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REVIEW



Meningococcal disease in adolescents and young adults: a review of the rationale for prevention through vaccination

Cynthia Burman^a, Lidia Serra^a, Charles Nuttens^b, Jessica Presa^c, Paul Balmer^a, and Laura York^a

^aPfizer Vaccine Medical Development, Scientific & Clinical Affairs, Collegeville, PA, USA; ^bPfizer Vaccines, Medical Development, Scientific & Clinical Affairs, Paris, France; ^cPfizer Vaccines, Medical & Scientific Affairs, Collegeville, PA, USA

ABSTRACT

Invasive meningococcal disease (IMD) caused by *Neisseria meningitidis* is characterized by high mortality and morbidity. While IMD incidence peaks in both infants and adolescents/young adults, carriage rates are often highest in the latter age groups, increasing IMD risk and the likelihood of transmission. Effective vaccines are available for 5 of 6 disease-causing serogroups. Because adolescents/young adults represent a significant proportion of cases, often have the highest carriage rate, and have characteristically low vaccination adherence, efforts should be focused on educating this population regarding long-term consequences of infection and the importance of meningococcal vaccination in prevention. This review describes the role of adolescents/young adults in meningococcal transmission and the clinical consequences and characteristics of IMD in this population. With a focus on countries with advanced economies that have specific meningococcal vaccination recommendations, the epidemiology of meningococcal disease and vaccination recommendations in adolescents/young adults will also be discussed.

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Introduction

Meningococcal disease is caused by the obligate human bacterium *Neisseria meningitidis*.¹ At least 12 distinct serogroups exist, of which serogroups A, B, C, W, X, and Y are the most common causes of IMD.¹ While respiratory tract infection with *N meningitidis* often leads to a period of asymptomatic nasopharyngeal carriage, in certain conditions, the bacteria can escape the mucosal barrier and replicate in the blood, which can rapidly lead to serious illness and death.^{1,2}

Meningococcal disease occurs worldwide;³ however, disease is generally uncommon, with < 5 annual cases per 100,000 persons in countries with advanced economies with meningococcal vaccination programs.^{4–6} Meningococcal disease clusters have also been reported in such countries, including France,⁷ the Netherlands,⁸ Canada,⁹ Australia,¹⁰ Ireland,¹¹ and the United Kingdom.¹² Meningococcal disease outbreaks, defined as multiple disease cases in a population attributed to the same serogroup over a short time period, have also occurred (eg, 44 cases per 100,000 students occurred during a US college outbreak in February 2015 compared with the US national incidence of 0.15 cases per 100,000 persons aged 17–22 years).¹³

Meningococcal disease rates vary with age, with the highest rates typically observed among infants; a second peak in incidence occurs in adolescents and young adults,^{2,3} with this population accounting for approximately one-third of total cases in some countries (eg, Austria, Czech Republic, Finland, and Sweden in 2016).¹⁴ However, *N meningitidis* acquisition does not always cause disease and often results

in asymptomatic colonization of the upper respiratory tract mucosa, a phenomenon known as carriage.² Although meningococcal disease is generally considered uncommon,^{4–6} carriage rates are relatively high, typically ranging from 10% to 35% in the general population.¹⁵ Although infants bear the greatest burden of disease, the highest carriage rates are often observed in adolescents and young adults (based on data from European countries in which serogroup B and C disease predominate).¹⁶ Therefore, improving vaccine availability, adherence to vaccination schedules, and promoting vaccination education in this age group should be goals in countries with significant meningococcal disease burden.

Vaccines are available to protect against 5 of the 6 predominant disease-causing meningococcal serogroups. Justification for vaccination of adolescents and young adults to protect against meningococcal disease includes countering waning immunity after childhood vaccination and achieving herd effects with high vaccine coverage in adolescents and young adults.¹⁷ Thus, this age group is an important target for disease control through vaccination.¹⁷

The purpose of this review is to describe the role of adolescents in *N meningitidis* transmission and the clinical consequences and characteristics of meningococcal disease in this age-based population. With a focus on countries with advanced economies¹⁸ that have specific recommendations in this population (ie, Australia, Canada, Europe, New Zealand, and the United States), the epidemiology of meningococcal disease in adolescents and the importance

of meningococcal vaccination of this population will be considered.

Role of adolescents and young adults in *N meningitidis* transmission

Transmitted through respiratory secretions, *N meningitidis* is often asymptotically carried at the mucosal surface of the nasopharynx.^{2,19} This process, known as carriage, is a prerequisite for the development of IMD. One of the most consistently identified risk factors for meningococcal nasopharyngeal carriage is age,¹⁹ with the highest carriage rates often observed in adolescents and young adults.¹⁶ In a systematic review and meta-analysis of data from 89 studies from European countries or countries in which meningococcal serogroup B (MenB) and meningococcal serogroup C (MenC) predominate, adolescents and young adults were determined to have the highest carriage rates of any age-based population, peaking at a point estimate of 23.7% for those aged 19 years.¹⁶

Characteristic social behaviors and not age appear to be largely responsible for the meningococcal carriage increase observed in adolescents and young adults,²⁰ with high *N meningitidis* carriage rates thought to result partly from social behaviors that increase transmission risk, such as dormitory or military barrack habitation, visiting bars, intimate kissing, and smoking.^{2,16,17,21} Carriage rates can rapidly increase among college students early in the school year²² and can vary according to environmental conditions.²³ Other factors associated with increased carriage risk include respiratory tract infections, socioeconomic status, and number and closeness of social contacts.^{20,24}

This risk of increased transmission in adolescents and young adults is supported by epidemiologic analyses finding a rapid increase in meningococcal carriage in the first month of the academic year, when university or college students are participating in social behaviors that aid in pathogen spread.²² Adolescents and young adults also are frequent travelers, which exposes them to meningococcal strains prevalent in other countries;²⁵ few seek professional healthcare advice before international travel.²⁶ High carriage rates in this population increase the likelihood of transmission and ultimately disease among adolescents and young adults as well as other age groups.¹⁷

Clinical consequences and characteristics of meningococcal infection in adolescents

Meningococcal disease develops rapidly, has a high mortality rate, and can cause serious and long-term complications in survivors.¹ The most common IMD manifestations are meningitis and septicemia, which can occur concomitantly.^{27,28} Signs and symptoms of meningitis in children aged > 5 years include headache, neck stiffness, fever, vomiting, photophobia, rash, irritability, agitation, drowsiness, and seizures.²⁸ In children and adolescents, septicemia typically manifests as lower limb pain, cold peripheries, and skin pallor; rash is a classic sign of meningococcal septicemia, occurring in 40% to 80% of cases.²⁸

Adolescents display a different clinical disease pattern than infants and typically have less rapid disease progression.^{27,29} For example, a 2006 study characterizing symptoms according to time from onset found that early symptoms specific to adolescents (aged 15–16 years) are common to other self-limiting viral illnesses, including headache, sore throat, and thirst, followed by general aches and fever within 5 to 8 hours.²⁹ Within 9 to 12 hours of onset, signs and symptoms in adolescents include drowsiness, difficulty breathing, diarrhea, neck stiffness, rash, and photophobia, as well as clinical symptoms of sepsis, such as leg pain, cold hands and feet, and abnormal skin color. Confusion/delirium, unconsciousness, and seizures typically occur 24 hours after onset. The authors note that leg pain, cold hands and feet, and abnormal skin color are signs of early meningococcal disease in adolescents, occurring within 12 hours of onset, and should be considered for early identification of disease rather than classic symptoms (eg, rash, meningism, unconsciousness, fever), which occur later in the adolescent disease course.²⁹ Notably, the median time from onset to hospital admission was longer in adolescents (22 hours in those aged 15–16 years) compared with younger children (13–14 hours in those aged < 1–4 years), suggesting that adolescents with meningococcal disease obtain medical attention later than young children, which might have detrimental effects on outcomes in adolescents.

Other studies note that signs and symptoms of meningococcal disease in older children are similar to those in adults and include fever, nausea, vomiting, photophobia, headache, agitation, decreased consciousness, and neck stiffness; seizures and focal neurologic signs are less commonly observed in older versus younger children.²⁷ Recently, meningococcal serogroup W (MenW) clonal complex 11 (cc11) has been responsible for several adolescent cases characterized by gastrointestinal presentations, including nausea, abdominal pain, vomiting, and diarrhea.³⁰

Despite antibiotic treatment for IMD, the case fatality rate (CFR) for meningococcal disease in the general population of many advanced economies (ie, Australia, Canada, Europe, New Zealand, and the United States) remains high (ranging from a CFR of 2.7% in New Zealand in 2016 to 13.9% in the United States in 2016).^{5,14,31–34} CFRs for meningococcemia are considerably higher (up to 40%).⁵ CFRs in adolescents and young adults are comparable with those of the general population. Based on the latest epidemiologic data reporting CFRs by age group in the United States, Europe, and New Zealand, CFRs in adolescents and young adults range from 8% to 12.5%.^{14,35,36} CFRs in adolescents can also vary by serogroup.³⁷ For instance, CFRs in adolescents in Quebec, Canada, between 1990 and 1994 were much higher for MenC than MenB disease (14% vs 7%). A similar finding was found in Australia between 1999 and 2015, with higher CFRs for MenC than MenB disease (6% vs 2%) in adolescents and young adults aged 15 to 24 years.³⁸

Among survivors of meningococcal infection, up to 20% suffer serious and long-term physical and psychological sequelae.^{39,40} In a study of IMD outcomes in adolescents and young adults (aged 16–22 years), sequelae were reported in 58% of 101 cases and included skin scarring (18%), vertigo (17%), mobility problems (13%), speech problems (13%), hearing problems (12%), upper limb function impairment

(4%), amputations (3%), and seizures (2%).⁴¹ In addition, 28% of cases had symptoms consistent with Raynaud's disease, and 41% to 53% reported that IMD affected leisure activities, physical abilities, academic achievements, home life, friendships, and job choices. Compared with age- and sex-matched controls, adolescents who survived IMD reported greater fatigue, decreased social support, reduced quality of life, and poorer educational outcomes, in addition to previously described memory, attention, and psychomotor speed limitations. Younger adolescents also showed a greater degree of cognitive deficit compared with older adolescents, which was thought to be attributable to the vulnerability of the developing brain to acute infections in younger adolescents. In a questionnaire-based study of IMD survivors published in 1998, approximately a quarter of whom were aged 10 to 19 years, many respondents reported decreases in quality of life and increased anxiety.³⁷

Epidemiology of meningococcal disease

Provision of relevant vaccination programs requires not only safe and effective vaccines against meningococcal disease but also consideration of contemporary surveillance data to identify at-risk populations and the prevalent disease-causing serogroups at a given time. Epidemiologic data for meningococcal disease indicate that although a general decline has been observed globally, IMD continues to be a concern in adolescents and young adults in countries with advanced economies. For example, outbreaks of meningococcal disease are uncommon and account for < 2% of all cases of meningococcal disease in the United States; however, adolescents and young adults are at increased risk when outbreaks do occur.⁴² This may be partly attributed to

lack of routine meningococcal vaccination against some disease-causing serogroups,⁴³ typical social behaviors,^{2,16,17,21} and high carriage rates.¹⁶ Mass gathering events have also been linked with meningococcal outbreaks in adolescents. For instance, the 2015 World Boy Scout Jamboree in Japan culminated in 6 MenW cases among attendees aged 15 to 17 years from Scotland and Sweden.⁴⁴

Overall incidence rates of meningococcal disease in adolescents and young adults compared with the general population vary geographically. However, in countries with advanced economies, incidence rates are typically higher in older adolescents and young adults than in the general population (Figure 1).^{14,33,34,45,46} In Australia, Canada, Europe, New Zealand, and the United States, the incidence of meningococcal disease is approximately 1.5- to 3-fold higher in older adolescents/young adults than in the general population based on the most recent surveillance data. The highest incidence of meningococcal disease among older adolescents and young adults in these countries was in older adolescents (aged 15–19 years) in New Zealand (3.1 cases per 100,000 population in 2016)³³ and the lowest in younger adolescents (aged 11–15 years) in the United States (0.04 cases per 100,000 population in 2016).³⁴

Meningococcal serogroup B is one of the most common causes of meningococcal disease in several countries with advanced economies, including Australia,³¹ Canada,³² Europe,¹⁴ New Zealand,³³ and the United States,⁴⁷ and, compared with the general population, disproportionately affects older adolescents and young adults in Australia³⁸ and the United States.³⁴ MenB disease has also been the cause of recent outbreaks at college campuses in the United States,⁴⁷ outbreaks in nursery and high schools,^{48–50} and a family

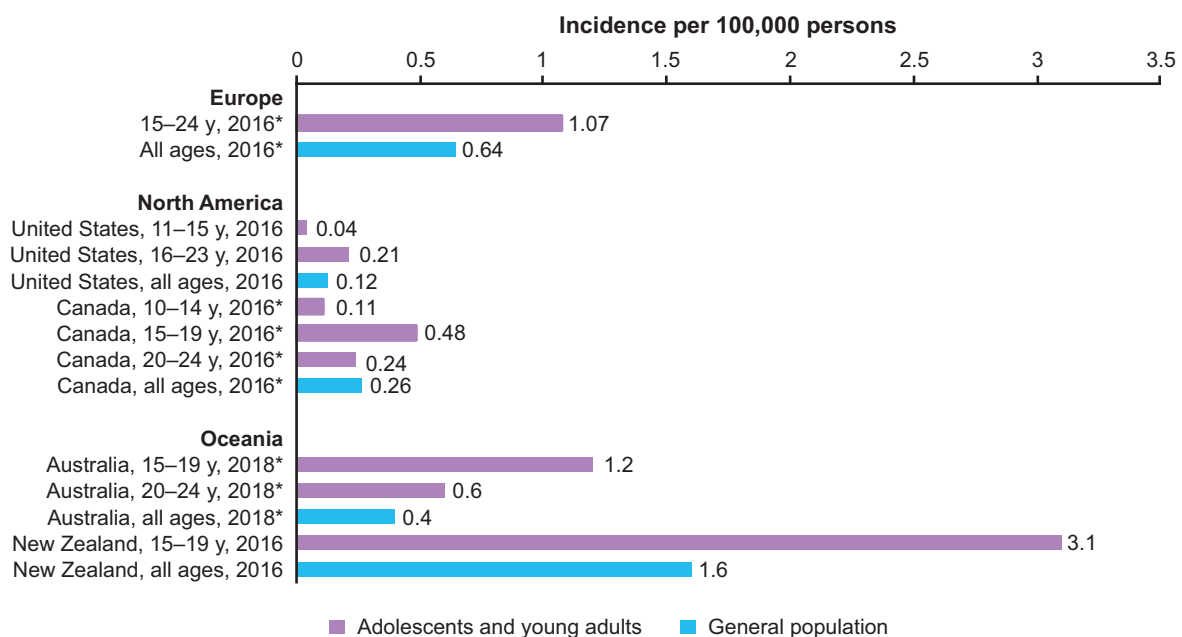


Figure 1. Incidence of meningococcal disease in adolescents by country.^{14,33,34,45,46}

*Data are for invasive meningococcal disease.

For the United States, data by age group are for the Active Bacterial Core Surveillance areas (California [3-county San Francisco Bay area], Colorado [5-county Denver area], Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York [15-county Rochester and Albany areas], Tennessee [20 counties]) excluding Oregon. Data for the general population are for national estimates reported to the National Notifiable Disease Surveillance System.

cluster of disease in Europe.⁵¹ An increase in MenW disease owing to endemic expansion of a single type cc11 has been observed across all age groups in England, Wales, and the Netherlands.^{12,52,53} In England and Wales, among those aged 5 to 19 years, cases of MenW cc11 increased from 3 in 2008/2009 to 15 in 2013/2014 compared with 21 in 2008/2009 and 98 in 2013/2014 across all ages.¹² In the Netherlands, the number of cases of MenW disease across all age groups increased by 418% from 2014/2015 to 2015/2016, with 55% (29/53 cases) being MenW cc11. An increase in the number of MenW c11 cases was observed in adolescents and young adults; however, the greatest increased burden was in the elderly.⁵³ In additional countries, including France,^{54,55} Spain,⁵⁶ Sweden,⁵⁷ Scotland,⁵⁷ and Australia,⁵⁸ an increasing number of cases due to MenW cc11 has been observed recently, and in some countries have been associated with adolescents/young adults and older age groups.^{53–55,57}

Meningococcal vaccination of adolescents and young adults

Various formulations of meningococcal vaccines are available, with the first formulations developed nearly 50 years ago.⁵⁹ Four types of meningococcal vaccines targeting various serogroups have been used in the last decade: outer membrane vesicle (OMV), polysaccharide, conjugate, and recombinant protein.^{60,61} Polysaccharide vaccines were the first introduced, in the 1970s,⁶² followed by OMV vaccines targeting specific MenB disease-causing strains in the late 1980s,⁶¹ conjugate vaccines in the late 1990s,⁶³ and recombinant protein MenB vaccines consisting of proteins found on the bacterial surface in the current decade.⁶⁰ However, polysaccharide vaccines are

no longer manufactured, as conjugate vaccines, in which the polysaccharide is conjugated to a carrier protein, were found to be more effective in children aged < 2 years.^{60,63} Meningococcal vaccines currently available in Australia, Canada, Europe, New Zealand, and the United States are listed in Table 1.^{60,63–86}

Several examples of the positive effects of vaccinating adolescents with meningococcal vaccines are available. For instance, vaccination of adolescents in the United States with a quadrivalent vaccine against serogroups A, C, W, and Y (MenACWY) decreased meningococcal disease due to serogroups C, W, and Y by 80% among those aged 11 to 19 years.¹ Similarly, following inclusion of monovalent MenC and MenACWY vaccines in routine childhood and adolescent vaccination programs between 2002 and 2007, the incidence of MenC disease in the Canadian general population decreased by 93% and the incidence of IMD overall decreased by 55%,³² indicative of both direct and indirect (herd) effects of vaccination. In addition, following an increase in the number of cases of MenB disease attributed to a particular virulent strain in the 1990s, New Zealand provided vaccination with a MenB OMV to those aged < 20 years between 2004 and 2006, resulting in a 90% decrease in disease attributed to the epidemic strain by 2010.⁸⁷ In the United Kingdom, routine adolescent MenC vaccination was replaced in the 2015/2016 school year with MenACWY vaccination in response to an increase in MenW cases in addition to a catch-up campaign for adolescents (aged 14–18 years) and new university entrants (aged ≤ 25 years).⁸⁸ After the first year of the campaign, those specifically targeted for vaccination showed a decline in MenW cases.⁸⁸

As adolescents and young adults are the primary carriers of meningococci, vaccination of this population can also

Table 1. Meningococcal vaccines currently licensed for use in adolescents and young adults in countries with advanced economies.*

	Vaccine Type	Serogroups Included	Year First Licensed	Countries/Regions of Licensure	Approved Ages
MenACWY-CRM ^{60,64–67} (Menveo®, GlaxoSmithKline)	Conjugate	ACWY	2010	Australia Canada Europe United States	≥ 2 months 2 months–55 years ≥ 2 years 2 months–55 years
MenACWY-D ^{60,63,68–71} (Menactra®, Sanofi Pasteur)	Conjugate	ACWY	2005	Australia Canada New Zealand United States	9 months–55 years
MenACWY-TT ^{72–74} (Nimenrix®, Pfizer)	Conjugate	ACWY	2012	Australia Canada Europe New Zealand	12 months–55 years 6 weeks–55 years ≥ 6 weeks 12 months–55 years
MenB-4C ^{60,63,75–78} (Bexsero®, GlaxoSmithKline)	Protein	B	2013	Australia Canada Europe United States	≥ 2 months 2 months–17 years ≥ 2 months 10–25 years
MenB-FHbp ^{60,79–82} (Trumenba®, Pfizer)	Protein	B	2014	Australia Canada Europe United States	≥ 10 years 10–25 years ≥ 10 years 10–25 years
MenC-CRM ^{63,83} (Menjugate®, GlaxoSmithKline)	Conjugate	C	2000	Canada	≥ 2 months
MenC-TT ^{63,84,85} (NeisVac-C®, Pfizer)	Conjugate	C	2000	Australia Canada New Zealand	≥ 8 weeks ≥ 2 months ≥ 8 weeks
MenC-TT/Hi-TT ^{63,86} (Menitorix®, GlaxoSmithKline)	Conjugate	C	2006	Australia	6 weeks–24 months

*Advanced economies were defined by the International Monetary Fund and included Australia, Canada, Europe, New Zealand, and the United States.¹⁸ Data are current as of June 2018.

decrease meningococcal carriage and transmission, inducing herd protection.¹⁷ For instance, a national vaccination campaign in the United Kingdom using a conjugate MenC vaccine in infants, children, and adolescents resulted in a statistically significant decrease in the prevalence of MenC carriage in adolescents aged 15 to 19 years lasting at least 2 years and resulting in 75% vaccine effectiveness against carriage.⁸⁹ However, vaccination of other age-based populations does not appear to confer herd effects in adolescents. The importance of vaccine uptake has also been demonstrated in France, where routine vaccination against MenC was recommended for infants and a catch-up for those aged 2 to 24 years.⁹⁰ However, the lack of adequate vaccine coverage, particularly among adolescents and young adults, was thought to have resulted in a lack of herd effect. Currently, the application of available meningococcal vaccination recommendations is suggested, with a stress on the importance of adolescents and young adults both for direct protection and for herd effects.

Current recommendations for meningococcal vaccination of adolescents and young adults

With the exception of vaccine-preventable diseases that occur specifically in adolescence and beyond, the goal of vaccination strategies in adolescents without chronic medical conditions is often to boost protective immune responses for vaccines previously administered during infancy and childhood.⁹¹ Specifically for meningococcal vaccines, given the seriousness of IMD because of its complications and the increased risk of carriage and disease in adolescents, many advanced economies recommend vaccination of this population against meningococcal disease, often as part of routine primary or booster immunizations or as a catch-up immunization if adolescents were not previously vaccinated at a younger age (Table 2).^{92–97}

Recommendations for meningococcal vaccination are dependent on specific characteristics of a country, including individual policies and funding considerations, as well as the overall incidence and frequency of outbreaks in that region. In addition, meningococcal recommendations usually vary depending on the locally prevalent serogroup.⁹⁸ For instance, in the United States, MenB accounts for approximately 56% of meningococcal disease cases in those 11 to 23 years of age.³⁴ The Advisory Committee on Immunization Practices (ACIP), which provides expert external advice and guidance on vaccine use to the Centers for Disease Control and Prevention (CDC),⁴³ recommends routine vaccination of all adolescents aged 11 to 18 years with a MenACWY vaccine.⁹⁶ A single dose should be administered as a primary dose at age 11 or 12 years, with a booster dose at age 16 years for those who received the first dose before age 16. ACIP also recommends the routine use of a MenB vaccine in those aged ≥ 10 years who are at increased risk of disease, including those who have persistent complement component deficiencies, anatomic or functional asplenia, or are routinely exposed to isolates of *N meningitidis* or exposed to a community experiencing a MenB disease outbreak (category A recommendation made for all persons in an age- or risk-factor-based group).⁹⁷ In addition, MenB vaccination should be considered in individuals aged

Table 2. Clinical recommendations for meningococcal vaccination of adolescents and young adults in advanced economies.*

	Age, Years	Recommendations
Australia ⁹²	15–19	MenB [†]
Canada ⁹³	12–24	MenC conjugate or MenACWY conjugate [‡] MenB-4C for those who want to protect against serogroup B infection
Europe ⁹⁴		
Austria	11–13	MenACWY
Cyprus	≥ 2	MenACWY polysaccharide (only on specific indications)
Czech Republic	13–17	MenACWY
	≥ 18	MenACWY and MenB
France	2–24	MenC (catch-up)
Germany	2–17	MenC (catch-up)
Greece	11–12	MenACWY
	≥ 13	MenACWY (catch-up)
Ireland	12–13	MenC
Italy	12–14	MenACWY
Liechtenstein	11–20	MenC (catch-up)
Poland	19	MenC
Spain	12	MenC
United Kingdom	13–15, 17–25	MenACWY conjugate [§]
New Zealand ⁹⁵	Adolescents/ young adults	MenC or MenACWY vaccination should be considered for those living or planning to live in communal accommodation
United States ^{96,97}	11–18	MenACWY (single dose at age 11 or 12 with booster at age 16 years)
	≥ 10	MenB (routine use for individuals aged ≥ 10 years at increased risk for MenB disease; consideration for individuals aged 16–23 years for short-term protection)

Data are current as of June 2018.

*Advanced economies were defined by the International Monetary Fund and included Australia, Canada, Europe, New Zealand, and the United States.¹⁸

[†]Particularly recommended for adolescents and young adults living in close quarters.

[‡]Dependent on local epidemiology and programmatic considerations.

[§]From September 2015, a MenACWY conjugate vaccine replaced the MenC vaccine.¹⁸

^{||}MenB vaccines are not currently licensed in New Zealand.

16 to 23 years for short-term protection against MenB disease (category B recommendation for individual clinical decision making).

In Canada, MenB is the most common cause of IMD in the general population, accounting for 63% of cases from 2011 to 2015.³² In adolescents aged 15 to 19 years, the most common causes of IMD from 2006 to 2011 were serogroups B and Y.⁹⁹ In Canada, dependent on provincial epidemiology and programs, routine use of either a conjugate MenC or MenACWY is recommended for adolescents and young adults from 12 to 24 years of age, even if previously vaccinated during early childhood.⁹³ Several Canadian provinces have recently elected to provide conjugate MenACWY vaccines to children and adolescents in response to an increase in cases covered by the vaccine.^{100–107} Similar to ACIP recommendations, vaccination against MenB is recommended on an individual basis for adolescents and young adults in Canada.⁹³

In Europe, adolescents and young adults aged 15 to 24 years experience the greatest burden of IMD of all age-based populations, accounting for 18.7% of cases in 2016.¹⁴ MenB is the most common cause of IMD in individuals 15 to 24 years of age, accounting for 52.1% of cases in 2016, followed by MenC (18.0% of cases) and MenW (16.0% of cases).¹⁴ As such, several

European countries recommend MenACWY and MenB meningococcal vaccination for adolescents.⁹⁴ In the United Kingdom, a MenACWY conjugate vaccine is recommended for individuals aged 13 to 25 years.¹⁰⁸ MenACWY vaccination is recommended for adolescents aged 11 to 13 years in Austria, 11 to 12 years in Greece, and 12 to 18 years in Italy.⁹⁴ MenC vaccination is recommended for adolescents aged 12 to 13 years in Ireland, 12 years in Spain, and 19 years in Poland; vaccination in Poland is not mandatory.⁹⁴ The Czech Republic recommends routine vaccination with MenACWY in adolescents aged 13 to 17 years and with both MenACWY and MenB vaccines for individuals aged ≥ 18 years, but vaccination is not mandatory.⁹⁴

In Australia, MenB disease predominated from 2002 to 2015, accounting for 43% to 78% of cases each year; however, MenW became the predominant disease-causing serogroup in 2016.³¹ In 2017, MenB accounted for 36% of cases and MenW for 37% of cases in Australia. The Australian Department of Health currently recommends MenB vaccination for adolescents aged 15 to 19 years, particularly for those living in close quarters, such as military accommodation or student residential accommodation, but does not recommend MenACWY as part of routine vaccination of healthy adolescents and young adults.⁹² However, a MenACWY vaccination campaign was initiated in 2016, during which the vaccine was offered to adolescents aged 15 to 19 years living in areas with a MenW outbreak.^{109–112}

In New Zealand, older adolescents (aged 15–19 years) have one of the highest rates of meningococcal disease among age-based groups.³³ In 2016, the most common cause of meningococcal disease was MenB. The New Zealand Ministry of Health recommends that MenACWY or MenC vaccination be considered for adolescents and young adults living or planning to live in communal accommodation, including hostels, student residences, boarding school, military accommodation, or correctional facilities.⁹⁵ Of note, MenB vaccines are not currently licensed in New Zealand.

Adherence of adolescents and young adults to recommended vaccination schedules

Although recommendations for use of meningococcal vaccines in adolescents and young adults exist in various countries with advanced economies,^{43,96,97,108,113–115} low vaccination adherence, particularly to multidose schedules, is common in this age group.^{116–118} Improving vaccination rates among adolescents and young adults can help decrease outbreaks of vaccine-preventable diseases and associated economic and societal costs and can improve herd protection.¹¹⁸ However, ensuring that adolescents and young adults adhere to recommended vaccination schedules can be challenging. The decreased frequency in which adolescents visit healthcare providers and difficulty in communicating and obtaining consent from the adolescent or parent/guardian also contribute to nonadherence with recommended vaccine schedules.¹⁷ These challenges can result in lower vaccine coverage in adolescents compared with younger age groups.¹⁷

Meningococcal vaccine coverage in adolescents varies by country and vaccine type (Figure 2).^{54,119–125} The highest coverage for MenC vaccine was reported in Portugal in 2015 in adolescents aged 14 years (98%),¹²⁴ and the lowest coverage was observed in France in 2016 in young adults aged 20 to 25 years (10%).¹²⁶ MenACWY coverage in adolescents was only reported in the United States, with 82% of adolescents aged 13 to 17 years receiving MenACWY in 2016.¹¹⁹

A recent systematic review found that strategies to increase vaccination uptake among adolescents, including mandatory vaccination in schools and reminder and distribution for adolescent vaccination, can considerably improve vaccine coverage and have led to significant decreases in the prevalence of associated diseases in this population.¹¹⁸ Adherence by adolescents and young adults to recommended vaccine schedules might also improve by decreasing the number of vaccine doses required. In the United States, vaccination against MenB infection among

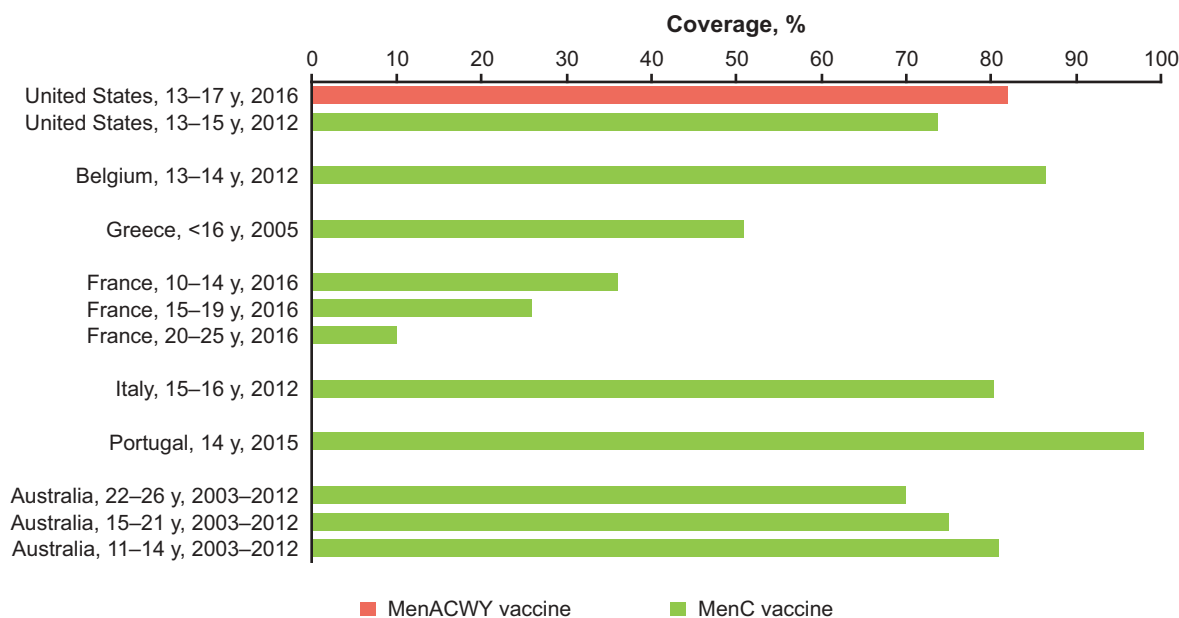


Figure 2. Coverage of meningococcal vaccines in adolescents.^{54,119–125}

MenC = Meningococcal serogroup C conjugate vaccine; MenACWY = quadrivalent meningococcal conjugate vaccine.

adolescents might improve given the availability of 2 meningococcal serogroup B vaccines (MenB-4C; MenB-FHbp) that can be administered as a 2-dose series.¹²⁷

Concomitant administration of meningococcal vaccines with other recommended vaccines might also improve coverage in adolescents and young adults.¹²⁸ The CDC notes that meningococcal conjugate and MenB vaccines can be administered during the same office visit but preferably at different injection sites.¹²⁹ Coadministration of meningococcal vaccines with other vaccines routinely recommended for adolescents also is possible, as no clinically relevant interactions have been observed.^{63,128,129} Concomitant administration also does not affect vaccine immunogenicity, as shown in studies of healthy adolescents in whom MenB-FHbp was coadministered with tetanus, diphtheria, and acellular pertussis (Tdap); Tdap/inactivated polio virus; or quadrivalent human papilloma virus vaccines.^{130–132} Simplified vaccination schedules can result in fewer healthcare visits and vaccine doses,¹³³ which could facilitate adherence by reducing logistical challenges and resources needed and increasing vaccine acceptability for providers, parents/guardians, and adolescents.

Educating healthcare providers and the general population about the risks of IMD and carriage in adolescents, available vaccines, and recommended vaccination schedules could also increase adherence. In one study, overall meningococcal vaccination rates increased among first-year college students who received educational materials before arriving on campus.¹³⁴ In France, where vaccinations typically are administered during visits to a general practitioner or pediatrician, meningococcal coverage rates are low.¹³⁵ In a survey of French general practitioners, only 33% routinely recommended MenC vaccination for their patients aged 2 to 24 years.¹³⁵ An educational campaign for healthcare providers and the general population, which can include information on meningococcal vaccine recommendations, benefits of vaccination, and risk of meningococcal disease in adolescents, might help increase meningococcal coverage rates and adherence.¹³⁵

Summary

Adolescents and young adults are at increased risk of meningococcal disease in many countries. Individuals in this age group are also the most common reservoir for transmission of *N meningitidis*. Several countries recommend routine vaccination of adolescents against meningococcal disease, with specific recommendations varying by local epidemiologic considerations, individual policies, and funding considerations. Benefits of meningococcal vaccination of adolescents and young adults include decreased rates of IMD and the potential for diminished nasopharyngeal carriage. Further data are needed regarding methods to improve adherence to vaccination schedules and coverage in this age group.

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