use approaches that maximize vaccination rates (e.g., education about the benefits of vaccination, convenient access, and the provision of Tdap at no charge).

**Prevaccination Testing**

Prevaccination serologic testing is not recommended.

**Demonstrating Immunity**

Immunity cannot be demonstrated through serologic testing because serologic correlates of protection are not well established.

**Controlling Pertussis Outbreaks in Health-Care Settings**

Prevention of pertussis transmission in health-care settings involves diagnosis and early treatment of clinical cases, droplet isolation of infectious patients who are hospitalized, exclusion from work of HCP who are infectious, and postexposure prophylaxis. Early diagnosis of pertussis, before secondary transmission occurs, is difficult because the disease is highly communicable during the catarrhal stage, when symptoms are still nonspecific. Pertussis should be considered in the differential diagnoses for any patient with an acute cough illness with severe or prolonged paroxysmal cough, particularly if characterized by posttussive vomiting, whoop, or apnea. Nasopharyngeal specimens should be taken, if possible, from the posterior nasopharynx with a calcium alginate or Dacron swab for cultures. Specimens should be taken, if possible, from the posterior nasopharynx with a calcium alginate or Dacron swab for cultures.

Health-care facilities should maximize efforts to prevent transmission of *Bordetella pertussis*. Precautions to prevent respiratory droplet transmission or spread by close or direct contact should be employed in the care of patients admitted to hospital with suspected or confirmed pertussis (265). These precautions should remain in effect until patients are improved clinically and have completed at least 5 days of appropriate antimicrobial therapy. HCP in whom symptoms (i.e., unexplained rhinitis or acute cough) develop after known pertussis exposure might be at risk for transmitting pertussis and should be excluded from work until 5 days after the start of appropriate therapy (3).

Data on the need for postexposure prophylaxis in Tdap-vaccinated HCP are inconclusive (264). Certain vaccinated HCP are still at risk for *B. pertussis*. Tdap might not preclude the need for postexposure prophylaxis. Postexposure antimicrobial prophylaxis is recommended for all HCP who have unprotected exposure to pertussis and are likely to expose a patient at risk for severe pertussis (e.g., hospitalized neonates and pregnant women). Other HCP should either receive postexposure antimicrobial prophylaxis or be monitored daily for 21 days after pertussis exposure and treated at the onset of signs and symptoms of pertussis.

**Varicella**

**Background**

**Epidemiology and Risk Factors**

Varicella is a highly infectious disease caused by primary infection with varicella-zoster virus (VZV). VZV is transmitted from person to person by direct contact, inhalation of aerosols from vesicular fluid of skin lesions of varicella or herpes zoster (HZ), a localized, generally painful vesicular rash commonly called shingles, or infected respiratory tract secretions that also might be aerosolized (266). The average incubation period is 14–16 days after exposure to rash (range: 10–21 days). Infected persons are contagious an estimated 1–2 days before rash onset until all lesions are crusted, typically 4–7 days after rash onset (266). Varicella secondary attack rates can reach 90% among susceptible contacts. Typically, primary infection with VZV results in lifetime immunity. VZV remains dormant in sensory-nerve ganglia and can reactivate at a later time, causing HZ. Before the U.S. childhood varicella vaccination program began in 1995, approximately 90% of varicella disease occurred among children aged <15 years (266). During 1997–2009, national varicella vaccine coverage among children aged 19–35 months increased from 27% to 90%, leading to dramatic declines of >85% in varicella incidence, hospitalizations, and deaths (267–269). The decline in disease incidence was greatest among children for whom vaccination was recommended; however, declines occurred in every age group including infants too young to be vaccinated and adults, indicating reduced communitywide transmission of VZV.

Current incidence of varicella among adults is low (<0.1/1,000 population), and adult cases represent <10% of all reported varicella cases (270). National seroprevalence data from 1999–2004 demonstrated that, in the early vaccine era, adults continued to have high immunity to varicella (271). In this study, 98% of persons aged 20–49 years had VZV-specific IgG antibodies. However, with declining likelihood of exposure to VZV, children and adolescents who did not receive 2 doses of varicella vaccine could remain susceptible to VZV infection as they age into adulthood, when varicella can be more severe.

The clinical presentation of varicella has changed since the implementation of the varicella vaccination program, with more than half of varicella cases reported in 2008 occurring among persons who were vaccinated previously, the majority of them children. Varicella disease in vaccinated children (breakthrough varicella) usually has a modified or atypical presentation; the rash is typically mild, with <50 lesions that are...
more likely to be predominantly maculopapular than vesicular (266). Fever is less common, and the duration of illness is shorter. Nevertheless, breakthrough varicella is infectious. One study indicated that vaccinated children with varicella with <50 lesions were only one third as infectious as unvaccinated children whereas those with ≥50 lesions were as infectious as unvaccinated children (272). Because the majority of adults are immune and few need vaccination, fewer breakthrough cases have been reported among adults than among children, and breakthrough varicella in adults has tended to be milder than varicella in unvaccinated adults (273,274).

The epidemiology of varicella in tropical and subtropical regions differs from that in the United States. In these regions, a higher proportion of VZV infections are acquired later in life. Persons emigrating from these regions might be more likely to be susceptible to varicella compared to U.S.-born persons and, therefore, are at a higher risk for developing varicella if unvaccinated and exposed (275,276).

**Disease in Health-Care Settings and Impact on Health-Care Personnel and Patients**

Although relatively rare in the United States since introduction of varicella vaccine, nosocomial transmission of VZV is well recognized and can be life-threatening to certain patients (277–289). In addition to hospital settings, nosocomial VZV transmission has been reported in long-term–care facilities and a hospital-associated residential facility (290,291). Sources of nosocomial exposure that have resulted in transmission include patients, HCP, and visitors with either varicella or HZ. Both localized and disseminated HZ in immunocompetent as well as immunocompromised patients have been identified as sources of nosocomial transmission of VZV. Localized HZ has been demonstrated to be much less infectious than varicella; disseminated HZ is considered to be as infectious as varicella (266). Nosocomial transmission has been attributed to delays in the diagnosis or reporting of varicella or HZ and in failures to implement control measures promptly. In hospitals and other health-care settings, airborne transmission of VZV from patients with either varicella or HZ has resulted in varicella in HCP and patients who had no direct contact with the index case-patient (284–288,291). Although all susceptible patients in health-care settings are at risk for severe varicella disease with complications, certain patients without evidence of immunity are at increased risk: pregnant women, premature infants born to susceptible mothers, infants born at <28 weeks’ gestation or who weigh ≤1,000 grams regardless of maternal immune status, and immunocompromised persons of all ages (including persons who are undergoing immunosuppressive therapy, have malignant disease, or are immunodeficient).

VZV exposures among patients and HCP can be disruptive to patient care, time-consuming, and costly even when they do not result in VZV transmission (281,282,292). Studies of VZV exposure in health-care settings have documented that a single provider with unrecognized varicella can result in the exposure of >30 patients and >30 employees (292). Identification of susceptible patients and staff, medical management of susceptible exposed patients at risk for complications of varicella, and furloughing of susceptible exposed HCP are time-consuming and costly (281,282).

With the overall reduction in varicella disease attributable to the success of the vaccination program, the risk for exposure to VZV from varicella cases in health-care settings is likely declining. In addition, an increasing proportion of varicella cases occur in vaccinated persons who are less contagious. Diagnosis of varicella has become increasingly challenging as a growing proportion of cases occur in vaccinated persons in whom disease is mild, and HCP encounter patients with varicella less frequently. Although not currently routinely recommended for the diagnosis and management of varicella, laboratory testing of suspected varicella cases is likely to become increasingly useful in health-care settings, especially as the positive predictive value of clinical diagnosis declines.

**Vaccine Effectiveness, Duration of Immunity, and Vaccine Safety**

**Vaccine Effectiveness**

Formal studies to evaluate vaccine efficacy or effectiveness have not been performed among adults. Studies of varicella vaccine effectiveness performed among children indicated good performance of 1 dose for prevention of all varicella (80%–85%) and >95% effectiveness for prevention of moderate and severe disease (266,293). Studies have indicated that a second dose among children produces an improved humoral and cellular immune response that correlates with improved protection against disease (266,294).

Varicella vaccine effectiveness is expected to be lower in adults than in children. Adolescents and adults require 2 doses to achieve seroconversion rates similar to those seen in children after 1 dose (266). A study of adults who received 2 doses of varicella vaccine 4 or 8 weeks apart and were exposed subsequently to varicella in the household estimated an 80% reduction in the expected number of cases (295).

**Duration of Immunity**

Serologic correlates of protection against varicella using commercially available assays have not been established for adults (266). In clinical studies, detectable antibody levels have persisted for at least 5 years in 97% of adolescents and adults who were administered 2 doses of varicella vaccine.
4–8 weeks apart, but boosts in antibody levels were observed following exposures to varicella, which could account for the long-term persistence of antibodies after vaccination in these studies (295). Studies have demonstrated that whereas 25%–31% of adult vaccine recipients who seroconverted lost detectable antibodies 1–11 years after vaccination (273,296), vaccine-induced VZV-specific T-cell proliferation (marker for cell-mediated immunity [CMI]) was maintained in 94% of adults 1 and 5 years postvaccination (297). Disease was mild in vaccinated persons who developed varicella after exposure to VZV, even among vaccinees who did not seroconvert or who lost detectable antibody (273,274). Severity of illness and attack rates among vaccinated adults did not increase over time. These studies suggest that VZV-specific CMI affords protection to vaccinated adults, even in the absence of detectable antibody response.

Vaccine Safety

The varicella vaccine has an excellent safety profile. In clinical trials, the most common adverse events among adolescents and adults were injection-site complaints (24.4% after the first dose and 32.5% after the second dose) (266,295). Varicella-like rash at the injection site occurred in 3% of vaccine recipients after the first dose and in 1% after the second. A nonlocalized rash occurred in 5.5% of vaccine recipients after the first dose and in 0.9% after the second, with a median number of lesions of five, at a peak of 7–21 and 0–23 days postvaccination, respectively (295). Data on serious adverse events among adults after varicella vaccination are limited, but the proportion of serious adverse events among all adverse events reported to the Vaccine Adverse Events Reporting System during 1995–2005 was low (5%) among both children and adults (298). Serious adverse events reported among children included pneumonia, hepatitis, HZ (some hospitalized), meningitis with HZ, ataxia, encephalitis, thrombocytopenic purpura. Not all adverse events reported after varicella vaccination have been laboratory confirmed to be attributable to the vaccine strain VZV (266,298).

Risk for transmission of vaccine virus was assessed in placebo recipients who were siblings of vaccinated children and among healthy siblings of vaccinated leukemic children (266). The findings suggest that transmission of varicella vaccine virus from healthy persons to susceptible contacts is very rare. The risk might be increased in vaccinees in whom a varicella-like rash develops after vaccination. However, this risk is also low. The benefits of vaccinating HCP without evidence of immunity outweigh this extremely low potential risk. Since implementation of the varicella vaccine program, transmission of vaccine virus has been documented from eight persons (all of whom had a rash after vaccination) resulting in nine secondary infections among household and long-term–care facility contacts (299). No transmission has been documented from vaccinated HCP.

Recommendations

Vaccination

Health-care institutions should ensure that all HCP have evidence of immunity to varicella. This information should be documented and readily available at the work location. HCP without evidence of immunity to varicella should receive 2 doses of varicella vaccine administered 4–8 weeks apart. If >8 weeks elapse after the first dose, the second dose may be administered without restarting the schedule. Recently vaccinated HCP do not require any restriction in their work activities; however, HCP who develop a vaccine-related rash after vaccination should avoid contact with persons without evidence of immunity to varicella who are at risk for severe disease and complications until all lesions resolve (i.e., are crusted over) or, if they develop lesions that do not crust (macules and papules only), until no new lesions appear within a 24-hour period.

Evidence of immunity for HCP includes any of the following (266):

- written documentation of vaccination with 2 doses of varicella vaccine,
- laboratory evidence of immunity$$$ or laboratory confirmation of disease,
- diagnosis or verification of a history of varicella disease by a health-care provider, or
- diagnosis or verification of a history of HZ by a health-care provider.

In health-care settings, serologic screening before vaccination of personnel without evidence of immunity is likely to be cost effective. Key factors determining cost-effectiveness include sensitivity and specificity of serologic tests, the nosocomial transmission rate, seroprevalence of VZV antibody in the personnel population, and policies for managing vaccine recipients developing postvaccination rash or who are

$$$ Commercial assays can be used to assess disease-induced immunity, but they often lack sensitivity to detect vaccine-induced immunity (i.e., they might yield false-negative results).

##### Verification of history or diagnosis of typical disease can be provided by any health-care provider (e.g., a school or occupational clinic nurse, nurse practitioner, physician assistant, or physician). For persons reporting a history of, or reporting with, atypical or mild cases, assessment by a physician or their designee is recommended, and one of the following should be sought: 1) an epidemiologic link to a typical varicella case or to a laboratory-confirmed case or 2) evidence of laboratory confirmation if it was performed at the time of acute disease. When such documentation is lacking, persons should not be considered as having a valid history of disease because other diseases might mimic mild atypical varicella.
exposed subsequently to VZV. Institutions may elect to test all unvaccinated HCP, regardless of disease history, because a small proportion of persons with a positive history of disease might be susceptible. For the purpose of screening HCP, a less sensitive and more specific commercial ELISA should be considered. The latex agglutination test can produce false-positive results, and HCP who remained unvaccinated because of false test results subsequently contracted varicella (289).

Routine testing for varicella immunity after 2 doses of vaccine is not recommended. Available commercial assays are not sensitive enough to detect antibody after vaccination in all instances. Sensitive tests that are not generally available have indicated that 92%–99% of adults develop antibodies after the second dose (266). Seroconversion does not always result in full protection against disease and, given the role of CMI for providing long-term protection, absence of antibodies does not necessarily mean susceptibility. Documented receipt of 2 doses of varicella vaccine supersedes results of subsequent serologic testing.

Health-care institutions should establish protocols and recommendations for screening and vaccinating HCP and for management of HCP after exposures in the work place. Institutions also should consider precautions for HCP in whom rash occurs after vaccination, although they should also consider the possibility of wild-type disease in HCP with recent exposure to varicella or HZ.

A vaccine to prevent HZ is available and recommended for all persons aged ≥60 years without contraindications to vaccination. HZ vaccine is not indicated for HCP for the prevention of nosocomial transmission, but HCP aged ≥60 years may receive the vaccine on the basis of the general recommendation for HZ vaccination, to reduce their individual risk for HZ.

Varicella Control Strategies

Appropriate measures should be implemented to manage cases and control outbreaks (300).

Patient Care

Only HCP with evidence of immunity to varicella should care for patients who have confirmed or suspected varicella or HZ. Airborne precautions (i.e., negative air-flow rooms) and contact precautions should be employed for all patients with varicella or disseminated HZ and for immunocompromised patients with localized HZ until dissemination infection is ruled out. These precautions should be kept in place until lesions are dry and crusted. If negative air-flow rooms are not available, patients should be isolated in closed rooms and should not have contact with persons without evidence of immunity to varicella. For immunocompetent persons with localized HZ, standard precautions and complete covering of the lesions are recommended.

Postexposure Management of HCP and Patients

Exposure to VZV is defined as close contact with an infectious person, such as close indoor contact (e.g., in the same room) or face-to-face contact. Experts differ regarding the duration of contact; some suggest 5 minutes, and others up to 1 hour; all agree that it does not include transitory contact (301).

All exposed, susceptible patients and HCP should be identified using the criteria for evidence of immunity. An additional criterion of evidence of immunity only for patients who are not immunocompromised or pregnant is birth in the United States before 1980. Postexposure prophylaxis with vaccination or varicella-zoster immunoglobulin, depending on immune status, of exposed HCP and patients without evidence of immunity is recommended (266).

HCP who have received 2 doses of vaccine and who are exposed to VZV (varicella, disseminated HZ, and uncovered lesions of a localized HZ) should be monitored daily during days 8–21 after exposure for fever, skin lesions, and systemic symptoms suggestive of varicella. HCP can be monitored directly by occupational health program or infection-control practitioners or instructed to report fever, headache, or other constitutional symptoms and any atypical skin lesions immediately. HCP should be excluded from a work facility immediately if symptoms occur. HCP who have received 1 dose of vaccine and who are exposed to VZV (varicella, disseminated HZ, and uncovered lesions of a localized HZ) (in the community or health-care setting/workplace) should receive the second dose within 3–5 days after exposure to rash (provided 4 weeks have elapsed after the first dose). After vaccination, management is similar to that of 2-dose vaccine recipients. Those who did not receive a second dose or who received the second dose >5 days after exposure should be excluded from work for 8–21 days after exposure.

Unvaccinated HCP who have no other evidence of immunity who are exposed to VZV (varicella, disseminated HZ, and uncovered lesions of a localized HZ) are potentially infective from days 8–21 after exposure and should be furloughed during this period. They should receive postexposure vaccination as soon as possible. Vaccination within 3–5 days of exposure to rash might modify the disease if infection occurred. Vaccination >5 days postexposure is still indicated because it induces protection against subsequent exposures (if the current exposure did not cause infection). For HCP at risk for severe disease for whom varicella vaccination is contraindicated (e.g., pregnant or immunocompromised HCP), varicella-zoster immune globulin after exposure is recommended. The varicella-zoster immune
globein product currently used in the United States, VariZIG (Cangene Corporation, Winnipeg, Canada), is available under an Investigational New Drug Application Expanded Access protocol; a sample release form is available at http://www.fda.gov/downloads/BiologicsBloodVaccines/SafetyAvailability/UCM176031.pdf. Varicella-zoster immune globulin might prolong the incubation period by a week, thus extending the time during which personnel should not work from 21 to 28 days. In case of an outbreak, HCP without evidence of immunity who have contraindications to vaccination should be excluded from the outbreak setting through 21 days after rash onset of the last identified case-patient because of the risk for severe disease in these groups. If the VZV exposure was to localized HZ with covered lesions, no work restrictions are needed if the exposed HCP had previously received at least 1 dose of vaccine or received the first dose within 3–5 days postexposure. A second dose should be administered at the appropriate interval. HCP should be monitored daily during days 8–21 after exposure for fever, skin lesions, and systemic symptoms suggestive of varicella and excluded from a work facility if symptoms occur. If at least 1 dose was not received, restriction from patient contact is recommended.

Diseases for Which Vaccination Might Be Indicated in Certain Circumstances

Health-care facilities and other organizations should consider including in their vaccination programs vaccines to prevent meningococcal disease, typhoid fever, and polio for HCP who have certain health conditions or who work in laboratories or regions outside the United States where the risk for work-related exposure exists.

Meningococcal Disease

Background

Epidemiology and Risk Factors

Meningococcal disease is rare among adults in the United States and incidence has decreased to historic lows; during 1998–2007 the average annual incidence of meningococcal disease was 0.28 (range: 0.26–0.31) cases per 100,000 population among persons aged 25–64 years (302).

Routine vaccination with meningococcal conjugate vaccine is recommended by ACIP for adolescents aged 11–18 years, with the primary dose at age 11–12 years and the booster dose at age 16 years. In 2010, coverage with meningococcal conjugate vaccine among persons aged 13–17 years was 62.7% (22).

Nosocomial transmission of Neisseria meningitidis is rare, but HCP have become infected after direct contact with respiratory secretions of infected persons (e.g., managing of an airway during resuscitation) and in a laboratory setting. HCP can decrease the risk for infection by adhering to precautions to prevent exposure to respiratory droplets (303,304) and by taking antimicrobial chemoprophylaxis if exposed directly to respiratory secretions.

Vaccine Effectiveness, Duration of Immunity, and Vaccine Safety

Two quadrivalent (A, C, W-135, Y) conjugate meningococcal vaccines (MCV4) are licensed for persons aged through 55 years (305,306). Both protect against two of the three serogroups that cause the majority of meningococcal disease in the United States and against 75% of disease among adults. Available data indicate that the majority of persons do not have enough circulating functional antibody to be protected ≥5 years after a single dose of MCV4. Both vaccines had similar safety profiles in clinical trials. Quadrivalent (A, C, W-135, Y) meningococcal polysaccharide vaccine (MPSV4) is available for use in persons aged ≥55 years. No vaccine for serogroup B meningococcal disease is licensed in the United States.

Recommendations

Vaccination

MCV4 is not recommended routinely for all HCP.

HCP Recommended to Receive Vaccine to Prevent Meningococcal Disease

A 2-dose vaccine series is recommended for HCP with known asplenia or persistent complement component deficiencies, because these conditions increase the risk for meningococcal disease. HCP traveling to countries in which meningococcal disease is hyperendemic or epidemic also are at increased risk for infection and should receive vaccine. Those with known asplenia or persistent complement component deficiencies should receive a 2-dose vaccine series. All other HCP traveling to work to high-risk areas should receive a single dose of MCV4 before travel if they have never received it or if they received it >5 years previously. Clinical microbiologists and research microbiologists who might be exposed routinely to isolates of N. meningitides should receive a single dose of MCV4 and receive a booster dose every 5 years if they remain at increased risk. Health-care personnel aged >55 years who have any of the above risk factors for meningococcal disease should be vaccinated with MPSV4 (305).