Measles in adults in Canada and the United States: implications for measles elimination and eradication

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Background
Despite the implementation of mass school catch-up campaigns for measles in Canada, an outbreak of measles occurred in early 1997 mostly affecting the adult population. The higher incidence in Canada in adults led us to compare immunization policies and the evolution of measles among adults in Canada and the US.

Methods
Based on information gathered from both national immunization programmes and surveillance systems.

Results
Although the proportion of cases occurring in adults has increased tremendously in both countries in the past decade, there was no increase in measles incidence in these populations. The most likely factors to explain the higher rate of measles occurring in adults in Canada are the younger age at administration of first dose in Canada, the delay in implementation of a second dose policy in Canada compared with the US combined with the lack of prematriculation immunization requirements in Canadian colleges and universities, and the higher rate of overseas travel to and from Canada. The situation in Canada may also have been exacerbated by incomplete efforts to control measles for many years without attempting to eliminate the disease.

Conclusions
In order to prevent measles in adults, high-risk groups must be identified and catch-up for selected groups considered. Vaccination of international travellers to endemic areas should be recommended until global elimination has been achieved. Appropriate measles control strategies in younger populations seem to be effective in preventing measles in adults. The experience in Canada and the US suggests that measles transmission in adults is unlikely to be a major impediment to regional elimination or global eradication.

Keywords
Measles, epidemiology, adults, Canada, United States

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Because it is so contagious, measles has traditionally been a disease affecting young children. When measles vaccination was introduced, it was thought that measles elimination could be achieved quickly with a routine one-dose programme. Experience has now taught policy makers that the high contagiousness of measles and vaccine failures will require two-dose programmes, in addition to achieving and maintaining very high levels of coverage, to permit elimination.

A major effort was undertaken by all countries in the Americas to achieve the goal of measles elimination by the year 2000. By 1995, Canada was the only country of the Americas which, in addition to the routine one-dose immunization programme, had not implemented either a routine two-dose measles immunization programme like the US or a mass catch-up campaign like all other countries. As a result, in 1995, Canada was probably the country with the highest susceptibility to measles in the Americas and was the country with the highest measles incidence rate. At this time, epidemiological projections indicated that Canada was likely to experience a major outbreak starting as early as April 1996. Most Canadian provinces and
territories reacted promptly and implemented a routine two-dose programme at 18 months or at 4–6 years (depending on the jurisdiction) and catch-up programmes involving school-age children (the catch-up was completed in seven provinces in 1996). These campaigns stopped outbreaks that started to develop, bringing the number of reported cases down to 327 for 1996 and apparently interrupted transmission of the measles virus during the later part of 1996. In early 1997, however, an epidemic developed in British Columbia on the west coast and spread to other Canadian provinces. The spread particularly affected Alberta, one of the four Canadian provinces that had not yet implemented a mass catch-up programme, and prompted this province to start a school-based catch-up vaccination campaign in April 1997. During 1997, 577 cases (1.9 per 100 000) were reported in Canada, 219 (38%) occurring in people >20 years. In contrast, only 138 cases (0.05 per 100 000) of measles had occurred in the US, including 44 (32%) in people >20 years of age.

This difference in measles incidence led us to compare the immunization policies and the evolution of measles among adults in Canada and the US. At a time when a goal for global eradication of measles might be established within the next few years, it is important to try to understand the reasons why Canada is experiencing a relatively high level of measles in adults compared to the US. More urgently, this understanding is important for Canada to take corrective actions, if necessary, in order to achieve the goal of measles elimination by the year 2000.4

**Sources of Information**

Data on measles incidence and age distribution of cases were obtained from the national reporting systems in both Canada and the US. Information on vaccine coverage, vaccine usage, vaccination strategy and outbreak control measures were obtained from the National Immunization Program, Centers for Disease Control and Prevention, Atlanta, Georgia in the US and the Division of Immunization, Laboratory Center for Disease Control, Ottawa, Ontario in Canada. Data on 1995 international travel activities for Canada were obtained from Statistics Canada7 and for the US from the US Department of Commerce.8

**Examination of Measles Epidemiology and Control Strategies**

**Epidemiology of measles in adults >20 years of age**

In the years preceding vaccine licensure, measles affected nearly every child. Both countries experienced a sharp decrease in the number of reported cases following the introduction of the vaccine in 1963 (Figure 1). The decrease seemed steeper in the US which may indicate that the immunization programme reached higher levels of coverage faster, corresponding to the 1967 US effort to eliminate measles. The average annual incidence rate in the post-vaccine period, particularly in the 1980s and 1990s was higher in Canada than in the US. The sensitivity and specificity of the measles national surveillance systems in the US and Canada, although difficult to compare, do not seem to be fundamentally different. The sensitivity of measles surveillance in the US has been estimated to be around 50%.9,10 In Canada, a reporting of only 30% of all measles cases was traditionally accepted as the most likely figure for a number of years. It is likely, however, that over the course of 1996 and 1997, surveillance of measles has improved in both countries due to enhanced elimination efforts. Further, both countries have very specific systems with high confirmation rates (either through laboratory confirmation which represents the majority of cases or through contact with a laboratory confirmed case).

Figure 2 presents the yearly measles incidence rate in the population aged >20 years as well as the overall proportion of all measles cases occurring within this population for both
Canada (since 1969) and the US (since 1980 as information on the proportion of adult cases reported before this date is limited). The proportion of cases occurring in these populations has slowly but steadily increased in Canada from almost 0% in 1969 to nearly 10% in 1996. Although the overall number of reported adult cases varies from one year to the other and is correlated with the occurrence of large outbreaks in the younger populations, there is no overall trend towards an increased incidence over this period. The increase in the proportion of cases occurring in adults, therefore, is the result of fewer cases in children whereas adults continue to be exposed and develop measles. In Canada, after the implementation of mass school catch-up campaigns in 1996, the proportion of cases occurring among adults jumped to nearly 40%. These cases occurring among adults mostly resulted from an outbreak which struck British Columbia. In addition, many other cases (isolated or small clusters) occurred in other provinces among adults as a result of the British Columbia outbreak or through other sources of international importations. Similarly, since 1980, the US has not observed an increase in the number of cases occurring in adult populations, with the exception of epidemic years, similar to the situation in Canada: only the proportion of total cases occurring in adults has increased. The average annual incidence rate in the US adult population over the last 3 years is lower than the rate in Canada. Unlike Canada, the proportion of cases occurring in adults in the US has been increasing faster from 5% in 1980 to around 40% in 1995–1996. This may indicate a better level of control in the younger age groups in the US over the last 15 years.

In Canada, between 1980 and 1995, 49.6% of cases occurring in populations ≥20 years occurred in the age group 20–24, 23.7% in the age group 25–29, 16.5% in the age group 30–39, and 10.2% in those aged ≥40. Comparatively, in the US, between 1980 and 1995, 46.1% of cases occurring in populations ≥20 years occurred in the age group 20–24, 25.2% in the age group 25–29, 22.9% in the age group 30–39, and 5.7% in those aged ≥40.

The number of imported measles cases to the US fell sharply in 1991 and from 1992 through 1994 as a result of successful efforts to control measles in Latin America and the Caribbean. In 1993 and 1994, the vast majority of international importations were coming from Asia and Europe. Most reported imported cases occurred among children and adolescents. Between 1986 and 1994, 226 imported cases (21.5%) occurred in adults ≥20 years of age. Data on imported measles in Canada are limited and have only been available since 1996. In 1996–1997, 19 importations were documented mostly from Europe and Asia, similar to the US. On a per capita basis there is higher travel activity to and from countries outside the Americas for Canada (0.14 and 0.12 trips a year per person to and from Canada respectively, using the Canadian population as a denominator) than for the US (0.06 and 0.05 trips a year per person to and from the US respectively, using the US population as denominator).

Measles in adults, both in Canada and the US, has mostly spread through colleges and universities. Outbreaks affecting non-institutionalized adult communities are rare, which may be a consequence of less person to person contact and a lower rate of susceptibility in this age group. Although young adults born after 1968 were probably not exposed to natural measles and susceptibility might be high in this group, most of the older adult population out of college or university would probably have been exposed to naturally circulating measles already.

No information is available in Canada or the US on the country of birth of measles cases which would indicate if measles among adults is more likely in people who have recently immigrated to either country. It is, however, interesting to note that British Columbia is an area of intensive travel and immigration in Canada. The vast majority of cases reported during the 1997 outbreaks, nevertheless, were among long-term residents of Canada.

In 1997, the only large outbreak involving adults in Canada was in British Columbia where a measles catch-up campaign had been conducted from April to June 1996. The campaign used measles-rubella vaccine and targeted all preschool and school-age children. It reached an overall coverage of 86.6% of the entire target population. Despite this campaign, an outbreak occurred among university students at Simon Fraser University in the greater Vancouver area. The outbreak started during the third week of January 1997 and lasted until mid-April. A total of 302 measles cases was reported. Sixty-four per cent of cases were in people ≥20 years and over. The attack rate was 19.2 times lower in populations immunized with two versus one dose of measles vaccine (0.87 per 100 000 versus 16.8 per 100 000 respectively in the school population targeted by the
1996 catch-up campaign). Among adults ≥20 years and whose immunization status was known, 82% of cases occurred in people who had previously received one dose of measles vaccine and only 18% in people reportedly never immunized. This is not unexpected in a moderately well-immunized population using a less than 100% effective vaccine. Transmission to school-age children was very limited. The highest attack rate was observed in 19-year-olds (second year of university) where it reached 87 per 100 000. There were very few cases among first-year university students as most had been immunized through the school-based second dose catch-up campaign in 1996.

In an attempt to control the outbreak, the provincial authorities implemented an emergency province-wide catch-up programme aimed at all post-secondary and prison institutions, as well as health-care workers in acute care settings. This campaign had limited success reaching only around 50% of the 300 000 target population; acceptability of the immunization campaign was higher in the affected campuses where coverage reached around 85%.

Other sporadic cases or small clusters also occurred among adult populations in Canada, more frequently in post-secondary institutions.

Since 1993, the proportion of measles outbreaks among adults in the US has increased, although most of these adult outbreaks have involved fewer than five cases. An exception to this general trend occurred in 1995, when a measles outbreak affected Ventura County, California. Over half of the 74 cases occurred in people ≥20 years. Transmission was documented in medical settings, but for many cases the transmission setting was unknown. The outbreak persisted for over 4 months.

**Evolution of immunization programmes and control strategies for measles in Canada and the US**

In both the US and Canada, measles vaccine was first licensed in 1963 and then introduced on a large scale but at a different pace in both countries. In 1963, in both countries, the vaccine was recommended for children 9 months and older. Due to concerns of lower vaccine effectiveness in children less than one year of age, in 1965 in the US and in 1968 in Canada, the recommended age for measles immunization was increased to one year. Although Canada kept this recommendation, the US increased the recommended age to 15 months and over in 1976. Only in 1994 did the US lower the recommended age for the administration of the measles vaccine down to 12–15 months. In addition, Canada relied exclusively on a one-dose schedule until 1996 whereas in the US, a second dose of measles vaccine (at school entry or for entry to secondary school) had been recommended since 1989.

In both countries, the vast majority of the measles vaccine used since 1968 contained the Moraten strain, mostly administered as MMR vaccine and produced by Merck Sharp and Dohme. Soon after introduction of the vaccine in 1966, the US announced its first elimination goal. In 1968, 59% of children aged 1–4 years and 50% of school children aged 5–9 years had received measles vaccine. By 1978, it was estimated that 63% of 1–4 years, 76% of 5–9 years and 72% of 10–13 years had been immunized against measles. In 1978, the US declared the goal to eliminate indigenous measles transmission by the year 1982. The basic strategy called for high vaccination levels with a single dose of measles vaccine. Compulsory vaccination before school entry was supposed to assure that at least 95% of children entering school had documentation of vaccination. However, many preschool children, especially those living in poor urban areas, remained unvaccinated. In response to a resurgence of measles, in 1989, the Immunization Practices Advisory Committee of the US Public Health Service recommended that school-age children receive a second dose of measles vaccine. In addition, in the early 1990s, special efforts were made to improve vaccination services to preschool children living in inner-city areas. By 1996 as many as 65% of school-age children had received a second dose of measles containing vaccine and national vaccine coverage among 2-year-old children had increased to 91%. Intensive efforts to increase vaccination coverage among preschool children may have led to some children, with inadequate documentation, for example, to receive second doses.

In a 1991 survey, 55% of US colleges reported prematriculation immunization requirements (PIR), 44% of which had a two-dose policy in place. From 1988 through 1991, 50 colleges reported 57 outbreaks of two or more cases including 37 (65%) concurrent with a community outbreak. Nine outbreaks started on campus and spread to the community and 28 started in the community and spread to the campus. Measles outbreaks were less likely to be reported by schools with a measles PIR in place, particularly a two-dose measles vaccine PIR.

In Canada, no reliable national estimate of vaccination coverage level was available until 1993. From available provincial data, it appears that measles vaccine was not used on a large scale until the early 1970s but it was assumed that national coverage has been higher than 85% since the late 1970s. Recent studies have indicated that 96–97% of 2-year-old children had received at least one dose of measles containing vaccine and 93–94% had received this dose after their first birthday. It is also assumed that coverage levels of school children with one dose of vaccine has been about 90–95% or higher for many years although there has been no rigorous assessment of coverage. Only three Canadian provinces (Ontario, New Brunswick and Manitoba), representing 43% of the population, have immunization against measles included in their school entry requirements (exemptions are granted for medical, philosophical or religious reasons). Other provinces have decided that immunization levels at school entry were high enough (95% and over) and that no such entry requirements were needed. The school catch-up campaigns undertaken in Canada among school-age children have had limited impact on college and university students since only one annual cohort now attending college/ university has benefited from this catch-up in 1996.

**Discussion**

Measles continues to be more common among adults in Canada than in the US. The greater circulation of measles virus in Canada compared with the US over the last 20 years might have been expected to result in an adult population with a higher level of naturally acquired protection. This virus circulation, however, even if higher has been relatively limited and has had little impact on the overall pool of susceptibles in Canada.

Of all the factors that could explain the higher rate of measles occurring in adults in Canada, the two most likely are younger
age at administration of the first dose in Canada and implement-
ment of a routine second dose policy for nearly 10 years in the
US, together with the implementation of prematriculation
immunization requirements in US colleges and universities.

The administration of the vaccine at an earlier age in Canada
may have prevented a greater number of cases to occur in
very young children than the US policy. However, because of
the higher rate of primary vaccine failure when vaccine is given
at an earlier age, this may have resulted in a larger build-up of
susceptibles in the adult population in Canada. Although this is
hard to quantify precisely, it is quite possible that the earlier
vaccination age in Canada resulted in up to 5% more sus-
cceptibles compared to the US policy. Due to the longer standing
two-dose policy in the US combined with PIR, the vast majority
of college and university students have received two doses
of measles containing vaccine. The recent implementation of
the school catch-up in Canada has, as yet, had no effect on the pool
of susceptibles in the post-secondary community with the
exception of the first year of university and colleges. The low
rate of measles in first-year college students in the British
Columbia outbreak demonstrates the effectiveness of the
campaign.

Since the two-dose prematriculation immunization policy has
not been totally enforced in all US colleges, the risk of outbreaks
in these colleges and universities that do not have requirements
remains. The US may experience a situation similar to that in
British Columbia.

The proportionally higher rate of international travel to
measles endemic countries for Canadians may also contribute to
a higher threat of importation and consequent increased rate of
measles in adults although the actual number of importations in
the US should be higher than that of Canada due to a popula-
tion nearly 10 times larger in the US.

Outbreaks of measles in adult populations in Canada and the
US have been limited over the past few years. The recent British
Columbia epidemic is the largest instance of cases based mostly
on incidence among adults in either country. Attempts to con-
troul outbreaks have mostly relied on revaccination of limited
groups potentially directly exposed to the measles cases. In
these circumstances, vaccination has been well accepted but of
dubious impact. The British Columbia experience with attempt-
ing to conduct mass immunization of adults in post-secondary
institutions was unique and identified several obstacles. Vaccine
acceptance in people not directly affected by the epidemic was
limited compared to that in younger age groups. In addition,
although the catch-up campaign probably had some effect on
curtailing the outbreak and preventing a larger number of cases,
its actual impact cannot be measured. The most effective way to
control measles in adults will remain adequate immunization of
younger age groups.

In addition to Canada and the US, outbreaks of measles in
adults have been observed in other parts of the world. The
problem is generally identified several years after a routine
measles vaccination programme has been implemented with
moderate to high levels of vaccine coverage, and a marked
reduction in measles virus circulation. While the vaccination
programme has primarily targeted infants, older people who
were not vaccinated and never experienced natural measles
remain susceptible to measles. When measles virus once again
circulates in a population partially protected by vaccination

several years later, a change of measles epidemiology is ob-
served with an increase in the average age of infection. Several
investigations in Africa have found an increase in the propor-
tion of measles cases occurring in adults following the introduc-
tion of routine infant immunization programmes.16–18 Recently
in Europe, relatively high levels of measles susceptibility have
been described via serological surveys in adolescents and young
adults in England and Spain.19–21

In 1997, simultaneous with the situation developing in Canada
there has been a relative resurgence of measles in Brazil, with
most cases being reported from São Paulo State. During 1997,
over 20 000 confirmed measles cases were reported from Brazil
with over half the cases occurring in unvaccinated people 20–29
years of age.22 Although the outbreak investigation is still on-
going and the role of adults in this outbreak is not fully under-
stood, proposed factors for this outbreak include: the presence
of large numbers of susceptible young adults in São Paulo,
possibly due to migration from rural areas with low measles
incidence; presence of large numbers of susceptible preschool
children due to low routine measles vaccination coverage and
the failure to conduct a follow-up vaccination campaign at the
appropriate time; and high population density. Moreover, many
cases have occurred among health-care workers, university
students and military recruits.

Conclusions

Canada is currently experiencing a situation that is likely to
occur in other countries that embark on measles elimination.
This situation occurs when an advanced control level has been
sustained for many years, but without 100% protection; less
than complete protection allows susceptibles to accumulate.
Adults, the age group most likely to travel internationally,
are likely to import measles, which can lead to re-establishing
endemic measles virus transmission. In the absence of effective
control measures, such importations could lead to outbreaks of
thousands of cases. Countries that have moved rapidly from
high levels of endemic measles to elimination are less likely
to experience this problem because most adults would have
previously had measles.

For countries that have not moved rapidly from endemic
measles to measles elimination, steps to prevent measles in adults
should be considered. Mass vaccination campaigns targeting
high-risk groups, if such groups could be identified, is one
approach. The cost-benefit ratio of such campaigns is likely to
be lower than campaigns targeting younger children and the
acceptance of such campaigns may also be lower, as was the
case in British Columbia. Probably the most cost-effective method
of preventing measles in adults is to stop measles virus circula-
tion in children through high vaccination coverage rates with
more than one dose of measles vaccine. In most developing
countries, rapid implementation of mass vaccination campaigns
will be the most cost-beneficial approach to achieving measles
elimination.

Ultimately, the global eradication of measles is the only way
to assure that outbreaks of measles will no longer threaten
Canadian and US populations. The experiences in Canada and
the US show that although some adults will remain susceptible
to measles, transmission among adults is unlikely to be a major
impediment to the global eradication of measles.
References


