Hib has declined by 99% in children less than five years of age, decreasing from an average incidence rate of 34.6 cases per 100,000 population in the pre-vaccine era to 0.5 cases per 100,000 population from 2011 to 2015.
- Nonetheless, vaccine coverage remains low, particularly among infants. Based on the 2015 cNICS, only 72% of children in Canada had received the recommended doses of Hib-containing vaccine by two years of age and 77% had received the recommended doses by seven years of age

Prior to the introduction of the Hib vaccine into provincial and territorial routine childhood vaccination schedules in 1988, Hib was the most common cause of bacterial meningitis in Canada (9), particularly among infants. With routine vaccination, the incidence of invasive disease due to Hib has declined by 99% in children less than five years of age, from 34.6 cases per 100,000 population in the pre-vaccine era (1986 to 1987)¹⁶ to 0.5 cases per 100,000 population from 2011 to 2015. In the general population, it has declined by 97% from 2.6 cases per 100,000 population in the pre-vaccine era (1986 to 1987) to 0.08 cases per 100,000 population from 2011 to 2015 (Figure 8).

¹⁶ The pre-vaccine era used for invasive disease due to Hib was 1986 to 1987. Although Hib vaccines were first introduced in 1986 and the Hib conjugate vaccine was introduced in 1992, national notifiable disease reporting of invasive Hib disease only began in 1986.

FIGURE 8: Number and incidence rate (per 100,000 population) of reported cases of invasive disease due to Hib in Canada by year, 1986 to 2015



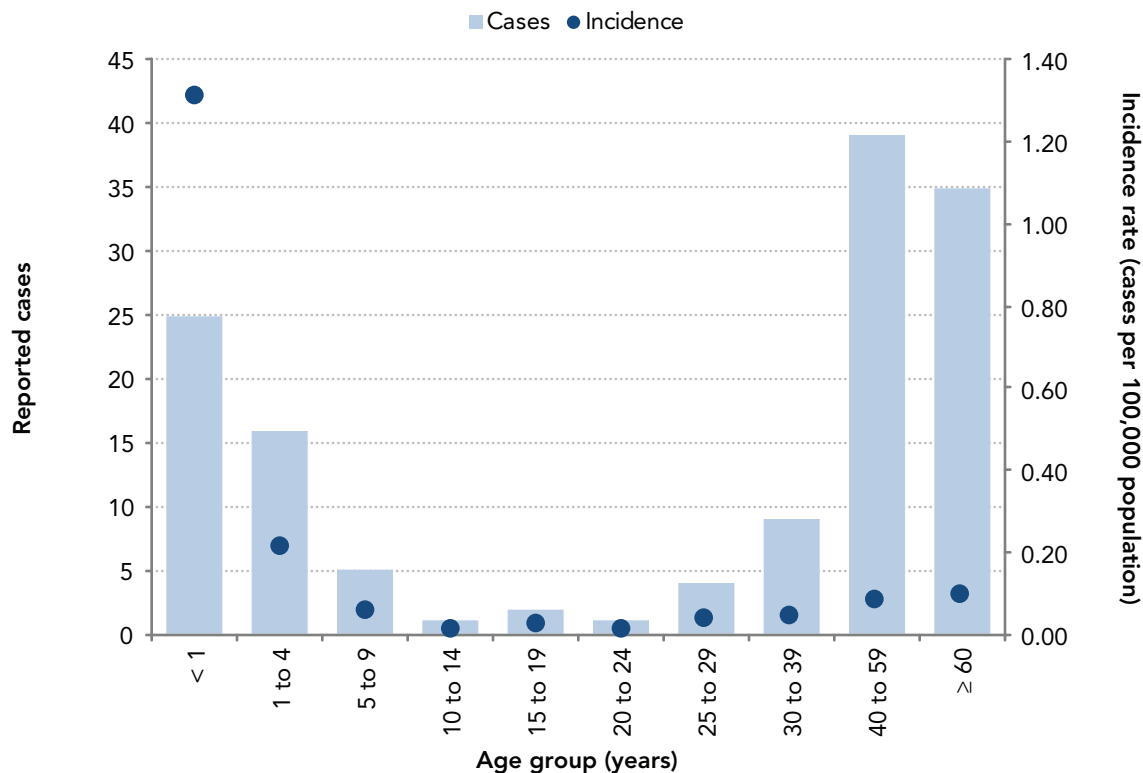
Epidemiology between 2011 and 2015

From 2011 to 2015, a total of 137 cases of invasive Hib were reported in Canada. The annual number of reported cases ranged from 24 to 33, with a median of 27 cases reported per year. Annual incidence rates ranged from 0.07 to 0.09 cases per 100,000 population (Figure 8). Cases were reported in every age group. For the time period as a whole, the highest overall incidence rate was reported among infants less than one year old (1.3 cases per 100,000 population), and one to four year olds (0.2 cases per 100,000 population) (Figure 9). The lowest overall incidence rate was reported among 20 to 24 year olds (0.01 cases per 100,000 population). Males accounted for 61% of cases overall (range: 50% to 67%). Based on data obtained through IMPACT, four cases of preventable¹⁷ Hib were reported among children less than five years of age between 2011 and 2015.

In 2015, 27 cases of invasive disease due to Hib cases were reported, with a corresponding incidence rate of 0.08 cases per 100,000 population. Incidence rates were highest among infants less than one year old (0.8 cases per 100,000 population) and one to four year olds (0.3 cases per 100,000 population).

¹⁷ A Hib case is considered preventable if it occurs in an infant who was age-eligible to have completed the primary Hib vaccination schedule (3 doses) but who was unvaccinated or under-vaccinated for age. Vaccine failures are not considered preventable.

FIGURE 9: Total number and overall incidence rate (per 100,000 population) of reported cases of invasive disease due to *Haemophilus influenzae* serotype b in Canada by age group, 2011 to 2015 (n=137)



Haemophilus influenzae type b vaccination coverage

Based on the 2015 cNICS, only 72% of children in Canada had received the recommended doses of Hib-containing vaccine by two years of age and 77% had received the recommended doses by seven years of age (10).

Further reading

- PHAC invasive *Haemophilus influenzae* type b disease webpage
- Canadian Immunization Guide *Haemophilus influenzae* type b vaccine chapter
- National Advisory Committee on Immunization *Haemophilus influenzae* type b vaccine guidance
- The epidemiology of invasive disease due to *Haemophilus influenzae* serotype a in the Canadian North from 2000 to 2010 (2013)

Invasive meningococcal disease

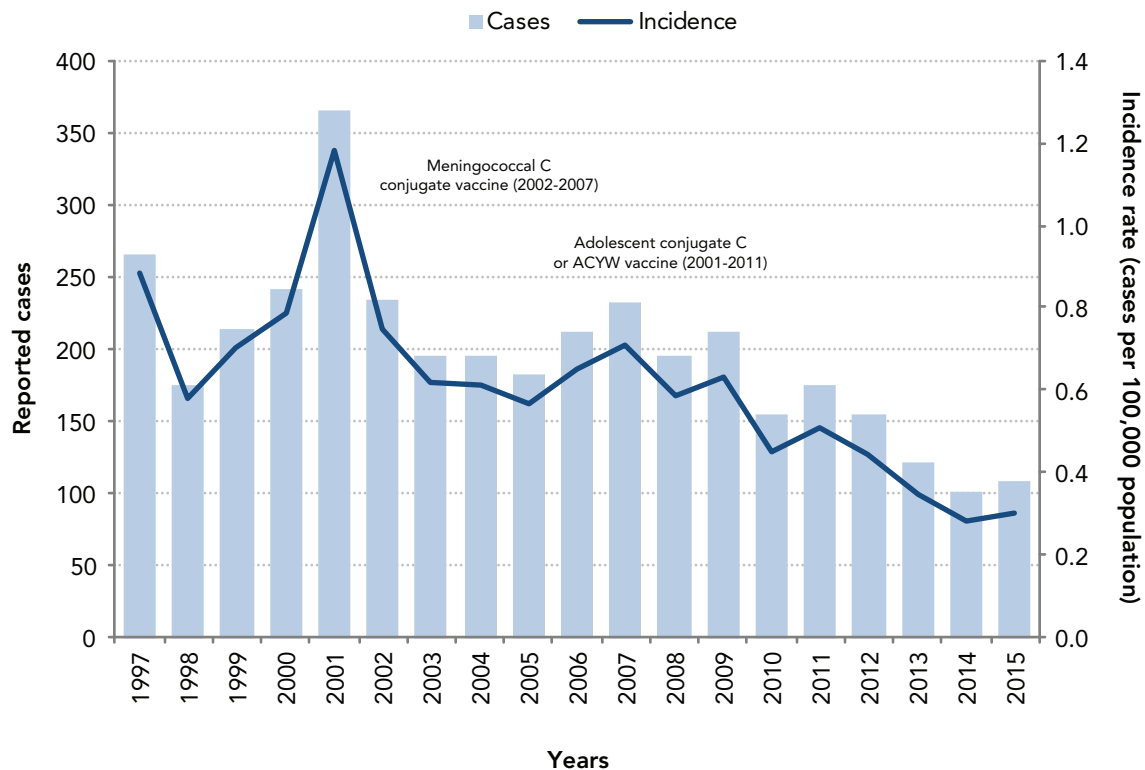
Key points:

- With routine vaccination, the incidence of IMD due to serogroup C in Canada has declined by 93% from an average incidence of 0.30 cases per 100,000 population in the pre-vaccine era to 0.02 cases per 100,000 population from 2011 to 2015. Overall IMD incidence has declined by 55% from an average incidence rate of 0.8 cases per 100,000 population in the pre-vaccine era to 0.4 cases per 100,000 population from 2011 to 2015.
- Serogroup B now accounts for the majority of reported IMD cases in Canada at 63% compared to only 6% for serogroup C. While vaccines targeting IMD serogroup B are not currently part of routine vaccination programs in Canada, meningococcal B vaccines have been used during outbreaks.
- Vaccination rates should be improved. Based on the 2015 cNICS, 88% of children in Canada had received the recommended dose of meningococcal C vaccine by two years of age.

Between 2002 and 2007, a variety of routine childhood and adolescent meningococcal vaccination programs using monovalent (targeting serogroup C) and quadrivalent (targeting serogroups A, C, W, and Y) conjugate vaccines were implemented in Canadian provinces and territories (19). With routine vaccination, the incidence of IMD serogroup C has declined by 93%, from an average incidence rate of 0.3 cases per 100,000 population in the pre-vaccine era (1997 to 2001)¹⁸ to 0.02 cases per 100,000 population from 2011 to 2015. The incidence of IMD overall has also decreased greatly (55%) from an average incidence rate of 0.8 cases per 100,000 population in the pre-vaccine era to 0.4 cases per 100,000 population from 2011 to 2015 (Figure 10). Although vaccines targeting IMD serogroup B are not currently part of routine vaccination programs in Canada, meningococcal B vaccines have been used during outbreaks.

¹⁸ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For IMD, this was 1997 to 2001, as the meningococcal C conjugate vaccine was introduced in all provinces and territories between 2002 and 2006.

FIGURE 10: Number and incidence rate (per 100,000 population) of reported invasive meningococcal disease cases¹⁹ in Canada by year, 1997 to 2015

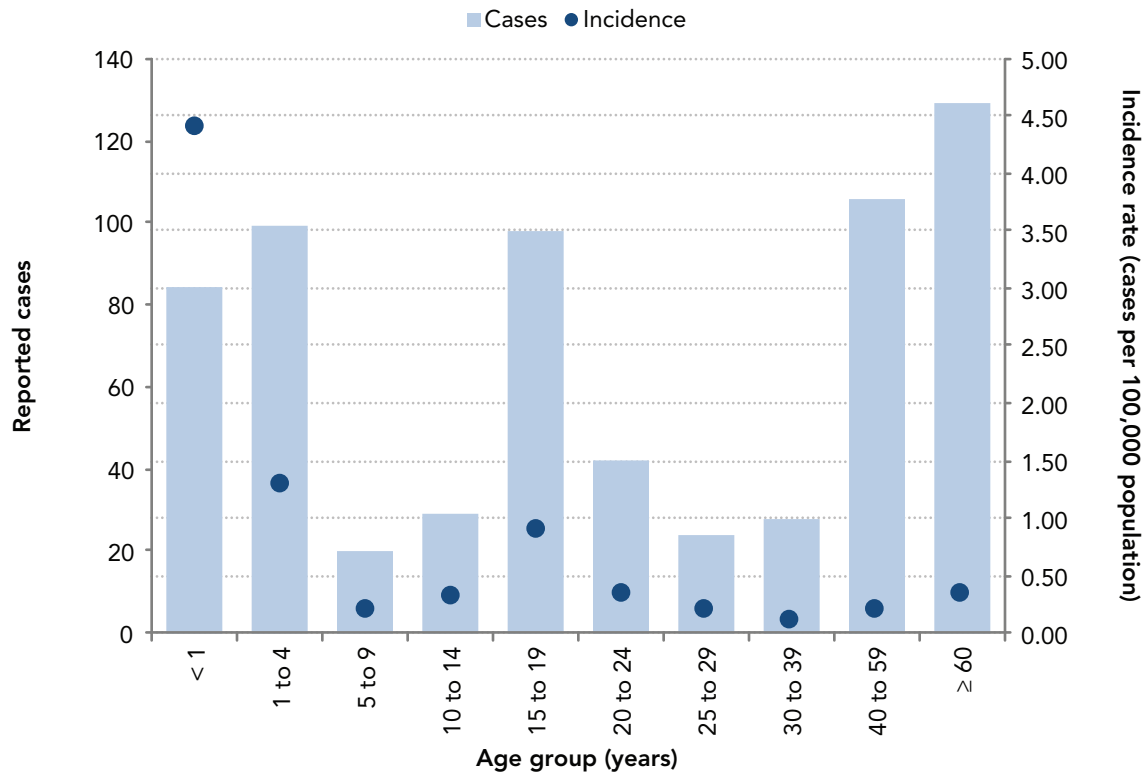


Epidemiology between 2011 and 2015

From 2011 to 2015, a total of 659 IMD cases were reported in Canada. The annual number of reported cases ranged from 101 to 175, with a median of 121 cases reported per year. Annual incidence rates ranged from 0.3 to 0.5 cases per 100,000 population (Figure 10). Though cases were reported in every age group, the highest incidence rate occurred in infants less than one year of age at 4.4 cases per 100,000 population. The lowest overall incidence rate was reported among 30 to 39 year olds (0.1 cases per 100,000 population). Cases were relatively evenly distributed across the sexes. During this time, 75 deaths associated IMD were reported to the eIMDSS, for a case-fatality rate of 11%.

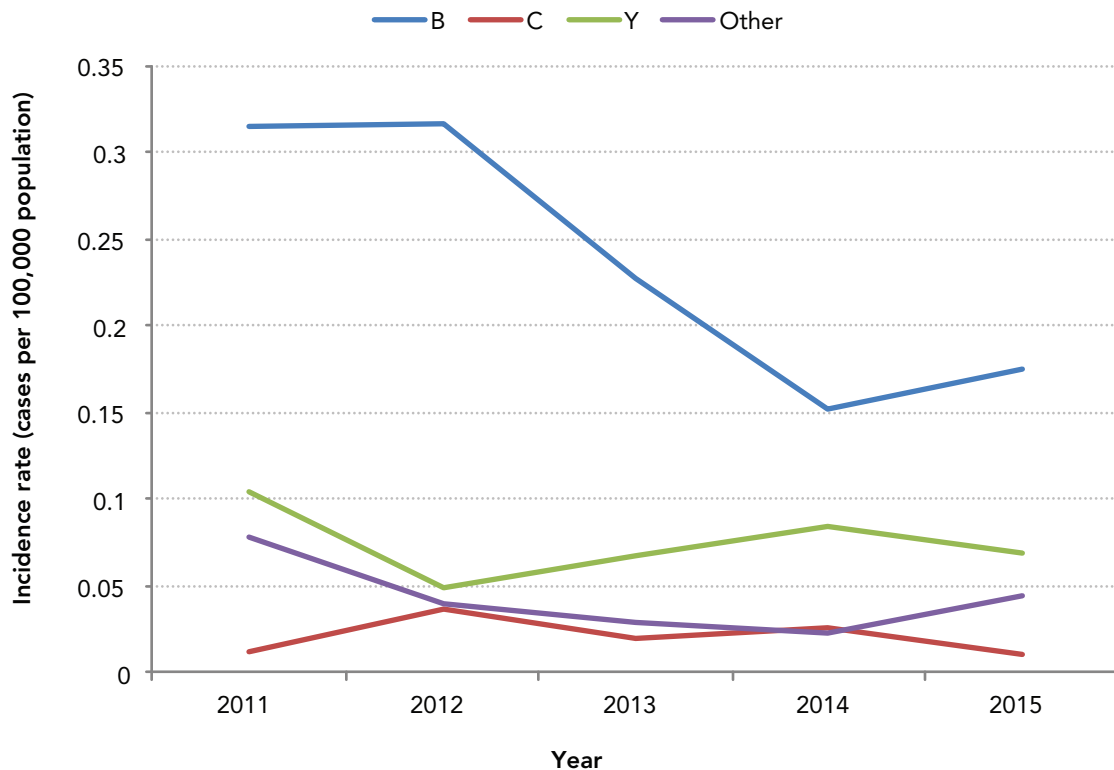
¹⁹ The IMD case definition has undergone numerous revisions. Between 1997 and 1999, both confirmed and clinical cases were reportable. On January 1st, 2000, only confirmed cases were nationally reportable. Both confirmed and probable cases were nationally reportable as of January 1st, 2006.

FIGURE 11: Total reported cases and overall incidence rate (per 100,000 population) of invasive meningococcal disease in Canada by age group, 2011 to 2015 (n=659)



Compared to other serogroups, IMD serogroup B had the highest annual incidence rates ranging from 0.2 to 0.3 cases per 100,000 population (54 to 110 cases) and accounted for 63% of cases. Disease caused by serogroup C remained rare, accounting for only 6% of cases. Annual incidence rates ranging between 0.01 and 0.04 cases per 100,000 population (four to 13 cases). Disease caused by serogroup Y had annual incidence rates ranging between 0.05 and 0.1 cases per 100,000 population (17 to 36 cases) and accounted for 20% of cases (Figure 12).

FIGURE 12: Incidence rate (per 100,000 population) of invasive meningococcal disease in Canada by year and serogroup²⁰, 2011 to 2015 (n=659)



In 2015, 108 IMD cases were reported, with a corresponding incidence rate of 0.30 cases per 100,000 population. Incidence rates were highest among infants less than one year of age (2.83 cases per 100,000 population), one to four year olds (0.90 cases per 100,000 population), and 15 to 19 year olds (0.67 cases per 100,000 population). Serogroup B accounted for the majority of the cases (58%), followed by serogroup Y (23%). Serogroup C accounted for only 4% of cases.

Invasive meningococcal disease vaccination coverage

Based on the 2013 cNICS, 88% of children in Canada had received the recommended dose of meningococcal C vaccine by two years of age (10).

²⁰ Other includes serogroup A, 29E, W, X, Z and non-groupable cases as well as cases with unknown serogroup.

Further reading

- PHAC invasive meningococcal disease webpage
- Canadian Immunization Guide meningococcal vaccine chapter
- National Advisory Committee on Immunization meningococcal vaccine guidance
- Enhanced surveillance of invasive meningococcal disease in Canada: 2006-2011
- Guidelines for the prevention and control of meningococcal disease (2005)
- Final report of outcomes from the National Consensus Conference for Vaccine-Preventable Diseases in Canada: Invasive meningococcal disease (2008)

Mumps

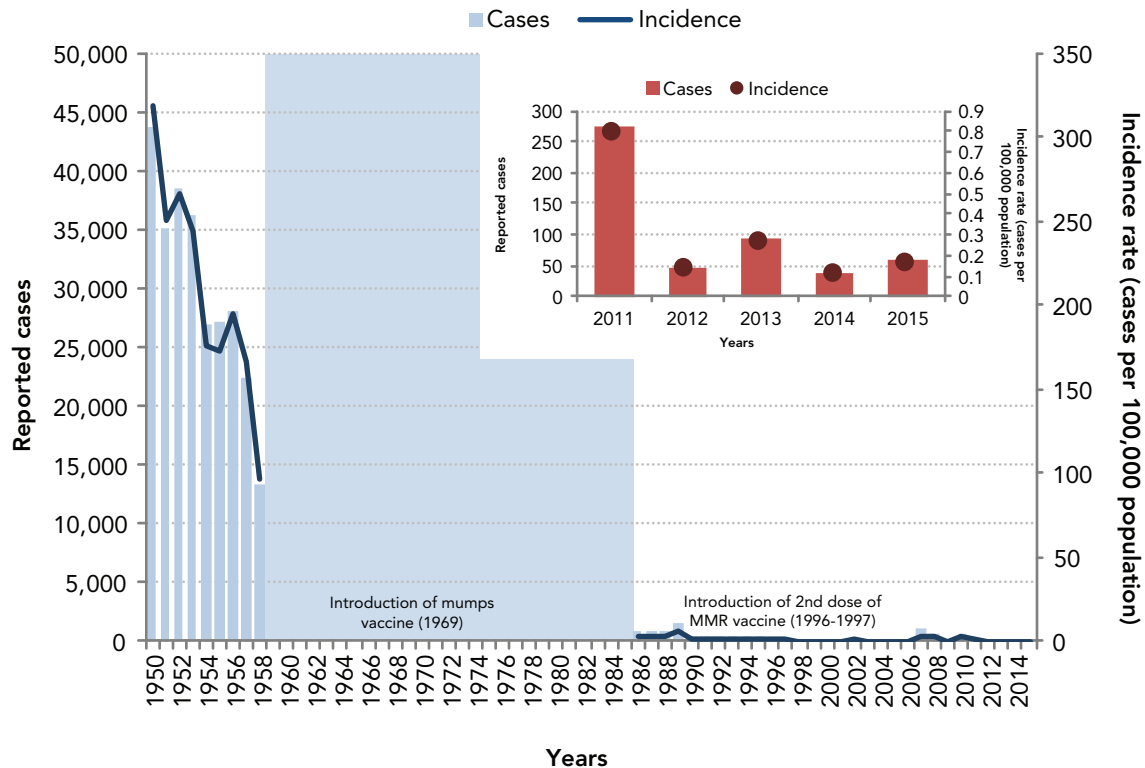
Key points:

- With routine vaccination, the incidence of mumps in Canada has declined by over 99% from an average incidence rate of 251.2 cases per 100,000 population in the pre-vaccine era to 0.3 cases per 100,000 population from 2011 to 2015.
- Mumps outbreaks continue to occur every two to five years underscoring the need for ongoing vigilance and improving vaccination coverage.
- Vaccination rates should be improved. Based on the 2015 cNICS, 89 % of children in Canada had received the recommended doses of mumps-containing vaccine by two years of age and 86% had received the recommended doses by seven years of age.

A mumps-containing vaccine was made available in Canada in 1969 and routine vaccination programs were in place across all provinces and territories by 1983 (20). Additionally, by 1996/97 most provinces and territories had two-dose programs in place (21). Prior to the introduction of the mumps vaccine, many thousands of cases were reported each year. With routine vaccination, the incidence of mumps has declined by over 99% from an average mumps incidence rate of 251.2 cases per 100,000 population in the pre-vaccine era (1950 to 1954)²¹ to 0.3 cases per 100,000 population from 2011 to 2015 (Figure 13). Although vaccination contributed to a significant reduction in disease, mumps continues to be a cyclical disease in Canada, with outbreaks occurring every two to five years.

²¹ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For mumps, this was 1950 to 1954. The mumps vaccine was authorized in Canada in 1969 and all provinces and territories had a mumps vaccine program by 1983. Mumps was taken off the notifiable disease list from 1959 to 1985 with decreased physician reporting in the years leading up to 1959, thus 1954 was chosen as the last year with reliable data that could be used in comparisons.

FIGURE 13: Number and incidence rate (per 100,000 population) of reported²² mumps cases in Canada by year, 1950 to 2015.



Epidemiology between 2011 and 2015

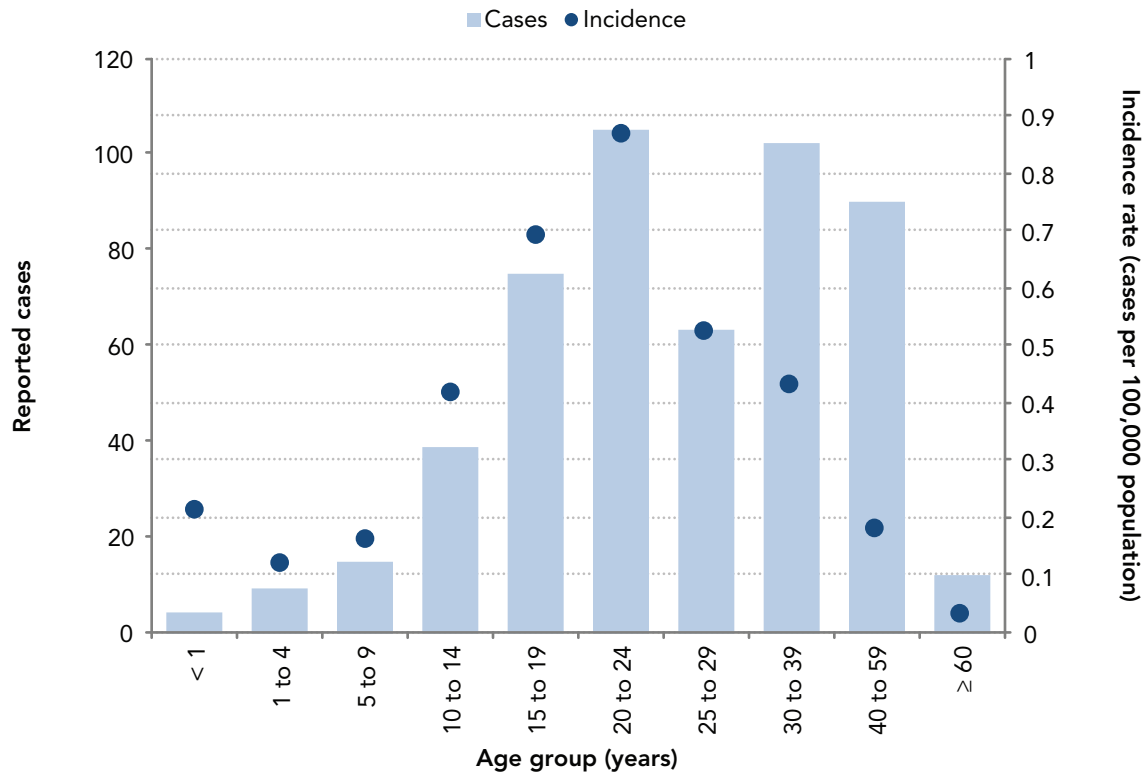
From 2011 to 2015, a total of 514 mumps cases were reported in Canada. The annual number of reported cases ranged from 40 to 273, with a median of 59 cases reported per year and a five-year average of 103 cases. Annual incidence rates ranged from 0.1 to 0.8 cases per 100,000 population (Figure 13). The incidence peak in 2011 was likely associated with various outbreaks that occurred throughout Canada during this time period.

Between 2011 and 2015, cases were reported in every age group. The most affected age group varied from year to year, but for the time period as a whole, the highest overall incidence rate was reported among 20 to 24 year olds (0.9 cases per 100,000 population), and 15 to 19 year olds (0.7 cases per 100,000 population). The lowest overall incidence rates were reported among adults 60 years and older (0.03 cases per 100,000 population) (Figure 14). Distribution varied by year across the sexes, with males accounting for 57% of cases overall, ranging from 50% to 68% annually.

In 2015, 59 mumps cases were reported, with a corresponding incidence rate of 0.2 cases per 100,000 population. Incidence rates were highest among 15 to 19 year olds (0.8 cases per 100,000 population) and 20 to 24 year olds (0.5 cases per 100,000 population).

²² Mumps was removed from the list of national notifiable diseases for the years 1959 to 1985(30).

FIGURE 14: Total number and overall incidence rate (per 100,000 population) of reported mumps cases in Canada by age group and year, 2011 to 2015 (n=514)



Mumps vaccination coverage

Based on the 2015 cNICS, 89% of children in Canada had received the recommended doses of mumps-containing vaccine by two years of age and 86% had received the recommended doses by seven years of age (10).

Further reading

- [PHAC mumps webpage](#)
- [Canadian Immunization Guide mumps vaccine chapter](#)
- [National Advisory Committee on Immunization mumps vaccine guidance](#)

VACCINE PREVENTABLE DISEASES WITH MODERATE LEVEL INCIDENCE IN CANADA

Pertussis

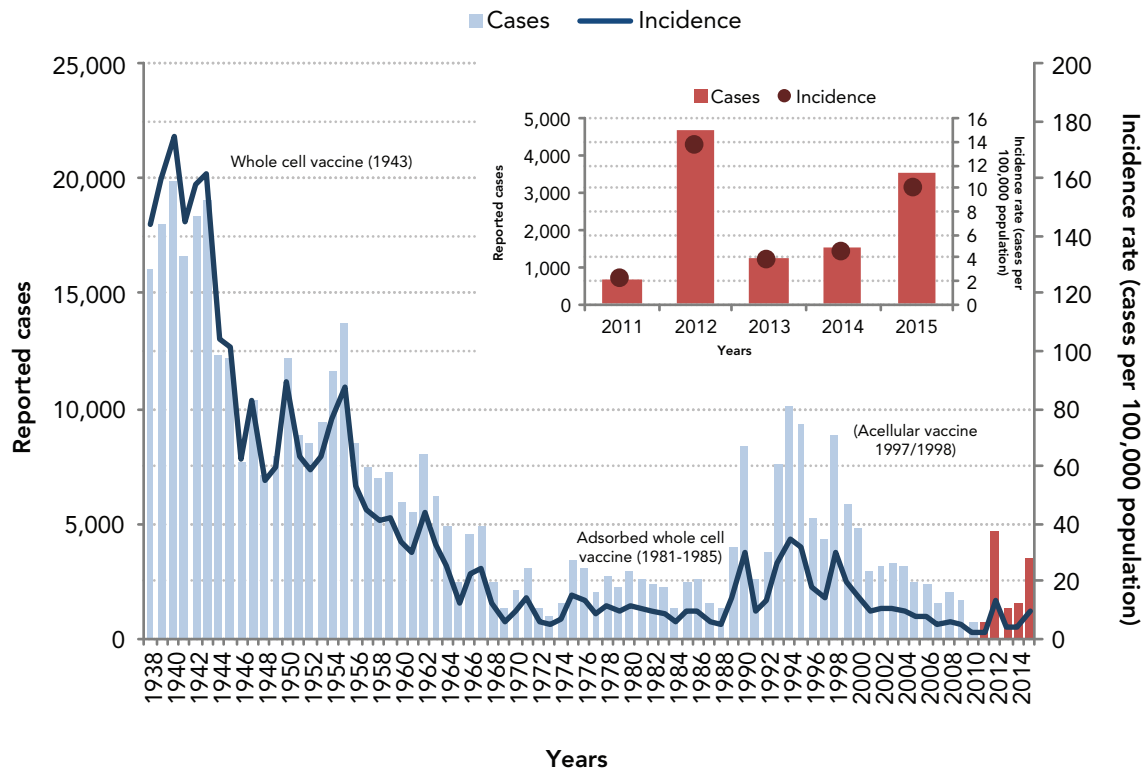
Key points:

- With routine vaccination, the incidence of pertussis has declined by 96% in Canada from an average incidence rate of 156.3 cases per 100,000 population in the pre-vaccine era to an average incidence of 6.6 cases per 100,000 population from 2011 to 2015.
- However, continued vigilance is imperative as incidence rates appear to be increasing since 2011 with numerous outbreaks occurring in 2012 and 2015.
- Vaccination coverage among children and adolescents is low. Based on the 2015 cNICS, only 77% of children in Canada had received the recommended doses of pertussis-containing vaccine by two years of age, 75% by seven years of age, and 60% by 17 years of age. Based on the 2014 aNICS, 10% of adults in Canada had received one dose of the pertussis-containing vaccine.

Pertussis is an endemic and cyclical disease in Canada, with peaks at two to five year intervals. Despite periodic increases, Canada has experienced an overall decline in pertussis incidence since the introduction of the whole-cell pertussis vaccine in 1943, acellular vaccines in 1997/1998, and the addition of an adolescent acellular dose to provincial and territorial vaccine programs between 1999 and 2004 (22,23). With routine vaccination, the incidence of pertussis has declined by 96% from an average incidence rate of 156.3 cases per 100,000 population in the pre-vaccine era (1938 to 1942)²³ to 6.6 cases per 100,000 population from 2011 to 2015 (Figure 15).

²³ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For pertussis, this was 1938 to 1942 as the whole cell pertussis vaccine was authorized in Canada in 1943.

FIGURE 15: Number and incidence rate (per 100,000 population) of reported pertussis cases in Canada by year, 1938 to 2015



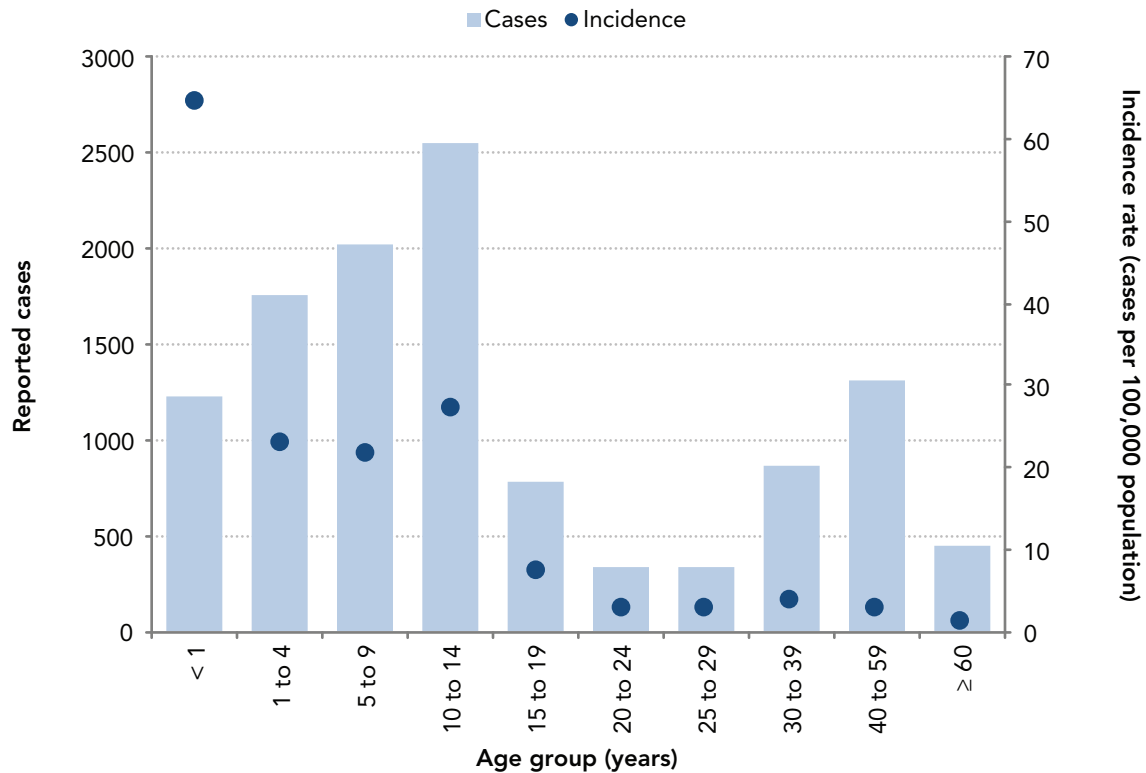
Epidemiology between 2011 and 2015

From 2011 to 2015, a total of 11,660 cases of pertussis were reported in Canada. The annual number of reported cases ranged from 694 to 4,655, with a median of 1,525 cases. Annual incidence rates ranged from 2.0 to 13.4 cases per 100,000 population (Figure 15) and appear to be increasing since a low in 2011. The incidence peaks in 2012 and 2015 were associated with numerous outbreaks that occurred throughout Canada.

Young infants and children are at the highest risk for disease, associated complications, and death, particularly those too young to complete their primary pertussis vaccination series. The highest overall incidence rates were reported among infants less than one year of age (64.5 cases per 100,000 population) and ten to 14 year olds (27.2 cases per 100,000) while the lowest were reported among adults 60 years of age and older (1.2 cases per 100,000 population, Figure 16). Females accounted for 55% of cases overall (range: 54% to 56%). Based on data reported from IMPACT, there was on average one death reported annually due to pertussis in children less than six months of age.

In 2015, 3,510 pertussis cases were reported, with a corresponding incidence rate of 9.8 cases per 100,000 population. Incidence rates were highest among infants less than 1 year of age (73.4 cases per 100,000 population) and ten to 14 year olds (40.1 cases per 100,000 population).

FIGURE 16: Total number and overall incidence rate (per 100,000 population) of reported pertussis cases in Canada, by age group, 2011 to 2015 (n=11,660)



Pertussis vaccination coverage

Based on the 2015 cNICS, only 77% of children in Canada had received the recommended doses of pertussis-containing vaccine by two years of age, 75% had received the recommended doses by seven years of age, and 60% had received the recommended doses by 17 years of age (10). Based on the 2014 aNICS, 10% of adults in Canada had received one dose of the pertussis-containing vaccine in adulthood.

Further reading

- [PHAC pertussis webpage](#)
- [Canadian Immunization Guide pertussis vaccine chapter](#)
- [National Advisory Committee on Immunization pertussis vaccine guidance](#)
- [Pertussis surveillance in Canada: Trends to 2012 \(2014\)](#)
- [Proceedings of the National Microbiology Laboratory pertussis workshop \(2006\)](#)
- [Final report of outcomes from the National Consensus Conference for Vaccine-Preventable Diseases in Canada: Pertussis](#)

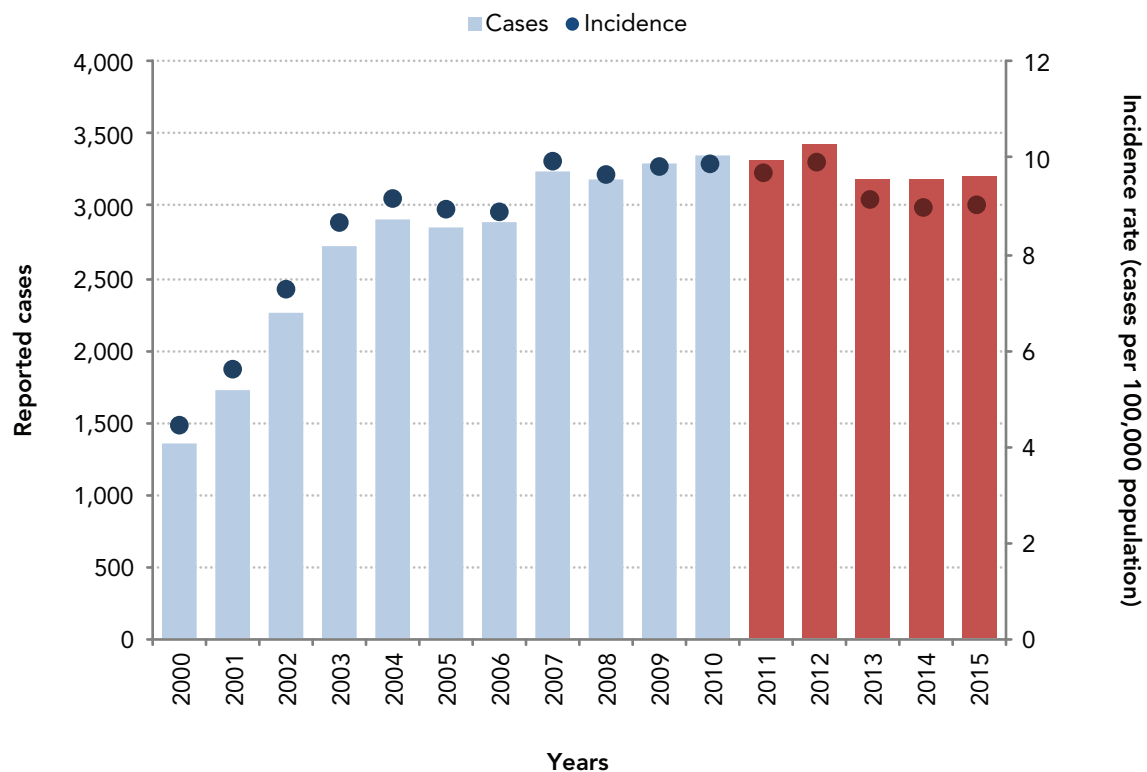
Invasive pneumococcal disease

Key points:

- Following the implementation of routine childhood vaccination between 2002 and 2006, IPD incidence among children less than two years of age has decreased substantially to an average of 19.5 cases per 100,000 population from 2011 to 2015. Conversely, incidence rates among adults 65 years of age and older have remained relatively unchanged since the early 2000s.
- Based on the 2015 cNICS, 80% of children in Canada had received the recommended doses of pneumococcal vaccine by two years of age. Based on the 2014 aNICS, 37% of adults 65 years and older in Canada had received a pneumococcal vaccine.

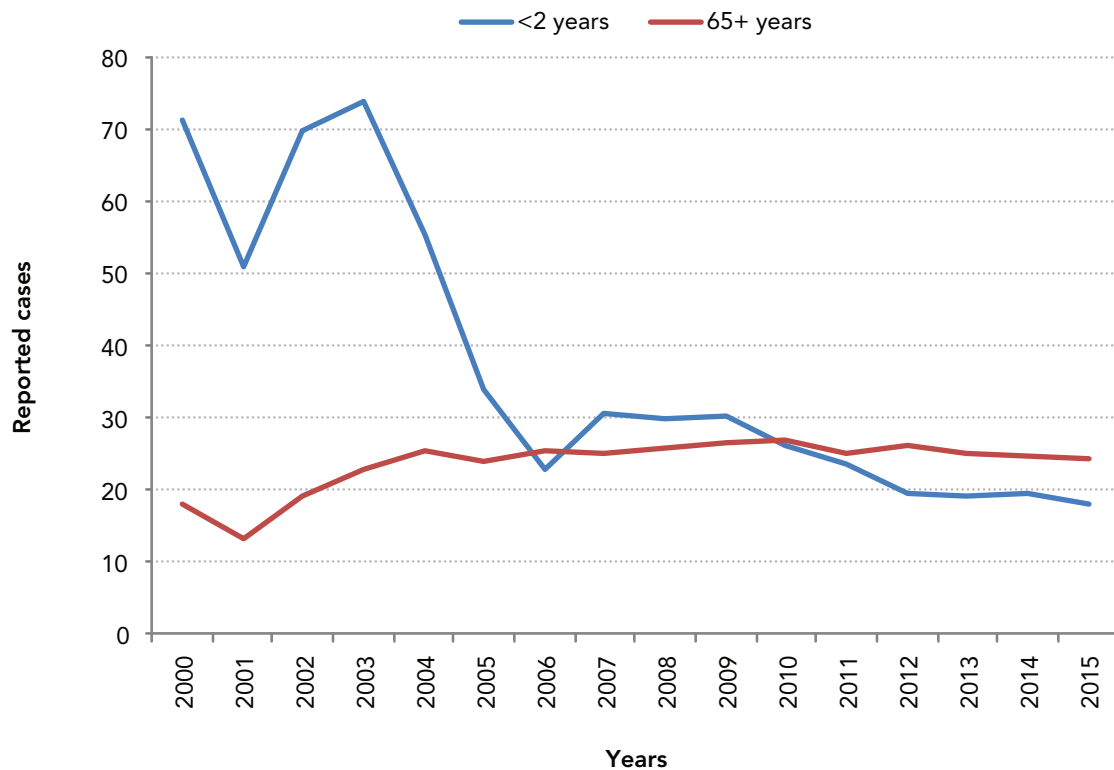
Streptococcus pneumoniae (pneumococcus) is the leading cause of invasive bacterial infections, bacterial pneumonia and acute otitis media in young children. Invasive pneumococcal disease (IPD) became nationally notifiable in 2000; before this time, only cases of pneumococcal meningitis were notifiable nationally. Following instability due to this change in reporting practice, overall annual incidence rates of IPD have remained relatively stable over the last decade, ranging between 8.9 and 9.9 cases per 100,000 population (Figure 17).

FIGURE 17: Number and incidence rate (per 100,000 population) of reported IPD cases in Canada, by year, 2000 to 2015



The NACI recommends routine immunization against IPD for those aged two years and under and those aged 65 years and older. In the absence of national surveillance data prior to 2000, incidence rates for children aged less than two years of age were estimated by various studies (between 1994 and 1999). These estimates of incidence ranged from 58.8 cases per 100,000 population to 112.2 cases per 100,000 population (24). Following the implementation of routine childhood vaccination between 2002 and 2006, IPD incidence among children less than two years of age has decreased to an average of 19.5 cases per 100,000 population from 2011 to 2015. Although the 23-valent pneumococcal polysaccharide vaccine has been licensed for use in Canada since 1983 and routine vaccination programs for those 65 years of age and older were in all provinces and territories by 2000 (25), the average incidence in this age group has remained relatively unchanged since the early 2000s (Figure 18).

FIGURE 18: Incidence of IPD, select jurisdictions and age groups, 2000 to 2015

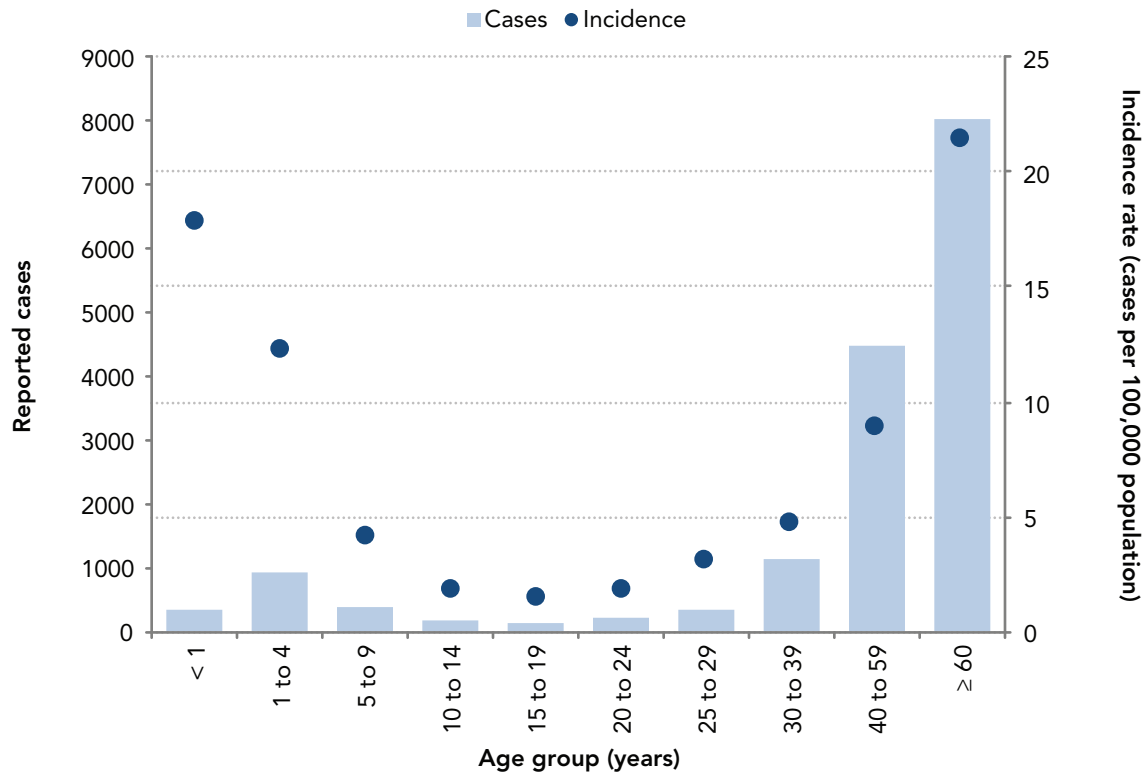


Epidemiology between 2011 and 2015

From 2011 to 2015, a total of 16,296 IPD cases were reported in Canada. The annual number of reported cases ranged from 3,178 to 3,418, with a median of 3,211 cases per year. Annual incidence rates ranged from 8.9 and 9.8 cases per 100,000 population (Figure 17). Cases were reported from every age group from 2011 to 2015. The highest overall incidence rate was reported among those aged 60 years of age and older (21.4 cases per 100,000 population), and infants less than one year old (17.7 cases per 100,000 population) (Figure 19). Males accounted for 55% of cases overall (range: 54% to 55%).

In 2015, 3,211 IPD cases were reported, with a corresponding incidence rate of 9.0 cases per 100,000 population. Incidence rates were highest among adults 60 years of age and older (20.4 cases per 100,000 population) and infants less than one year of age (14.2 cases per 100,000 population).

FIGURE 19: Total number and overall incidence rate (per 100,000 population) of reported invasive pneumococcal disease cases in Canada by age group, 2011 to 2015 (n=16,296)



IPD vaccination coverage

Based on the 2015 cNICS, only 80% of children in Canada had received the recommended doses of pneumococcal vaccine by two years of age.²⁴ Based on the 2014 aNICS, 37% of adults 65 years of age and older in Canada had received a pneumococcal vaccine (10).

²⁴ Indicated by four doses for the Northwest Territories and Nunavut; three doses in other provinces/territories.

Further reading

- PHAC invasive pneumococcal disease webpage
- Canadian Immunization Guide pneumococcal vaccine chapter
- National Advisory Committee on Immunization pneumococcal vaccine guidance
- Final report of outcomes from the National Consensus Conference for Vaccine-Preventable Diseases in Canada: Invasive pneumococcal disease
- Serotype distribution of invasive *Streptococcus pneumoniae* in Canada after the introduction of the 13-valent pneumococcal conjugate vaccine, 2010–2012
- National Laboratory Surveillance of Invasive Streptococcal disease in Canada – Annual Summary 2013
- National Laboratory Surveillance of Invasive Streptococcal disease in Canada – Annual Summary 2014

Varicella

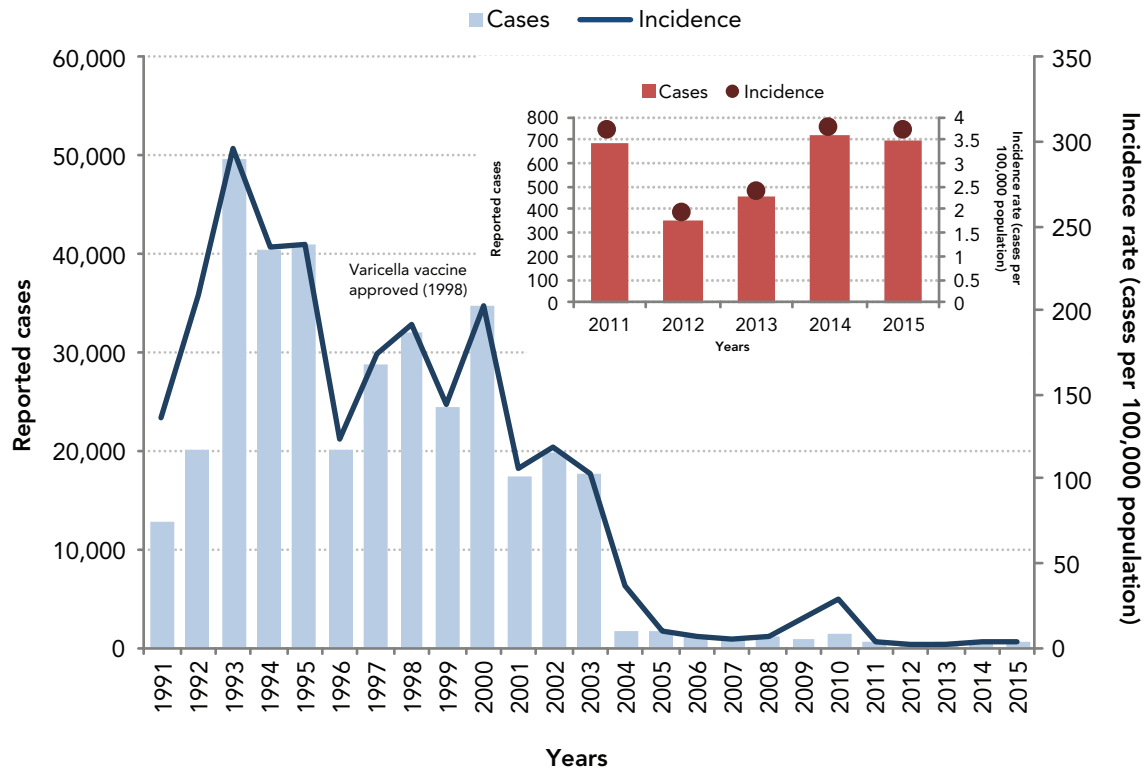
Key points

- Although nationally notifiable, varicella is not reportable in all jurisdictions. Data presented is therefore an underestimate of the true burden of varicella in Canada.
- With routine vaccination, the incidence of varicella in Canada has declined by 99% from an average incidence rate of 214.3 cases per 100,000 population in the pre-vaccine era to 3.1 cases per 100,000 population from 2011 and 2015. Data from IMPACT also suggests an overall decline in hospitalisations associated with serious varicella infections.
- Vaccination rates should be improved. Based on the 2015 cNICS, only 75% of children in Canada had received the recommended doses of varicella-containing vaccine by two years of age.

The varicella vaccine was first approved in Canada in 1998 and routine varicella vaccination programs were implemented in Canadian provinces and territories between 2000 and 2007 (26). Based on data from reporting jurisdictions, the average incidence of varicella has declined by approximately 99% from 214.3 cases per 100,000 population in the pre-vaccine era (1993 to 1997)²⁵ to an average incidence of 3.1 cases per 100,000 population between 2011 and 2015 (Figure 20).

²⁵ The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring. For varicella, this was 1993 to 1997, as the first varicella vaccine was approved for use in Canada in 1998.

FIGURE 20: Number and incidence rate (per 100,000 population) of reported²⁶ varicella cases in Canada by year, 1993 to 2015



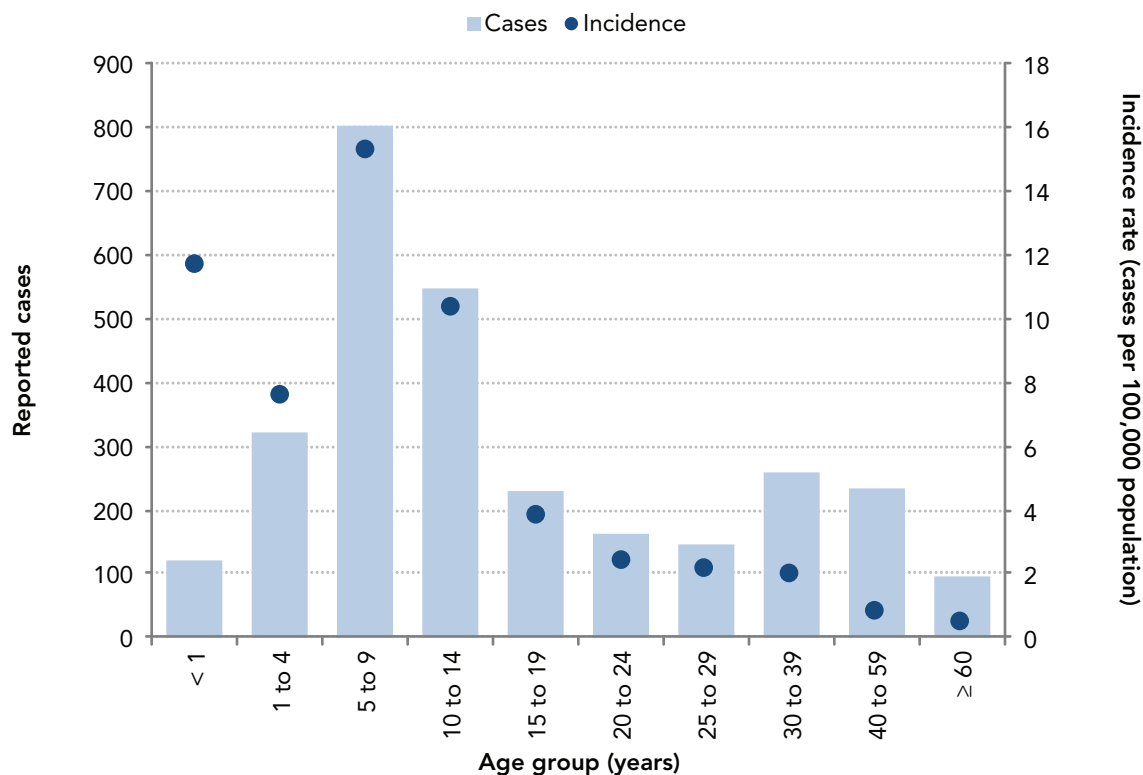
Epidemiology between 2011 and 2015

Based on data from reporting jurisdictions, 2,913 varicella cases were reported in Canada from 2011 to 2015. The annual number of reported cases ranged from 355 to 720, with a median of 681 cases per year. Annual incidence rates ranged from 1.9 to 3.7 cases per 100,000 population (Figure 20). Cases were reported in every age group. The most-affected age group varied from year to year, but for the time period as a whole, the highest overall incidence rate was reported among five to nine year olds (15.3 cases per 100,000 population) and infants less than one year old (11.7 cases per 100,000 population) (Figure 21). The lowest overall incidence was reported among adults 60 years of age and older (0.5 cases per 100,000 population). Males accounted for 53% of cases overall (range: 49% to 55%).

²⁶ Data was not available for British Columbia (1993 to 2015), Saskatchewan (1996 to 1997, 2001 to 2015), Manitoba (1991 to 2015), Ontario (1991 to 1992, 2004, 2011-2012), Quebec (1991 to 2015), Newfoundland and Labrador (2015), Nova Scotia (1998 to 2015) and Yukon (2009 to 2012). Reporting for cases in Nunavut began in 2000. In Ontario, varicella is reported at both individual and aggregate-level. Counts from Ontario for 1993-2003 represent aggregate-level cases which represent the total number of cases occurring in a health unit jurisdiction without individual case details. Counts from Ontario for 2005-2008 and 2011-2015 represent individually reported cases which include lab-confirmed cases and severe cases of varicella such as those leading to hospitalization or death. Ontario has notified the CNDSS that there is systematic under-reporting of varicella for their jurisdiction.

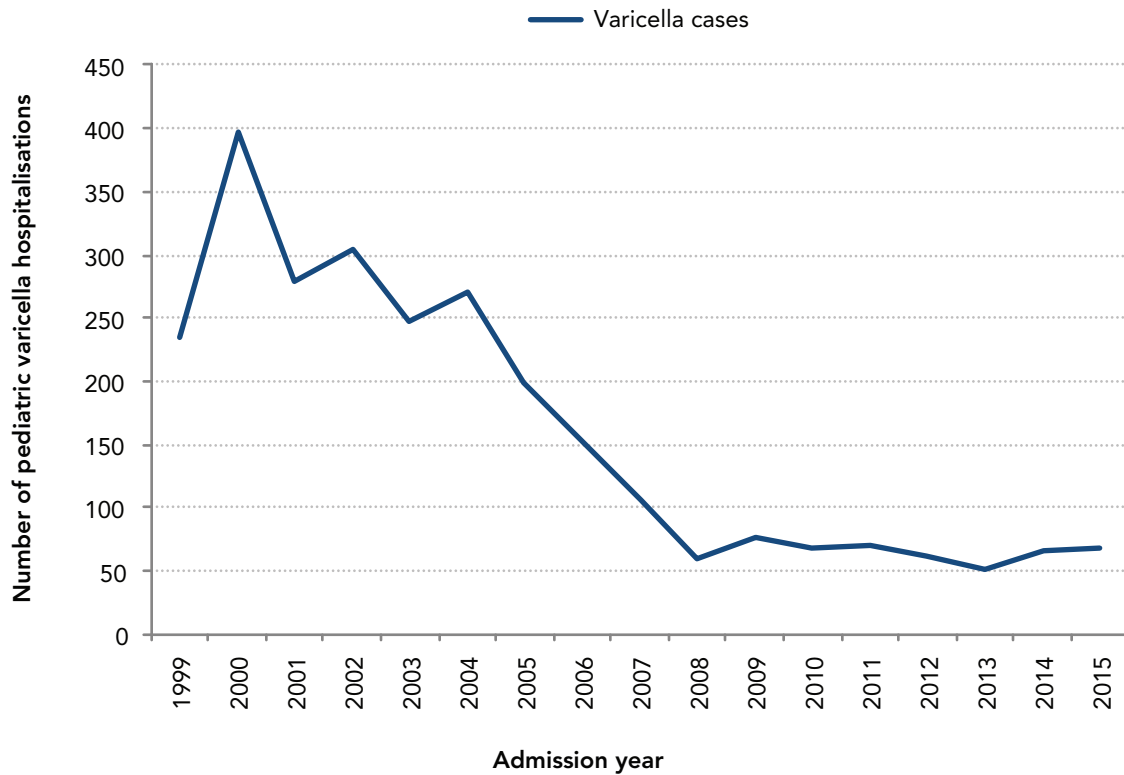
In 2015, 702 varicella cases were reported, with a corresponding incidence rate of 3.7 cases per 100,000 population. Incidence rates were highest among ten to 14 year olds (15.9 cases per 100,000 population), five to nine year olds (13.8 cases per 100,000 population), and infants less than one year old (13.7 cases per 100,000 population).

FIGURE 21: Total number and overall incidence rate (per 100,000 population) of reported varicella cases in Canada by age group, 2011 to 2015 (n=2,913)



Data from IMPACT demonstrate an overall decline in paediatric hospitalisations associated with serious varicella infections since the introduction of routine vaccination programs; decreasing from 234 hospitalisations reported in 1999 to an annual average of 64 hospitalisations (range 52 to 71 cases) from 2011 and 2015 (Figure 22). In this latter time period, 55% of hospitalized patients were male and the majority (93%) occurred among children who were immunocompromised, not eligible for varicella vaccination, or not vaccinated. No deaths associated with varicella were reported through IMPACT.

Figure 22: Number of pediatric varicella hospitalisations in Canada reported through IMPACT, 1991 to 2015



Varicella vaccination coverage

Based on the 2015 cNICS, only 75% of children in Canada had received the recommended dose of varicella vaccine by two years of age (10).

Further reading

- [PHAC varicella webpage](#)
- [Canadian Immunization Guide varicella vaccine chapter](#)
- [National Advisory Committee on Immunization varicella vaccine guidance](#)
- [Final report of outcomes from the National Consensus Conference for Vaccine-Preventable Diseases in Canada: Varicella](#)

CONCLUSION

The findings of this report underscore the pivotal role of publicly-funded infant and childhood vaccination programs in reducing the burden of VPDs. For many VPDs, incidence rates are declining with reported case counts at record lows for some. Enhancing vaccination coverage rates is therefore key to reducing the burden of VPDs in Canada, and worldwide.

Canada continues to maintain its elimination status for measles, rubella, CRS/CRI and polio. The Pan American Health Organization officially certified the Region of the Americas free of endemic measles in 2016 and free of rubella and congenital rubella syndrome in 2015. Certification of elimination of polio occurred in 1994. Despite the large number of measles cases reported in Canada during this time period, ongoing endemic transmission of the measles virus was not re-established and Canada's measles elimination status remains intact. Between 2011 and 2015, low level incidence rates of less than one case per 100,000 population were reported for diphtheria, tetanus, invasive disease due to Hib, IMD, and mumps. Moderate annual incidence rates of greater than or equal to one case per 100,000 population were reported for pertussis, IPD, and varicella.

Imported cases of measles continue to occur, with risks of secondary spread within Canada. Furthermore, outbreaks of endemic diseases to Canada such as mumps and IMD (serotype B) occur, preventable cases of Hib among infants continue to be reported, the potential exists for a resurgence of pertussis particularly among infants, and there has been no change in incidence rates of IPD among adults age 65 years and older. Taken together, these factors underscore the need for Canada to increase our vigilance with respect to vaccine preventable diseases.

Strong surveillance systems are important to provide data for ongoing monitoring and will continue to provide important information in support of ongoing national vaccination recommendations. Added health benefits could be achieved by increasing rates of vaccination with currently recommended vaccines. As the number of vaccines recommended for adolescents and adults increase, there are opportunities (and challenges) to enhance the rate of vaccination among these populations. The greatest additional gains can come from understanding the characteristics of the under-immunized and unimmunized populations and improving vaccination coverage among these populations. History demonstrates the importation of disease into under- or unimmunized populations can result in outbreaks. Clear and understandable public communication about the risks and benefits of vaccination are important, especially when disease rates are low. Vaccines are one of the greatest achievements of biomedical science and public health. Continued commitment to vaccine programs is essential to advance their public health benefits.

ACKNOWLEDGEMENTS

We are grateful to local, provincial, and territorial public health staff for their continued support and tireless efforts in communicable disease surveillance and control as well as outbreak investigations. We also thank the healthcare providers and laboratorians who diligently reported case information to their local health authorities. Finally, we thank IMPACT researchers and nurse monitors and the Canadian Pediatric Society for their work in elucidating the burden of vaccine preventable diseases in the hospitalised pediatric populations.

APPENDIX A: METHODS AND LIMITATIONS

SURVEILLANCE DATA SOURCES

Canadian Notifiable Disease Surveillance System

National surveillance data for polio, diphtheria, tetanus, invasive disease due to *Haemophilus influenzae* serotype b (Hib), mumps, pertussis, and invasive pneumococcal disease (IPD) were obtained through the Canadian Notifiable Disease Surveillance System (CNDSS), a surveillance system coordinated by the Public Health Agency of Canada (PHAC). Data aggregated by year, sex, province or territory, and age group are voluntarily provided by provincial and territorial partners on an annual basis. Age groups include infants less than one year old, one to four year olds, five to nine year olds, ten to 14 year olds, 15 to 19 year olds, 20 to 24 year olds, 25 to 29 year olds, 30 to 39 year olds, 40 to 59 year olds, and adults 60 years of age and older. In addition, eight jurisdictions (British Columbia, Alberta, Saskatchewan, Ontario, Quebec, Prince Edward Island, the Yukon, and Nunavut), provide case-level data to CNDSS. These jurisdictions accounted for approximately 90% of the Canadian population between 2011 and 2015. Data in this report are current as of February 2017.

Canadian Measles and Rubella Surveillance System

National, enhanced surveillance data for measles, rubella, and CRS/CRI were obtained through the Canadian Measles and Rubella Surveillance System (CMRSS). Provincial and territorial departments of health submit case-level, non-nominal epidemiologic data weekly to the PHAC on all cases that meet the national case definitions, including zero-reporting. The National Microbiology Laboratory (NML) provides genotype results for confirmed cases.

Enhanced Invasive Meningococcal Disease Surveillance System

National surveillance data for invasive meningococcal disease (IMD) were obtained through the enhanced Invasive Meningococcal Disease Surveillance System (eIMDSS). Provincial and territorial departments of health submit case-level, non-nominal epidemiologic and laboratory data annually to the PHAC on all cases of IMD that meet the national case definition (27). Provincial and territorial public health and/or hospital laboratories send all *Neisseria meningitidis* isolates to the NML for confirmation and organism characterization. Probabilistic matching on province/territory, date of birth or age, sex, onset date, and serogroup is conducted to link epidemiologic and laboratory data for cases with incomplete information.

Canada's Immunization Monitoring Program, ACTIVE

The Canadian Immunization Monitoring Program, Active (IMPACT) is a national surveillance initiative managed by the Canadian Paediatric Society (CPS) and conducted by the IMPACT network of paediatric investigators at 12 tertiary-care paediatric hospitals across Canada. Funding is provided by PHAC to the CPS for IMPACT. The IMPACT Data Monitoring Centre submits case-level, non-nominal epidemiologic and laboratory data quarterly to the PHAC on five VPDs. Data on paediatric hospitalisations at IMPACT hospitals due to varicella and Hib were obtained through IMPACT.

Canadian Acute Flaccid Paralysis Surveillance System

National surveillance data for acute flaccid paralysis (AFP) in children less than 15 years of age is a World Health Organization (WHO) recommended strategy for detecting poliovirus circulation. National AFP surveillance data were obtained through the Canadian Acute Flaccid Paralysis Surveillance System (CAFPSS). Data are voluntarily provided by participating physicians and IMPACT nurse monitors who submit completed case report forms on an ongoing basis to the Canadian Paediatric Surveillance Program. The forms are then forwarded to the PHAC for medical adjudication in order to rule out polio as the cause of AFP and to ensure that cases meet the national AFP case definition.

VACCINATION COVERAGE DATA SOURCES

2013 Childhood National Immunization Coverage Survey

The Public Health Agency of Canada (PHAC) routinely monitors vaccination coverage in Canada through the childhood National Immunization Coverage Survey (cNICS)(10). Since 1994, the cNICS has been conducted every two years to estimate national uptake for all routine childhood vaccinations recommended by the National Advisory Committee on Immunization (NACI), to report vaccination coverage estimates to international organizations, and to develop appropriately targeted public education strategies. Note that these reported numbers are most likely underestimates as data were collected primarily from parent-held vaccination records, in which some doses may be missing or recorded with incomplete information such as missing or illegible dates. In addition, in jurisdictions where vaccinations are recorded by vaccine and where the measles-mumps-rubella-varicella (MMRV) vaccine is in use, some doses of this vaccine may be recorded as MMR, thus leading to an under-counting of varicella vaccination.

2014 Adult National Immunization Coverage Survey

Since 2001, the adult National Immunization Coverage Survey (aNICS) has been conducted every two years by the PHAC(10). Results from the aNICS are used to monitor national coverage levels for all routine adult vaccination recommended by the NACI, to report vaccination coverage estimates to international organizations, and to develop appropriately targeted public education strategies. Target populations include adults with or without chronic medical conditions and health care workers.

POPULATION DATA SOURCES

Population estimates

For all VPDs except CRS/CRI, denominator data for incidence rate calculations were obtained from Statistics Canada annual July 1st population estimates (28).

Live births

For CRS/CRI, denominator data for incidence rate calculations were obtained from Statistics Canada's Birth Database (29).

ANALYSES

Analyses performed for this report include frequency counts, crude and age-specific incidence rates, and age and sex distributions as appropriate. Case-level CNDSS data were used to calculate IPD incidence rates for adults 65 years of age and older. Populations of those provinces and territories that did not submit case-level data were removed from the denominators of incidence rate calculations. Exclusion of non-vaccine preventable serotypes was not possible for IPD in this analysis. The pre-vaccine era was defined as the five years before vaccine introduction, or the closest possible five years where stable reporting was occurring (30).

Limitations

General limitations associated with data collected from passive surveillance systems should be considered in the interpretation of the results presented in this report, including differences in reporting practices across jurisdictions, reporting delays, missing or incomplete data, duplicate reports and under-reporting. As surveillance activities are ongoing, all data are subject to change. With the exception of VPDs under elimination in Canada, cases reported to the national level are not reviewed to ensure that they meet national case definitions. Because of the unreliability of results based on small numbers, caution should be used when interpreting results such as incidence rates and sex distribution based on less than 20 cases.

Due to the passive nature of many of the surveillance systems used to provide data for this report, reported cases are expected to be underestimates of the true burden of disease. Under-reporting is also likely among adolescents and adults (who may be less likely to be seen by a health care professional) and for milder or asymptomatic illness or those diseases where laboratory confirmation of disease is infrequent. However, under-reporting of diseases is less likely to be a concern for those diseases under elimination (i.e., polio, measles, rubella and CRS/CRI) due in part to the high profile of these diseases and strong laboratory and healthcare reporting to public health.

Data for most of the surveillance systems are not received from provinces and territories in real time, nor are most cases reported at the national level linked with laboratory and epidemiological data. Outbreak surveillance data are not available nationally for any of the VPDs (with the exception of measles, rubella, and IMD). Detailed case vaccination history, manifestations, and mortality information is not available for VPDs where data were obtained through CNDSS. Case-level data available from CNDSS was not available from Manitoba, Newfoundland and Labrador, New Brunswick, Nova Scotia, and the Northwest Territories. The populations of these jurisdictions were removed from the IPD incidence rate calculations where case level data were used exclusively. Data from the remaining provinces and territories represents approximately 90% of the Canadian population. As the death data available through Statistics Canada has not been validated, this information was not presented in this report.

The limitations of the coverage data obtained from cNICS and aNICS have been documented elsewhere but it should be noted that these numbers are most likely underestimates as data were collected primarily from parent-held vaccination records, in which some doses may be missing or recorded with incomplete information such as missing or illegible date (10). In addition, in jurisdictions where vaccinations are recorded by vaccine and where the measles-mumps-rubella-varicella (MMRV) vaccine was in use, some doses of this vaccine may have been recorded as MMR, thus leading to an under-counting of varicella vaccination.

REFERENCES

- (1) Public Health Agency of Canada. Brief Report: Hepatitis B Infection in Canada. 2011; Available at: www.phac-aspc.gc.ca/id-mi/pdf/hepB-eng.pdf. Accessed February 20, 2017.
- (2) Ehreth J. The value of vaccination: a global perspective. *Vaccine* 2003;21:4105.
- (3) Centers for Disease Control and Prevention (CDC). Appendix: Methods for the cost-benefit analyses presented in "*Benefits from Immunization during the Vaccines for Children Program Era — United States, 1994–2013*". *Morbidity and Mortality Weekly Report* 2014;63:352.
- (4) Public Health Agency of Canada. Poliomyelitis (polio) surveillance. 2014; Available at: www.phac-aspc.gc.ca/im/vpd-mev/poliomyelitis/surveillance-eng.php.
- (5) Public Health Agency of Canada. Elimination of Measles, Rubella and Congenital Rubella Syndrome in Canada, Documentation and Verification Report. 2011.
- (6) Rotondo J, Desai S, Pless R, Ahmad R, Squires S, Booth TF. Acute flaccid paralysis surveillance: The need for ruling out polio infection. *Paediatrics & child health* 2015;6:309.
- (7) Varughese PV, Acres SE. Measles in Canada: surveillance summary. *Canada diseases weekly report* 1979;5:121.
- (8) Varughese PV, Acres SE. Measles in Canada - 1986. *Canadian Medical Association journal* 1987;136(11):1183.
- (9) Public Health Agency of Canada. *Canadian Immunization Guide, 7th Edition*. Ottawa, ON: Government of Canada; 2006.
- (10) Public Health Agency of Canada. Childhood national immunization coverage survey, 2015. 2017; Available at: www.statcan.gc.ca/daily-quotidien/170628/dq170628a-eng.htm.
- (11) Macey JF, Tam T, Lipskie T, Tipples G, EisBrenner T. Rubella Elimination, the Canadian Experience. *The Journal of infectious diseases* 2011;204(suppl_2):S585.
- (12) Lim G, Harris T, Desai S, Crowcroft N, Mazzulli T, Kozlowski T, et al. Rubella immunity among prenatal women in Ontario, 2006-2010. *BMC Infectious Diseases* 2013 2 August 2013;13(362).
- (13) Lai FY, Dover DC, Lee B, Fonseca K, Solomon N, Plitt SS, et al. Determining rubella immunity in pregnant Alberta women 2009-2012. *Vaccine* 2015;33(5):635-641.
- (14) Gilbert N, Rotondo J, Shapiro J, Sherrard L, Fraser W, Ward B. Seroprevalence of rubella antibodies and determinants of susceptibility to rubella in a cohort of pregnant women in Canada, 2008-2011. *Vaccine* 2017 29 April 2017.
- (15) MacDougall H. Be Wise - Immunize! Vaccination in Canada, 1798-1978. *Canadian Pharmacists Journal* 2007;140(2_suppl):S5.
- (16) Immunize Canada. Diphtheria. 2017; Available at: www.immunize.ca/en/diseases-vaccines/diphtheria.aspx.
- (17) Public Health Agency of Canada. Diphtheria. 2014; Available at: www.phac-aspc.gc.ca/im/vpd-mev/diphtheria-diphtherie-eng.php.
- (18) Ruttly CJ. The Middle-Class Plague: Epidemic Polio and the Canadian State, 1936-1937. 1999; Available at: www.healthheritageresearch.com/MCPlague.html.

- (19) National Advisory Committee on Immunization (NACI). Update on the Invasive Meningococcal Disease and Meningococcal Vaccine Conjugate Recommendations. Canada Communicable Disease Report 2009;35(ACS-3).
- (20) Furesz J, Varughese P, Acres SE, Davies JW. Rubella immunization strategies in Canada. Reviews of infectious diseases 1985;Suppl 1:S191.
- (21) Public Health Agency of Canada. Guidelines for the Prevention and Control of Mumps Outbreaks in Canada. Canada Communicable Disease Report 2010;36S1.
- (22) Cutcliffe N. Building on the Legacy of Vaccines in Canada: Value, Opportunities, and Challenges. 2010.
- (23) Barreto L, Van Exan R, Ruddy C. The Challenge of Whooping Cough: Canada's Role in the Development of Pertussis Vaccines. 2006.
- (24) National Advisory Committee on Immunization (NACI). Statement on the Recommended Use of Pneumococcal Conjugate Vaccine. Canada Communicable Disease Report 2002;28(ACS-2).
- (25) Squires SG, Pelletier L. Publicly-funded influenza and pneumococcal immunization programs in Canada: a progress report. Canada Communicable Disease Report 2000;26(17):141.
- (26) Wayne A, Jacobs P, Tan B. The impact of the universal infant varicella immunization strategy on Canadian varicella-related hospitalization rates. Vaccine 2013;31(42):4744.
- (27) Public Health Agency of Canada. Case Definitions for Communicable Diseases Under National Surveillance. Canada Communicable Disease Report 2009;35S2.
- (28) Statistics Canada. CANSIM Table 051-0001. Estimates of population, by age group and sex for July 1, Canada, provinces and territories. 2016; Available at: <http://www5.statcan.gc.ca/cansim/a26?id=510001>.
- (29) Statistics Canada. CANSIM Table 102-4502. Live births, by month, Canada, provinces and territories. 2016; Available at: <http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=1024502>.
- (30) Canadian Medical Association. Association Notes. Public Health: A new look in communicable disease reporting. Canadian Medical Association journal 1959;80:478.



