

Immunization of Health-Care Personnel

Recommendations of the Advisory Committee on Immunization Practices (ACIP)



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1. For varicella postexposure prophylaxis for persons without evidence of immunity who have contraindications for vaccination and who are at risk for severe disease and complications, the product currently used in the United States, VariZIG (Cangene Corporation, Winnipeg, Canada), is available under an Investigational New Drug Application Expanded Access Protocol.
2. The interval between administration of Td and Tdap might be <5 years as indicated in package insert.
3. One Tdap product, Adacel (sanofi pasteur, Toronto, Canada), is labeled for use in persons aged 11–64 years. The other Tdap product, Boostrix (GlaxoSmithKline Biologicals, Rixensart, Belgium), is labeled for use in persons aged ≥10 years. Until ACIP reviews the current recommendations on use of Tdap in persons aged ≥65 years, either Tdap product may be used in persons aged ≥65 years.
4. Meningococcal conjugate vaccines are licensed only as a single dose. The 2-dose series of meningococcal conjugate vaccine is recommended for persons with certain medical risk factors, and the booster dose of meningococcal conjugate vaccine is recommended for persons who remain at increased risk for a prolonged period.

On the cover: An adult female health-care professional receiving an intramuscular vaccination into her left shoulder muscle from a nurse.

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Recommendations of the Advisory Committee on Immunization Practices (ACIP)

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Summary

This report updates the previously published summary of recommendations for vaccinating health-care personnel (HCP) in the United States (CDC. Immunization of health-care workers: recommendations of the Advisory Committee on Immunization Practices [ACIP] and the Hospital Infection Control Practices Advisory Committee [HICPAC]. MMWR 1997;46[No. RR-18]). This report was reviewed by and includes input from the Healthcare (formerly Hospital) Infection Control Practices Advisory Committee. These updated recommendations can assist hospital administrators, infection-control practitioners, employee health clinicians, and HCP in optimizing infection prevention and control programs. The recommendations for vaccinating HCP are presented by disease in two categories: 1) those diseases for which vaccination or documentation of immunity is recommended because of risks to HCP in their work settings for acquiring disease or transmitting to patients and 2) those for which vaccination might be indicated in certain circumstances. Background information for each vaccine-preventable disease and specific recommendations for use of each vaccine are presented. Certain infection-control measures that relate to vaccination also are included in this report. In addition, ACIP recommendations for the remaining vaccines that are recommended for certain or all adults are summarized, as are considerations for catch-up and travel vaccinations and for work restrictions. This report summarizes all current ACIP recommendations for vaccination of HCP and does not contain any new recommendations or policies.

The material in this report originated in the National Center for Immunization and Respiratory Diseases, Anne Schuchat, MD, Director.

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The recommendations provided in this report apply, but are not limited, to HCP in acute-care hospitals; long-term-care facilities (e.g., nursing homes and skilled nursing facilities); physician's offices; rehabilitation centers; urgent care centers, and outpatient clinics as well as to persons who provide home health care and emergency medical services.

Introduction

This report updates the previously published summary of recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Healthcare (formerly Hospital) Infection Control Practices Advisory Committee (HICPAC) for vaccinating health-care personnel (HCP) in the United States (1). The report, which was reviewed by and includes input from HICPAC, summarizes all current ACIP recommendations for vaccination of HCP and does not contain any new recommendations or policies that have not been published previously. These recommendations can assist hospital administrators, infection-control practitioners, employee health clinicians, and HCP in optimizing infection prevention and control programs.

HCP are defined as all paid and unpaid persons working in health-care settings who have the potential for exposure to patients and/or to infectious materials, including body substances, contaminated medical supplies and equipment, contaminated environmental surfaces, or contaminated air. HCP might include (but are not limited to) physicians, nurses, nursing assistants, therapists, technicians, emergency medical service personnel, dental personnel, pharmacists, laboratory personnel, autopsy personnel, students and trainees, contractual staff not employed by the health-care facility, and persons (e.g., clerical, dietary, housekeeping, laundry, security, maintenance, administrative, billing, and volunteers) not directly involved in patient care but potentially exposed to infectious agents that can be transmitted to and from HCP and patients (2).

Because of their contact with patients or infective material from patients, many HCP are at risk for exposure to (and possible transmission of) vaccine-preventable diseases. Employers and HCP have a shared responsibility to prevent occupationally acquired infections and avoid causing harm to patients by taking reasonable precautions to prevent transmission of vaccine-preventable diseases. Vaccination programs are therefore an essential part of infection prevention and control for HCP. Optimal use of recommended vaccines helps maintain immunity and safeguard HCP from infection, thereby helping protect patients from becoming infected; pertinent ACIP statements on various individual vaccines and diseases have been published (Table 1). Nationwide, ongoing implementation of these vaccine recommendations through well-managed vaccination programs could substantially reduce both the number of susceptible HCP in any setting in which they interact with patients and their risks for transmitting vaccine-preventable diseases to patients, other HCP, and other contacts (3).

HICPAC and CDC have recommended that secure, preferably computerized, systems should be used to manage

vaccination records for HCP so records can be retrieved easily as needed (3). Each record should reflect immunity status for indicated vaccine-preventable diseases (i.e., documented disease, vaccination history, or serology results) as well as vaccinations administered during employment and any documented episodes of adverse events after vaccination (4). For each vaccine, the record should include date of vaccine administration (including for those vaccines that might have been received prior to employment), vaccine manufacturer and lot number, edition and distribution date of the language-appropriate Vaccine Information Statement (VIS) provided to the vaccinee at the time of vaccination, and the name, address, and title of the person administering the vaccine (4). Accurate vaccination records can help to rapidly identify susceptible HCP (i.e., those with no history of vaccination or lack of documentation of immunity) during an outbreak situation and can help reduce costs and disruptions to health-care operations (5–7). HCP should be provided a copy of their vaccination records and encouraged to keep it with their personal health records so they can readily be made available to future employers.

HICPAC has encouraged any facility or organization that provides direct patient care to formulate a comprehensive vaccination policy for all HCP (3). The American Hospital Association has endorsed the concept of vaccination programs for both hospital personnel and patients (8). To ensure that all HCP are up to date with respect to recommended vaccines, facilities should review HCP vaccination and immunity status at the time of hire and on a regular basis (i.e., at least annually) with consideration of offering needed vaccines, if necessary, in conjunction with routine annual disease-prevention measures (e.g., influenza vaccination or tuberculin testing). These recommendations (Tables 2 and 3) should be considered during policy development. Several states and health-care facilities have established requirements relating to assessment of vaccination status and/or administration of one or more vaccines for HCP (9,10). Disease-specific outbreak control measures are described in this report and elsewhere (3,11,12). All HCP should adhere to all other recommended infection-control guidelines, whether or not they are individually determined to have immunity to a vaccine-preventable disease.

Methods

In 2008, the ACIP Immunization of Health-Care Personnel Work Group (the Work Group) was formed as a subgroup of the ACIP Adult Immunization Work Group to update the previously published recommendations for immunization of HCP. The Work Group comprised professionals from

academic medicine (pediatrics, family medicine, internal medicine, occupational and environmental medicine, and infectious disease); federal and state public health professionals; and liaisons from the Society for Healthcare Epidemiology of America and HICPAC. The Work Group met monthly, developed an outline for the report, worked closely with subject matter experts at CDC (who developed, revised, and updated sections of the report), and provided subsequent critical review of the draft documents. The approach of the Work Group was to summarize previously published ACIP recommendations and not to make new recommendations or policies; a comprehensive list of publications containing the various vaccine-specific recommendations is provided (Table 1). In February 2011, the updated report was presented to ACIP, which voted to approve it.

The recommendations for vaccination of HCP are presented below by disease in two categories: 1) those diseases for which routine vaccination or documentation of immunity is recommended for HCP because of risks to HCP in their work settings and, should HCP become infected, to the patients they serve and 2) those diseases for which vaccination of HCP might be indicated in certain circumstances. Vaccines recommended in the first category are hepatitis B, seasonal influenza, measles, mumps, and rubella, pertussis, and varicella vaccines. Vaccines in the second category are meningococcal, typhoid, and polio vaccines. Except for influenza, all of the diseases prevented by these vaccines are notifiable at the national level (13). Main changes from the 1997 ACIP recommendations have been summarized (Box).

Diseases for Which Vaccination Is Recommended

On the basis of documented nosocomial transmission, HCP are considered to be at substantial risk for acquiring or transmitting hepatitis B, influenza, measles, mumps, rubella, pertussis, and varicella. Current recommendations for vaccination are provided below.

Hepatitis B

Background

Epidemiology and Risk Factors

Hepatitis B is an infection caused by the hepatitis B virus (HBV), which is transmitted through percutaneous (i.e., breaks in the skin) or mucosal (i.e., direct contact with mucous membranes) exposure to infectious blood or body fluids. The virus is highly infectious; for nonimmune persons,

disease transmission from a needlestick exposure is up to 100 times more likely for exposure to hepatitis B e antigen (HBeAg)-positive blood than to HIV-positive blood (14). HBV infection is a well recognized occupational risk for U.S. HCP and globally. The risk for HBV is associated with degree of contact with blood in the work place and with the hepatitis B e-antigen status of the source persons (15). The virus is also environmentally stable, remaining infectious on environmental surfaces for at least 7 days (16).

In 2009 in the United States, 3,371 cases of acute HBV infection were reported nationally, and an estimated 38,000 new cases of HBV infection occurred after accounting for underreporting and underdiagnosis (17). Of 4,519 persons reported with acute HBV infection in 2007, approximately 40% were hospitalized and 1.5% died (18). HBV can lead to chronic infection, which can result in cirrhosis of the liver, liver failure, liver cancer, and death. An estimated 800,000–1.4 million persons in the United States are living with chronic HBV infection; these persons serve as the main reservoir for continued HBV transmission (19).

Vaccines to prevent hepatitis B became available in the United States in 1981; a decade later, a national strategy to eliminate HBV infection was implemented, and the routine vaccination of children was recommended (20). During 1990–2009, the rate of new HBV infections declined approximately 84%, from 8.5 to 1.1 cases per 100,000 population (17); the decline was greatest (98%) among persons aged <19 years, for whom recommendations for routine infant and adolescent vaccination have been applied. Although hepatitis B vaccine coverage is high in infants, children, and adolescents (91.8% in infants aged 19–35 months and 91.6% in adolescents aged 13–17 years) (21,22), coverage remains lower (41.8% in 2009) for certain adult populations, including those with behavioral risks for HBV infection (e.g., men who have sex with men and persons who use injection drugs) (23).

Hepatitis B in Health-Care Settings

During 1982, when hepatitis B vaccine was first recommended for HCP, an estimated 10,000 infections occurred among persons employed in a medical or dental field. By 2004, the number of HBV infections among HCP had decreased to an estimated 304 infections, largely resulting from the implementation of routine preexposure vaccination and improved infection-control precautions (24–26).

The risk for acquiring HBV infection from occupational exposures is dependent on the frequency of percutaneous and mucosal exposures to blood or body fluids (e.g., semen, saliva, and wound exudates) containing HBV, particularly fluids containing HBeAg (a marker for high HBV replication and viral load) (27–31). The risk is higher during the professional

BOX. Summary of main changes* from 1997 Advisory Committee on Immunization Practices/Hospital (now Healthcare) Infection Control Practices Advisory Committee recommendations for immunization of health-care personnel (HCP)

Hepatitis B

- HCP and trainees in certain populations at high risk for chronic hepatitis B (e.g., those born in countries with high and intermediate endemicity) should be tested for HBsAg and anti-HBc/anti-HBs to determine infection status.

Influenza

- Emphasis that all HCP, not just those with direct patient care duties, should receive an annual influenza vaccination
- Comprehensive programs to increase vaccine coverage among HCP are needed; influenza vaccination rates among HCP within facilities should be measured and reported regularly.

Measles, mumps, and rubella (MMR)

- History of disease is no longer considered adequate presumptive evidence of measles or mumps immunity for HCP; laboratory confirmation of disease was added as acceptable presumptive evidence of immunity. History of disease has never been considered adequate evidence of immunity for rubella.
- The footnotes have been changed regarding the recommendations for personnel born before 1957 in routine and outbreak contexts. Specifically, guidance is provided for 2 doses of MMR for measles and mumps protection and 1 dose of MMR for rubella protection.

Pertussis

- HCP, regardless of age, should receive a single dose of Tdap as soon as feasible if they have not previously received Tdap.
- The minimal interval was removed, and Tdap can now be administered regardless of interval since the last tetanus or diphtheria-containing vaccine.
- Hospitals and ambulatory-care facilities should provide Tdap for HCP and use approaches that maximize vaccination rates.

Varicella

Criteria for evidence of immunity to varicella were established. For HCP they include

- written documentation with 2 doses of vaccine,
- laboratory evidence of immunity or laboratory confirmation of disease,
- diagnosis of history of varicella disease by health-care provider, or diagnosis of history of herpes zoster by health-care provider.

Meningococcal

- HCP with anatomic or functional asplenia or persistent complement component deficiencies should now receive a 2-dose series of meningococcal conjugate vaccine. HCP with HIV infection who are vaccinated should also receive a 2 dose series.
- Those HCP who remain in groups at high risk are recommended to be revaccinated every 5 years.

Abbreviations: HBsAg = Hepatitis B surface antigen; anti-HBc = hepatitis B core antibody; anti-HBs = hepatitis B surface antibody; Tdap = tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine; HIV = human immunodeficiency virus.

*Updated recommendations made since publication of the 1997 summary of recommendations (CDC Immunization of health-care workers: recommendations of the Advisory Committee on Immunization Practices [ACIP] and the Hospital Infection Control Practices Advisory Committee [HICPAC]. MMWR 1997;46[No. RR-18]).

training period and can vary throughout a person's career (1). Depending on the tasks performed, health-care or public safety personnel might be at risk for HBV exposure; in addition, personnel providing care and assistance to persons in outpatient settings and those residing in long-term-care facilities (e.g., assisted living) might be at risk for acquiring or facilitating transmission of HBV infection when they perform procedures that expose them to blood (e.g., assisted blood-glucose monitoring and wound care) (32–34).

A Federal Standard issued in December 1991 under the Occupational Safety and Health Act mandates that hepatitis B vaccine be made available at the employer's expense to all health-care personnel who are exposed occupationally to blood or other potentially infectious materials (35). The Federal Standard defines occupational exposure as reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that might result from the performance of an employee's duties (35). Occupational Safety and Health Administration

(OSHA) vaccination practice requirements (e.g., preexposure and postexposure antibody testing) are based on current ACIP recommendations. OSHA regulations might have accelerated the use of hepatitis B vaccine in HCP (36).

Data from a national, cross-sectional survey demonstrated that during 2002–2003, an estimated 75% of HCP had received the 3-dose hepatitis B vaccination series (37). Since 2002, rates of 1-dose and 3-dose vaccination coverage have remained stable. Data obtained through the National Health Interview Survey (NHIS) in 2009 demonstrated a ≥ 1 -dose coverage rate of 75%–77% and a ≥ 3 -dose rate of 67%–68% among HCP aged 18–49 years (23). Similarly, data obtained through the National Immunization Survey–Adult (NIS-Adult) in 2007 demonstrated a ≥ 3 -dose coverage of 62% among HCP aged 18–64 years (38). The Healthy People 2020 goal (objective no. IID-15.3) of a hepatitis B vaccination coverage rate of 90% among HCP (39) has not been achieved.

Vaccine Effectiveness, Duration of Immunity, and Vaccine Safety

Vaccine Effectiveness

The 3-dose vaccine series administered intramuscularly at 0, 1, and 6 months produces a protective antibody response in approximately 30%–55% of healthy adults aged ≤ 40 years after the first dose, 75% after the second dose, and $>90\%$ after the third dose (40–42). After age 40 years, $<90\%$ of persons vaccinated with 3 doses have a protective antibody response, and by age 60 years, protective levels of antibody develop in approximately 75% of vaccinated persons (43). Smoking, obesity, genetic factors, and immune suppression also are associated with diminished immune response to hepatitis B vaccination (43–46).

Duration of Immunity

Protection against symptomatic and chronic HBV infection has been documented to persist for ≥ 22 years in vaccine responders (47). Immunocompetent persons who achieve hepatitis B surface antibody (anti-HBs) concentrations of ≥ 10 mIU/mL after preexposure vaccination have protection against both acute disease and chronic infection. Anti-HBs levels decline over time. Regardless, responders continue to be protected, and the majority of responders will show an anamnestic response to vaccine challenge (47–51). Declines might be somewhat faster among persons vaccinated as infants rather than as older children, adolescents, or adults and among those administered recombinant vaccine instead of plasma vaccine (which has not been commercially available in the United States since the late 1980s). Although immunogenicity is lower among immunocompromised persons, those who achieve

and maintain a protective antibody response before exposure to HBV have a high level of protection from infection (52).

Among persons who do not respond to a primary 3-dose vaccine series (i.e., those in whom anti-HBs concentrations of ≥ 10 mIU/mL were not achieved), 25%–50% respond to an additional vaccine dose, and 44%–100% respond to a 3-dose revaccination series using standard or high dosage vaccine (43,53–58). Persons who have measurable but low (i.e., 1–9 mIU/mL) levels of anti-HBs after the initial series have better response to revaccination than persons who have no anti-HBs (49,53,54). Persons who do not have protective levels of anti-HBs 1–2 months after revaccination either are infected with HBV or can be considered primary nonresponders; for the latter group, genetic factors might be associated with nonresponse to hepatitis B vaccination (54,58,59). ACIP does not recommend more than two vaccine series in nonresponders (52).

Vaccine Safety

Hepatitis B vaccines have been demonstrated to be safe when administered to infants, children, adolescents, and adults (52,60,61). Although rare cases of arthritis or alopecia have been associated temporally with hepatitis B vaccination, recent data do not support a causal relationship between hepatitis B vaccine and either arthritis or alopecia (61–63). During 1982–2004, an estimated 70 million adolescents and adults and 50 million infants and children in the United States received ≥ 1 dose of hepatitis B vaccine (52). The most frequently reported side effects in persons receiving hepatitis B vaccine are pain at the injection site (3%–29%) and temperature of $>99.9^\circ\text{F}$ ($>37.7^\circ\text{C}$) (1%–6%) (64–67). However, in placebo-controlled studies, these side effects were reported no more frequently among persons receiving hepatitis B vaccine than among persons receiving placebo (40,41,64–67). Revaccination is not associated with an increase in adverse events.

Hepatitis B vaccination is contraindicated for persons with a history of hypersensitivity to yeast or any vaccine component (4,64–66). Persons with a history of serious adverse events (e.g., anaphylaxis) after receipt of hepatitis B vaccine should not receive additional doses. As with other vaccines, vaccination of persons with moderate or severe acute illness, with or without fever, should be deferred until illness resolves (4). Vaccination is not contraindicated in persons with a history of multiple sclerosis, Guillain-Barré Syndrome, autoimmune disease (e.g., systemic lupus erythematosus and rheumatoid arthritis), or other chronic diseases. Pregnancy is not a contraindication to vaccination; limited data suggest that developing fetuses are not at risk for adverse events when hepatitis B vaccine is administered to pregnant women (4,68). Available vaccines contain noninfectious hepatitis B surface antigen (HBsAg) and do not pose any risk for infection to the fetus.

Recommendations

Two single-antigen hepatitis B vaccines, Recombivax HB (Merck & Co., Inc., Whitehouse Station, New Jersey) and Engerix-B (GlaxoSmithKline Biologicals, Rixensart, Belgium) and one combination hepatitis A and hepatitis B vaccine, Twinrix (GlaxoSmithKline Biologicals), are available in the United States. Primary vaccination consists of ≥ 3 intramuscular doses of hepatitis B vaccine or of the combined hepatitis A and hepatitis B vaccine. The hepatitis vaccine series does not need to be restarted if the second or third dose is delayed. Detailed vaccination recommendations are available in previously published guidelines (52). Vaccine schedules are available at <http://www.cdc.gov/vaccines/recs/schedules/adult-schedule.htm#HCWs>. In adults, hepatitis B vaccine always should be administered into the deltoid muscle. Longer needles (up to 1.5 inches in length) might be required for obese adults (4).

Preexposure

Unvaccinated and Incompletely Vaccinated HCP and Trainees: Pre- and Postvaccination Serologic Testing

- Prevaccination serologic testing for previous infection is not indicated for the majority of persons being vaccinated because of occupational risk unless the hospital or health-care organization considers such testing cost-effective (3,52,69–72). However, such testing is indicated for HCP and is cost-effective in certain high-risk populations (see HCP and Trainees at Additional Risk), regardless of vaccination status (71,73).
- All unvaccinated persons whose work- and training-related activities involve reasonably anticipated risk for exposure to blood or other infectious body fluids (e.g., HCP, long-term-care facility staff, and public safety workers) should be vaccinated with the complete, ≥ 3 -dose hepatitis B vaccine series.
- Persons with an incomplete series are not considered protected and should complete the ≥ 3 -dose series.
- Because higher risk has been reported during the professional training period, the vaccination series should be completed before trainees have contact with blood; vaccination should be offered in schools of medicine, dentistry, nursing, laboratory technology, and other allied health professions.
- To determine the need for revaccination and to guide postexposure prophylaxis, postvaccination serologic testing should be performed for all HCP at high risk for occupational percutaneous or mucosal exposure to blood or body fluids. Postvaccination serologic testing is performed 1–2 months after administration of the last dose of the vaccine series using a method that allows

detection of the protective concentration of anti-HBs (≥ 10 mIU/mL). Persons determined to have anti-HBs concentrations of ≥ 10 mIU/mL after receipt of the primary vaccine series are considered immune, and the result should be documented. Immunocompetent persons have long-term protection and do not need further periodic testing to assess anti-HBs levels. Postvaccination testing for persons at low risk for mucosal or percutaneous exposure to blood or body fluids (e.g., public safety workers and HCP without direct patient contact) likely is not cost effective (52); however, persons who do not undergo postvaccination testing should be counseled to seek immediate testing if exposed.

- Persons determined to have anti-HBs concentrations of < 10 mIU/mL soon after receipt of the primary vaccine series should be revaccinated. For these persons, administration of a second complete 3-dose series on an appropriate schedule, followed by anti-HBs testing 1–2 months after the third dose, usually is more practical than conducting serologic testing after each additional dose of vaccine.
- Persons who do not have a protective concentration of anti-HBs (≥ 10 mIU/mL) after revaccination (i.e., after receiving a total of 6 doses) should be tested for HBsAg and anti-HBc to determine infection status. Those determined not to be infected but who have anti-HBs < 10 mIU/mL (nonresponders) should be considered susceptible to HBV infection and should be counseled about precautions to prevent HBV infection and the need to obtain hepatitis B immune globulin (HBIG) postexposure prophylaxis for any known or likely exposure to HBsAg-positive blood (72). Persons determined to be infected (anti-HBc-positive) and positive for HBsAg should be provided counseling regarding how to prevent HBV transmission to others and referred for further evaluation (e.g., HBV viral load testing), care, treatment, and other services, as appropriate (69–71). Persons who are HBsAg-positive and who perform exposure-prone procedures should seek counsel from a review panel comprised of experts with a balanced perspective (e.g., HCPs' personal physicians and infectious disease specialists) regarding the procedures that they can perform safely. They should not be excluded from work (69). Persons who were infected in the past (anti-HBc-positive but negative for HBsAg) require no vaccination or treatment.

Postexposure

The need for postexposure prophylaxis should be evaluated immediately after HCP experience any percutaneous, ocular, mucous-membrane or nonintact skin exposure to blood or body fluid in the workplace. Decisions to administer

postexposure prophylaxis should be based on the HBsAg status of the source and the vaccination history and vaccine-response status of the exposed HCP (Table 4) (72).

Unvaccinated and Incompletely Vaccinated HCP and Trainees

- Unvaccinated or incompletely vaccinated persons who experience a workplace exposure from persons known to be HBsAg-positive should receive 1 dose of hepatitis B immune globulin HBIG (i.e., passive vaccination) as soon as possible after exposure (preferably within 24 hours). The effectiveness of HBIG when administered >7 days after percutaneous or permucosal exposures is unknown (Table 4).
- Hepatitis B vaccine should be administered in the deltoid muscle as soon as possible after exposure; HBIG should be administered at the same time at another injection site. The 3-dose hepatitis B vaccine series should be completed for previously unvaccinated and incompletely vaccinated persons who have needlestick or other percutaneous exposures, regardless of the HBsAg status of the source and whether the status of the source is known. To document protective levels of anti-HBs (≥ 10 mIU/mL), postvaccination testing of persons who received HBIG for postexposure prophylaxis should be performed after anti-HBs from HBIG is no longer detectable (4–6 months after administration).

Vaccinated HCP and Trainees

- Vaccinated HCP with documented immunity (anti-HBs concentrations of ≥ 10 mIU/mL) require no postexposure prophylaxis, serologic testing, or additional vaccination.
- Vaccinated HCP with documented nonresponse to a 3-dose vaccine series should receive 1 dose of HBIG and a second 3-dose vaccine series if the source is HBsAg-positive or known to be at high risk for carrying hepatitis. If the source is known or determined to be HBsAg-negative, these previously nonresponding HCP should complete the revaccination series and undergo postvaccination testing to ensure that their response status is documented (Table 4). Postvaccination testing of persons who received HBIG for PEP should be performed after anti-HBs from HBIG is no longer detectable (4–6 months after administration).
- Vaccinated HCP with documented nonresponse to two 3-dose vaccine series should receive 2 doses of HBIG, 1 month apart if the source is HBsAg-positive or known to be at high risk for carrying hepatitis; no additional vaccination is necessary. If the source is known or determined to be HBsAg-negative, these previously

nonresponding HCP need no additional testing or treatment (Table 4).

- Vaccinated HCP with no documentation of postvaccination serologic response who are exposed to an HBsAg-positive source should have serum obtained for anti-HBs testing immediately. Those determined to have protective levels of antibody (anti-HBs ≥ 10 mIU/mL) require no additional treatment; those with concentrations < 10 mIU/mL should receive 1 dose of HBIG, along with a booster dose of hepatitis B vaccine. To document protective levels of anti-HBs (≥ 10 mIU/mL), postvaccination testing of persons who received HBIG for postexposure prophylaxis should be performed after anti-HBs from HBIG is no longer detectable (4–6 months after administration).
- Vaccinated HCP with no documentation of postvaccination serologic response who are exposed to a source with unknown infection status should be tested for anti-HBs. Those determined to have protective levels of antibody require no additional treatment; those with concentrations < 10 mIU/mL should receive a booster dose of hepatitis B vaccine and serologic testing 1–2 months later.
- Vaccinated HCP with no documentation of postvaccination serologic response who are exposed to a source known to be HBsAg-negative require no testing or treatment (Table 4).

HCP and Trainees at Additional Risk

- Regardless of vaccination history, HCP and trainees in certain high-risk populations, including those born in geographic regions with high HBsAg prevalence ($\geq 8\%$) and intermediate (2%–7%) prevalence (71), unvaccinated U.S.-born HCP whose parents were born in regions of high HBsAg prevalence, HIV-positive HCP, HCP who have disclosed having engaged or currently engaging in high-risk substance abuse or sexual behaviors, and HCP who require immunosuppressive therapy or who are on hemodialysis should be tested for HBsAg and anti-HBc/anti-HBs to determine infection status. For those who are unvaccinated, blood should be drawn for testing before the first dose of vaccine is administered, and vaccination should be administered during the same health-care visit. Persons testing negative for hepatitis B infection or immunity should be managed in the same manner as other uninfected HCP. Persons determined to be HBsAg-positive should be provided counseling regarding how to prevent HBV transmission to others and referred for further evaluation (e.g., HBV viral load testing), care, treatment, and other services as appropriate (69–71). Persons who are HBsAg-positive and who perform exposure-prone procedures should seek counsel from a review panel comprised of experts with a balanced perspective (e.g., personal physicians

of HCP and infectious disease specialists) regarding the procedures that they can perform safely. They should not be excluded from work (69). Additional information regarding prevaccination testing for HCP with other hepatitis B risk factors and for pregnant women has been published previously (52,71). HCP receiving hemodialysis should be provided annual anti-HBs testing and should be administered a booster dose of vaccine when anti-HBs levels decline to <10 mIU/mL (52).

- For other immunocompromised HCP (e.g., HIV-infected persons, hematopoietic stem-cell transplant recipients, and persons receiving chemotherapy), the frequency of postvaccination testing and the need for booster doses has not been determined (52).

Other Considerations

- Occupational health programs and others responsible for infection prevention and control should identify all staff whose work-related activities involve exposure to blood or other potentially infectious body fluids in a health-care, laboratory, public safety, or institutional setting (including employees, students, contractors, attending clinicians, emergency medical technicians, paramedics, and volunteers); provide education to staff to encourage vaccination; and implement active follow-up, with reminders to track completion of the vaccine series and postvaccination testing among persons receiving vaccination (72).
- In partnership with state and local health authorities, household, sex, or needle-sharing contacts of HBsAg-positive HCP and trainees should be identified, tested, vaccinated (if indicated), and provided with counseling and referral for needed services, when appropriate.

Influenza

Background

Epidemiology and Risk Factors

Influenza causes an estimated average of >200,000 hospitalizations and 3,000–49,000 deaths annually in the United States (74–76). The majority of influenza-related severe illnesses and deaths occur among persons with chronic medical conditions, infants and young children, seniors, and pregnant women (74–78). Reducing the risk for influenza among persons at higher risk for complications is a major focus of influenza prevention strategies (77).

Influenza Transmission in Health-Care Settings

HCP are exposed to patients with influenza in the workplace and are thus at risk of occupationally acquired influenza and of

transmitting influenza to patients and other HCP. In a cross-sectional survey of hospital house staff (physicians in training), 37% reported influenza-like illness during September–April, and 9% reported more than one respiratory illness. Length of illness varied (range: 1–10 days; mean: 7 days), as did days of work missed (range: 0–10 days; mean: 0.7 days) (79). Infected HCP who continue to work while ill might transmit influenza to patients, many of whom are at increased risk for severe outcomes from influenza. HCP are therefore recommended for routine annual influenza vaccination (77).

Few randomized trials of the effect that influenza vaccination has on illness in HCP have been conducted. In one randomized trial of 427 HCP, influenza vaccination of HCP failed to decrease episodes of respiratory infection or duration of illness but was associated with a 28% decrease in absenteeism (from 1.4 days to 1.0 day) attributable to respiratory infections (80). No laboratory confirmation of influenza was obtained in this study. In another randomized trial among HCP, vaccination was associated with a significantly lower rate of serological evidence of influenza infection, with a vaccine efficacy rate of 88% for influenza A and 89% for influenza B ($p < 0.05$) (81); however, no significant differences were noted in days of febrile respiratory illness or absenteeism.

Influenza can cause outbreaks of severe respiratory illness among hospitalized persons and long-term-care residents (82–90). Influenza outbreaks in hospitals (86–88) and long-term-care facilities (91) have been associated with low vaccination rates among HCP. One nonrandomized study demonstrated an increase in HCW vaccination rates and decrease in nosocomially acquired, laboratory-confirmed influenza in a hospital after a mobile cart-based HCP vaccination program was introduced (86). Several randomized controlled studies of the impact of HCP vaccination on morbidity and mortality in long-term care facilities have been performed (92–95). These studies have demonstrated substantial decreases in all-cause mortality (92–95) and influenza-like illness (92,94,95). However, studies which examine and demonstrate efficacy in preventing more specific outcomes (e.g., laboratory-confirmed influenza illness and mortality) are lacking. Recent systematic reviews suggest that vaccination of HCP in settings in which patients also were vaccinated provided significant reductions in deaths among elderly patients from all causes and deaths from pneumonia, but also note that additional randomized controlled trials are warranted (96,97), as are examination of more specific outcomes.

Preventing influenza among HCP who might serve as sources of influenza virus transmission provides additional protection to patients at risk for influenza complications. Vaccination of HCP can specifically benefit patients who cannot receive vaccination (e.g., infants aged <6 months or those with severe

allergic reactions to prior influenza vaccination), patients who respond poorly to vaccination (e.g., persons aged ≥ 85 years and immune-compromised persons), and persons for whom antiviral treatment is not available (e.g., persons with medical contraindications). Although annual vaccination has long been recommended for HCP and is a high priority for reducing morbidity associated with influenza in health-care settings (98–100), national survey data have demonstrated that the vaccination coverage level during the 2008–09 season was 52.9% (101).

Considerations Regarding Influenza Vaccination of HCP

Barriers to HCP acceptance of influenza vaccination have included fear of vaccine side effects (particularly influenza-like symptoms), insufficient time or inconvenience, perceived ineffectiveness of the vaccine, perceived low likelihood of contracting influenza, avoidance of medications, and fear of needles (79,102–109). Factors demonstrated to increase vaccine acceptance include a desire for self-protection, previous receipt of influenza vaccine, a desire to protect patients, and perceived effectiveness of vaccine (79,105,106,109–112). Strategies that have demonstrated improvement in HCP vaccination rates have included campaigns to emphasize the benefits of HCP vaccination for staff and patients, vaccination of senior medical staff or opinion leaders, removing administrative barriers (e.g., costs), providing vaccine in locations and at times easily accessible by HCP, and monitoring and reporting HCP influenza vaccination rates (99,113–120). Intranasally administered live attenuated influenza vaccine (LAIV) is an option for healthy, nonpregnant adults aged < 50 years who dislike needles.

The practice of obtaining signed declinations from HCP offered influenza vaccination has been adopted by some institutions but has not yet been demonstrated to exceed coverage rates of $> 70\%$ – 80% (99,115,121–123). Institutions that require declination statements from HCP who refuse influenza vaccination should educate and counsel these HCP about benefits of the vaccine.

Each health-care facility should develop a comprehensive influenza vaccination strategy that includes targeted education about the disease, including disease risk among HCP and patients, and about the vaccine. In addition, the program should establish easily accessible vaccination sites and inform HCP about their locations and schedule. Facilities that employ HCP should provide influenza vaccine at no cost to personnel (124). The most effective combination of approaches for achieving high influenza vaccination coverage among HCP likely varies by institution. Hospitals and health-care

organizations in the United States traditionally have employed an immunization strategy that includes one or more of the following components: education about influenza, easy access to vaccine, incentives to encourage immunization, organized campaigns, institution of declination policies, and legislative and regulatory efforts (e.g., vaccination requirements) (99, 115, 121–126).

Beginning January 1, 2007, the Joint Commission on Accreditation of Health-Care Organizations required accredited organizations to offer influenza vaccinations to staff, including volunteers and licensed independent practitioners and to report coverage levels among HCP (127). Standards are available for measuring vaccination coverage among HCP as a measure of program performance within a health-care setting (128). Beginning January 2013, the Centers for Medicaid Services will require acute care hospitals to report HCP influenza vaccine as part of its hospital inpatient quality reporting program.*

Vaccine Effectiveness, Duration of Immunity, and Vaccine Safety

Effectiveness of influenza vaccines varies from year to year and depends on the age and health status of the person getting the vaccine and the similarity or “match” between the viruses or virus in the vaccine and those in circulation. Vaccine strains are selected for inclusion in the influenza vaccine every year based on international surveillance and scientists’ estimations about which types and strains of viruses will circulate in a given year. Annual vaccination is recommended because the predominant circulating influenza viruses typically change from season to season and, because immunity declines over time postvaccination (77).

In placebo-controlled studies among adults, the most frequent side effect of vaccination was soreness at the vaccination site (affecting 10%–64% of patients) that lasted < 2 days (129,130). These injection-site reactions typically were mild and rarely interfered with the recipient’s ability to conduct usual daily activities. The main contraindication to influenza vaccination is a history of anaphylactic hypersensitivity to egg or other components of the vaccine. A history of Guillain-Barré Syndrome within 6 weeks following a previous dose of influenza vaccine is considered to be a precaution for use of influenza vaccines (77).

*US Department of Health and Human Services. Medicare program; hospital inpatient prospective payment systems for acute care hospitals and the long-term care hospital prospective payment system and FY2012 rates; hospitals’ FTE resident caps for graduate medical education payment; final rules. Federal Register 2011;76:51631–3.

Recommendations

Vaccination

Annual influenza vaccination is recommended for all persons aged ≥ 6 months who have no medical contraindication; therefore, vaccination of all HCP who have no contraindications is recommended. The influenza vaccine is evaluated annually with one or more vaccine strains updated almost every year. In addition, antibody titers decline during the year after vaccination. Thus, annual vaccination with the current season's formulation is recommended. Annual vaccination is appropriate and safe to begin as early in the season as vaccine is available. HCP should be among the groups considered for prioritized receipt of influenza vaccines when vaccine supply is limited.

Two types of influenza vaccines are available. LAIV is administered intranasally and is licensed for use in healthy nonpregnant persons aged 2–49 years. The trivalent inactivated vaccine (TIV) is administered as an intramuscular injection and can be given to any person aged ≥ 6 months. Both vaccine types contain vaccine virus strains that are selected to stimulate a protective immune response against the wild-type viruses that are thought to be most likely in circulation during the upcoming season. Use of LAIV for HCP who care for patients housed in protective inpatient environments has been a theoretic concern, but transmission of LAIV in health-care settings has not been reported. LAIV can be used for HCP who work in any setting, except those who care for severely immunocompromised hospitalized persons who require care in a protective environment. HCP who themselves have a condition that confers high risk for influenza complications, who are pregnant, or who are aged ≥ 50 years should not receive LAIV and should be administered TIV instead. An inactivated trivalent vaccine containing 60 mcg of hemagglutinin antigen per influenza vaccine virus strain (Fluzone High-Dose [sanofi pasteur]) is an alternative inactivated vaccine for persons aged ≥ 65 years. Persons aged ≥ 65 years may be administered any of the standard-dose TIV preparations or Fluzone High-Dose (77). The majority of TIV preparations are administered intramuscularly. An intradermally administered TIV was licensed in May 2011 and is an alternative to other TIV preparations for persons aged 18–64 years (131).

Use of Antiviral Drugs for Treating Exposed Persons and Controlling Outbreaks

Use of antiviral drugs for chemoprophylaxis or treatment of influenza is an adjunct to (but not a substitute for) vaccination. Oseltamivir or zanamivir are recommended currently for chemoprophylaxis or treatment of influenza (132,133). TIV

can be administered to exposed, unvaccinated HCP at the same time as chemoprophylaxis, but LAIV should be avoided because the antiviral medication will prevent viral replication needed to stimulate a vaccine response (77). Antivirals are used often among patients during outbreaks in closed settings such as long-term-care facilities but also can be administered to unvaccinated HCP during outbreaks, when an exposure to a person with influenza occurs, or after exposure when vaccination is not thought to be protective against the strain to which a vaccinated HCP was exposed. Chemoprophylaxis consists of 1 dose (of either antiviral drug) daily for 10 days, and treatment consists of 1 dose twice daily for 5 days. In many instances of HCP exposure, watchful waiting and early initiation of treatment if symptoms appear is preferred rather than use of antiviral chemoprophylaxis immediately after exposure. The intensity and duration of the exposure and the underlying health status of the exposed worker are important factors in clinical judgments about whether to provide chemoprophylaxis. If chemoprophylaxis is used, the provider should base choice of the agent on whether the circulating strain or strains of influenza have demonstrated resistance to particular antivirals.

Program Evaluation

- Health-care administrators should include influenza vaccination coverage among HCP as a measure of quality of care (124).
- Influenza vaccination rates among HCP within facilities should be regularly measured and reported, and ward-, unit-, and specialty-specific coverage rates should be provided to staff and administration (124). Such information might be useful to promote compliance with vaccination policies.

Measles

Background

Epidemiology and Risk Factors

Measles is a highly contagious rash illness that is transmitted by respiratory droplets and airborne spread. Severe complications, which might result in death, include pneumonia and encephalitis. Before the national measles vaccination program was implemented in 1963, almost every person acquired measles before adulthood; an estimated 3–4 million persons in the United States acquired measles each year (134). Approximately 500,000 persons were reported to have had measles annually, of whom 500 persons died, 48,000 were

hospitalized, and another 1,000 had permanent brain damage from measles encephalitis (134).

Through a successful 2-dose measles vaccination program (i.e., a first dose at age 12–15 months and a second dose between ages 4–6 years) (135) and better measles control throughout the region of the Americas (136), endemic transmission of measles was interrupted in the United States, and measles was declared eliminated from the country in 2000 (137). However, measles remains widespread in the majority of countries outside the Western Hemisphere, with an estimated 20 million measles cases occurring worldwide (138) and approximately 164,000 related deaths (139). Thus, the United States continues to experience international importations that might lead to transmission among U.S. residents and limited outbreaks, especially in unvaccinated populations (140–143).

During 2001–2008, a total of 557 confirmed measles cases were reported in the United States from 37 states and the District of Columbia (annual median: 56; range: 37 in 2004 to 140 in 2008), representing an annual incidence of less than one case per million population (144). Of the 557 reported case-patients, 126 (23%) were hospitalized (annual median: 16; range: 5–29); of these, at least five case-patients were admitted to intensive care. Two deaths were reported, both in 2003 (144).

Of the 557 reported case-patients during 2001–2008, a total of 223 (40%) were adults, including 156 (28%) aged 20–39 years and 67 (12%) aged ≥ 40 years. Of the 438 measles cases among U.S. residents, 285 (65%) cases were considered preventable (i.e., occurred among persons who were eligible for vaccination but were unvaccinated) (144). The remaining 153 (35%) cases were considered nonpreventable. Cases were defined as nonpreventable if they occurred among U.S. resident case-patients who had received ≥ 1 dose of measles-containing vaccine, if patients were vaccinated as recommended if traveling internationally, or if they were not vaccinated but had other evidence of immunity (i.e., were born before 1957 and therefore presumed immune from natural disease in childhood, had laboratory evidence of immunity, or had documentation of physician-diagnosed disease) or for whom vaccination is not recommended. During 2001–2008, a total of 12.5% (one of eight) of measles cases reported to CDC among HCP occurred in persons born before 1957; the other seven cases occurred among HCP born after 1957.

Measles-mumps-rubella (MMR) vaccination policies have been enforced with variable success in United States health-care facilities over the past decade. Even though medical settings were a primary site of measles transmission during the 1989–1991 measles resurgence (145,146), as of September

2011, only three states (New York, Oklahoma, and Rhode Island) had laws mandating that all hospital personnel have proof of measles immunity and did not allow for religious or philosophic exemptions (147).

Vaccine coverage in the United States is high; in 2010, a total of 91.5% of children aged 19–35 months had received 1 dose of MMR vaccine (21); during 2009–2010, a total of 94.8% of kindergartners had evidence of 2 doses (148); and in 2010, a total of 90.5% of adolescents had evidence of 2 doses (22). Nationally representative data on MMR vaccine coverage of U.S. HCP are not available.

Measles Transmission and the Costs of Mitigating Measles Exposures in Health-Care Settings

Health-care-associated cases of measles are of public health concern. Because of the severity of measles, infected persons are likely to seek medical care in primary health-care facilities, emergency departments, or hospitals (141,149,150). Medical settings played a prominent role in perpetuating outbreaks of measles transmission during the 1989–1991 measles resurgence (145,146) and were a primary site of measles transmission in a health-care-associated outbreak in 2008 (149). During 2001–2008, a total of 27 reported measles cases were transmitted in U.S. health-care facilities, accounting for 5% of all reported U.S. measles cases.

Because of the greater opportunity for exposure, HCP are at higher risk than the general population for becoming infected with measles. A study conducted in 1996 in medical facilities in a county in Washington state indicated that HCP were 19 times more likely to develop measles than other adults (151). During 2001–2008, in the 23 health-care settings in which measles transmission was reported, eight cases occurred among HCP, six (75%) of whom were unvaccinated or had unknown vaccination status. One health-care provider was hospitalized in an intensive care unit for 6 days from severe measles complications (142). During a health-care-associated measles outbreak in Arizona in 2008 with 14 cases, six cases were acquired in hospitals, and one was acquired in an outpatient setting. One unvaccinated health-care worker developed measles and infected a hospital emergency room patient who required intensive care following hospital admission for measles (149).

High costs also are involved in evaluating and containing exposures and outbreaks in health-care facilities, as well as a substantial disruption of regular hospital routines when control measures are instituted, especially if hospitals do not have readily available data on the measles immunity status

of their staff and others included in the facility vaccination program. In 2005 in Indiana, one hospital spent more than \$113,000 responding to a measles outbreak (142), and in 2008 in Arizona, two hospitals spent \$799,136 responding to and containing cases in their facilities (149). The Arizona outbreak response required rapid review of measles documentation of 14,844 HCP at seven hospitals and emergency vaccination of approximately 4,500 HCP who lacked documentation of measles immunity. Serologic testing at two hospitals among 1,583 HCP without documented history of vaccination or without documented laboratory evidence of measles immunity revealed that 138 (9%) of these persons lacked measles IgG antibodies (149).

Vaccine Effectiveness, Duration of Immunity and Seroprevalence Studies, and Vaccine Safety

Vaccine Effectiveness

MMR vaccine is highly effective in preventing measles with a 1-dose vaccine effectiveness of 95% when administered on or after age 12 months and a 2-dose vaccine effectiveness of 99% (135).

Duration of Immunity and Seroprevalence Studies

Two doses of live measles vaccine are considered to provide long-lasting immunity (135). Although antibody levels decline following vaccination, a study examining neutralizing antibody levels up to 10 years following the second dose of MMR vaccine in children indicates that antibodies remain above the level considered protective (152).

Studies among HCP in the United States during the measles resurgence in the late 1980s through early 1990s demonstrated that 4%–10% of all HCP lacked measles IgG antibodies (153–156). During the 2008 Arizona outbreak, of the 1,077 health-care providers born during or after 1957 without documented measles immunity, 121 (11%) were seronegative (149). In a study of measles seroprevalence among 469 newly hired HCP at a hospital in North Carolina who were born before 1957, and thus considered immune by age, who could not provide written evidence of immunity to measles, serologic testing indicated that six (1.3%) lacked measles IgG antibodies (157). Other serologic studies of hospital-based HCP indicate that 2%–9% of those born before 1957 lacked antibodies to measles (156,158–160).

A survey conducted during 1999–2004 found a seroprevalence of measles antibodies of 95.9% among persons in the U.S. population aged 6–49 years (161). The survey

indicated that the lowest prevalence, 92.4%, was among adults born during 1967–1976 (161). A 1999 study of U.S. residents aged ≥ 20 years determined that 93% had antibodies to measles virus (162).

Vaccine Safety

Measles vaccine is administered in combination with the mumps and rubella components as the MMR vaccine in the United States. Monovalent measles vaccine rarely has been used in the United States in the past 2 decades and is no longer available. After decades of use, evidence demonstrates that MMR vaccine has an excellent safety profile (134).

The majority of documented adverse events occur in children. In rare circumstances, MMR vaccination of adults has been associated with the following adverse events: anaphylaxis (approximately 1.0–3.5 occurrences per million doses administered) (134), thrombocytopenia from the measles component or rubella component (a rate of three to four cases for every 100,000 doses) (134), and acute arthritis from the rubella component (arthralgia develops among approximately 25% of rubella-susceptible postpubertal females after MMR vaccination, and approximately 10% have acute arthritis-like signs and symptoms) (135). When joint symptoms occur, they generally persist for 1 day–3 weeks and rarely recur (135). Chronic joint symptoms attributable to the rubella component of the MMR vaccine are reported very rarely, if they occur at all. Evidence does not support an association between MMR vaccination and any of the following: hearing loss, retinopathy, optic neuritis, Guillain-Barré Syndrome, type 1 diabetes, Crohn's disease, or autism (135,163–169).

A woman can excrete the rubella vaccine virus in breast milk and transmit the virus to her infant, but the infection remains asymptomatic (135). Otherwise, persons who receive MMR or its component vaccines do not transmit measles, rubella, or mumps vaccine viruses (135). No transmission of MMR vaccine virus in a health-care setting has been documented.

Recommendations

Vaccination

All persons who work in health-care facilities should have presumptive evidence of immunity to measles. This information should be documented and readily available at the work location. Recently vaccinated HCP do not require any restriction in their work activities.

Presumptive evidence of immunity to measles for persons who work in health-care facilities includes any of the following:

- written documentation of vaccination with 2 doses of live measles or MMR vaccine administered at least 28 days apart,[†]
- laboratory evidence of immunity,[§]
- laboratory confirmation of disease, or
- birth before 1957.[¶]

Prevaccination Testing

Prevaccination antibody screening before MMR vaccination for an employee who does not have adequate presumptive evidence of immunity is not necessary unless the medical facility considers it cost effective (134,170–172) although no recent studies have been conducted. For HCP who have 2 documented doses of MMR vaccine or other acceptable evidence of immunity to measles, serologic testing for immunity is not recommended. In the event that a HCP who has 2 documented doses of MMR vaccine is tested serologically and determined to have negative or equivocal measles titer results, it is not recommended that the person receive an additional dose of MMR vaccine. Such persons should be considered to have presumptive evidence of measles immunity. Documented age-appropriate vaccination supersedes the results of subsequent serologic testing. Because rapid vaccination is necessary to halt disease transmission, during outbreaks of measles, serologic screening before vaccination is not recommended.

Use of Vaccine and Immune Globulin for Treating Exposed Persons and Controlling Outbreaks

Following airborne infection–control precautions and implementing other infection–control measures are important to control the spread of measles but might fail to prevent all nosocomial transmission, because transmission to other susceptible persons might occur before illness is recognized. Persons infected with measles are infectious 4 days before rash onset through 4 days after rash onset.

When a person who is suspected of having measles visits a health-care facility, airborne infection–control precautions should be followed stringently. The patient should be asked immediately to wear a medical mask and should be placed

in an airborne-infection isolation room (i.e., a negative air-pressure room) as soon as possible. If an airborne-infection isolation room is not available, the patient should be placed in a private room with the door closed and be asked to wear a mask. If possible, only staff with presumptive evidence of immunity should enter the room of a person with suspect or confirmed measles. Regardless of presumptive immunity status, all staff entering the room should use respiratory protection consistent with airborne infection–control precautions (i.e., use of an N95 respirator or a respirator with similar effectiveness in preventing airborne transmission) (3,150).

Because of the possibility, albeit low (~1%), of measles vaccine failure in HCP exposed to infected patients (173), all HCP should observe airborne precautions in caring for patients with measles. HCP in whom measles occurs should be excluded from work until ≥4 days following rash onset. Contacts with measles-compatible symptoms should be isolated, and appropriate infection-control measures (e.g., rapid vaccination of susceptible contacts) should be implemented to prevent further spread (174).

If measles exposures occur in a health-care facility, all contacts should be evaluated immediately for presumptive evidence of measles immunity. HCP without evidence of immunity should be offered the first dose of MMR vaccine and excluded from work from day 5–21 following exposure (135). HCP without evidence of immunity who are not vaccinated after exposure should be removed from all patient contact and excluded from the facility from day 5 after their first exposure through day 21 after the last exposure, even if they have received postexposure intramuscular immune globulin of 0.25 mL/kg (40 mg IgG/kg) (135). Those with documentation of 1 vaccine dose may remain at work and should receive the second dose.

Case-patient contacts who do not have presumptive evidence of measles immunity should be vaccinated, offered intramuscular immune globulin of 0.25 mL/kg (40 mg IgG/kg), which is the standard dosage for nonimmunocompromised persons (135), or quarantined until 21 days after their exposure to the case-patient. Contacts with measles-compatible symptoms should be isolated, and appropriate infection-control measures should be implemented to prevent further spread. If immune globulin is administered to an exposed person, observations should continue for signs and symptoms of measles for 28 days after exposure because immune globulin might prolong the incubation period.

Available data suggest that live virus measles vaccine, if administered within 72 hours of measles exposure, will prevent, or modify disease (134). Even if it is too late to provide effective postexposure prophylaxis by administering MMR, the vaccine can provide protection against future exposure to all three infections. Identifying persons who lack evidence of measles immunity during

[†] The first dose of measles-containing vaccine should be administered on or after the first birthday; the second dose should be administered no earlier than 28 days after the first dose.

[§] Measles immunoglobulin (IgG) in the serum; equivocal results should be considered negative.

[¶] The majority of persons born before 1957 are likely to have been infected naturally and may be presumed immune, depending on current state or local requirements. For unvaccinated personnel born before 1957 who lack laboratory evidence of measles immunity or laboratory confirmation of disease, health-care facilities should consider vaccinating personnel with 2 doses of MMR vaccine at the appropriate interval. For unvaccinated personnel born before 1957 who lack laboratory evidence of measles immunity or laboratory confirmation of disease, health-care facilities should recommend 2 doses of MMR vaccine during an outbreak of measles.

contact investigations provides a good opportunity to offer MMR vaccine to protect against measles as well as mumps and rubella, not only for HCP who are part of an organization's vaccination program, but also for patients and visitors. If an exposed person is already incubating measles, MMR vaccination will not exacerbate symptoms. In these circumstances, persons should be advised that a measles-like illness occurring shortly after vaccination could be attributable either to natural infection or to the vaccine strain. In such circumstances, specimens should be submitted for viral strain identification.

Mumps

Background

Epidemiology and Risk Factors

Mumps is an acute viral infection characterized by fever and inflammation of the salivary glands (usually parotitis) (175). The spectrum of illness ranges from subclinical infection (20%–40%) to nonspecific respiratory illness, sialadenitis including classic parotitis, deafness, orchitis, and meningoencephalitis; severity increases with age (175). In the prevaccine era, mumps was a common childhood illness, with approximately 186,000 mumps cases reported in the United States per year (176). After the introduction of the Jeryl Lynn strain mumps vaccine in 1967 and the implementation of the 1-dose mumps vaccine policy for children in 1977 (177), reports of mumps cases in the United States declined 99% (178). During 1986–1987, an increase in reported mumps cases occurred, primarily affecting unvaccinated adolescents and young adults. In the late 1980s, sporadic outbreaks continued to occur that affected both unvaccinated and 1-dose vaccinated adolescents and young adults (178). In 1989, a second dose of MMR vaccine was recommended nationwide for better measles control among school-aged children (179). Historically low rates of mumps followed with only several hundred reported cases per year in the United States during 2000–2005.

In 1998, a national goal to eliminate mumps was set for 2010 (180). However, in 2006, a total of 6,584 mumps cases were reported in the United States, the largest U.S. mumps outbreak in nearly 20 years (181–183). Whereas overall national mumps incidence was 2.2 per 100,000 population, eight states in the Midwest were the most affected, with 2.5–66.1 cases per 100,000 population (183). The highest incidence (31.1 cases per 100,000 population) was among persons aged 18–24 years (e.g., college-aged students), the majority of whom had received 2 doses of mumps-containing vaccine. Of the 4,017 case-patients for whom age and vaccination status were known, 1,786 (44%) were aged ≥ 25 years (incidence: 7.2 cases per 100,000 persons); of these 1,786 patients, 351 (20%) received

at least 2 doses, 444 (25%) received 1 dose, 336 (19%) were unvaccinated, and 655 (37%) had unknown vaccination status.

Since the 2006 resurgence, two additional large U.S. mumps outbreaks have occurred, both during 2009–2010, one among members of a religious community with cases occurring throughout the northeastern United States (184) and the other in Guam (185); both outbreaks primarily affected children and adolescents in crowded environments who had received 2 doses of vaccine.

Vaccine coverage in the United States is high; in 2010, approximately 91.5% of children aged 19–35 months had received 1 dose of MMR vaccine (21); during 2009–2010, a total of 94.8% of kindergartners had evidence of 2 doses (148). In 2010, a total of 90.5% of adolescents had evidence of 2 doses (22). Nationally representative data on MMR vaccine coverage of U.S. HCP are not available.

Mumps Transmission and the Costs of Mitigating Mumps Exposures in Health-care Settings

Although health-care-associated transmission of mumps is infrequent, it might be underreported because of the high percentage (~20%–40%) of infected persons who might be asymptomatic (186–189). In a survey of 9,299 adults in different professions conducted in 1968, before vaccine was used routinely, the rate of mumps acquisition was highest among dentists and HCP, with rates of 18% among dentists and 15% among physicians (37% for pediatricians), compared with 9% among primary and secondary school teachers and 2% among university staff members (190).

In the postvaccine era, mumps transmission also has been documented in medical settings (191–193). During a Tennessee mumps outbreak during 1986–1987, a total of 17 (12%) of 146 hospitals and three (50%) of six long-term-care facilities reported one or more practices that could contribute to the spread of mumps, including not isolating patients with mumps, assigning susceptible staff to care for patients with mumps, and not immunizing susceptible employees. Health-care-associated transmission resulted in six cases of mumps infections among health-care providers and nine cases of mumps infections among patients (191). In Utah in 1994, two health-care providers in a hospital developed mumps after they had contact with an infected patient (192). During the 2006 outbreak, one health-care facility in Chicago experienced ongoing mumps transmission lasting 4 weeks (193).

During the 2006 multistate U.S. outbreak, 144 (8.5%) of 1,705 adult case-patients in Iowa for whom occupation was known were health-care providers (Iowa Department of Public Health, unpublished data, 2006). Whether transmission occurred from patients, coworkers, or persons in

the community is unknown. During the 2009–2010 outbreak in the northeastern region of the United States, seven (0.2%) of the 3,400 case-patients were health-care providers, six of whom likely were infected by patients because they had no other known exposure.

Exposures to mumps in health-care settings also can result in added economic costs because of furlough or reassignment of staff members from patient-care duties or closure of wards (194). In 2006, a Kansas hospital spent \$98,682 containing a mumps outbreak (195). During a mumps outbreak in Chicago in 2006, one health-care facility spent \$262,788 controlling the outbreak (193).

Vaccine Effectiveness, Duration of Immunity and Seroprevalence Studies, and Vaccine Safety

Vaccine Effectiveness

MMR vaccine has a 1-dose vaccine effectiveness in preventing mumps of 80%–85% (range: 75%–91%) (175,196–199) and a 2-dose vaccine effectiveness of 79%–95% (199–202). In a study conducted on two Iowa college campuses during the 2006 mumps outbreak among a population that was primarily vaccinated with 2 doses, 2-dose vaccine effectiveness ranged from 79% to 88% (202).

Duration of Immunity and Seroprevalence Studies

Mumps antibody levels wane over time following the first or second dose of vaccination (203,204), but the correlates of immunity to mumps are poorly understood and the significance of these waning antibody levels is unclear. A study on a university campus in Nebraska in 2006 indicated lower levels of mumps neutralizing antibodies among students who had been vaccinated with a second MMR dose >15 years previously than among those who had been vaccinated 1–5 years previously, but the difference was not statistically significant ($p>0.05$) (205). In a 2006 study on a university campus in Kansas, students with mumps were more likely to have received a second dose of MMR vaccine ≥ 10 years previously than were their roommates without mumps (206). However, another 2006 study from an Iowa college campus identified no such association (202).

During 1999–2004, national seroprevalence for mumps antibodies for persons aged 6–49 years was 90% (95% confidence interval [CI]: 88.8–91.1) (207). In the Nebraska study, 414 (94%) of the 440 participants were seropositive for mumps antibodies (205). A study in Kansas in 2006 indicated that 13% of hospital employees lacked antibodies to the mumps virus (195). In a recent study on mumps seroprevalence among 381 newly hired health-care personnel at a hospital in North Carolina who were born before 1957 and thus considered

immune by age and who could not provide written evidence of immunity to mumps, serologic testing indicated that 14 (3.7%) lacked IgG antibodies to mumps (157).

Vaccine Safety

Mumps vaccine is administered in combination with the measles and rubella components as the MMR vaccine in the United States. Monovalent mumps vaccine has rarely been used in the United States in the past 2 decades and is no longer available. After decades of use, evidence demonstrates that MMR vaccine has an excellent safety profile. The most common adverse reactions to the mumps component of the MMR vaccine are parotitis 10–14 days after vaccination and low-grade fever (175). On the basis of biologic plausibility, orchitis, arthritis, or sensorineural deafness might rarely follow vaccination (175).

The majority of documented adverse events occur in children. In rare circumstances, MMR vaccination of adults has been associated with anaphylaxis (approximately 1.0–3.5 occurrences per million doses administered) (134), thrombocytopenia from the measles component or rubella component (rate: three to four cases for every 100,000 doses) (134), and acute arthritis from the rubella component (arthralgia develops among approximately 25% of rubella-susceptible postpubertal females after MMR vaccination, and approximately 10% have acute arthritis-like signs and symptoms) (135). When joint symptoms occur, they generally persist for 1 day–3 weeks and rarely recur (135). Chronic joint symptoms attributable to the rubella component of the MMR vaccine are reported rarely, if they occur at all. Evidence does not support a link between MMR vaccination and hearing loss, retinopathy, optic neuritis, Guillain-Barré Syndrome, type 1 diabetes, Crohn's disease, or autism (135,163–169).

A woman can excrete the rubella vaccine virus in breast milk and transmit the virus to her infant, but the infection remains asymptomatic (135). Otherwise, persons who receive MMR or its component vaccines do not transmit measles, rubella, or mumps vaccine viruses (135). No transmission of MMR vaccine virus in a health-care setting has been documented.

Recommendations

Vaccination

All persons who work in health-care facilities should have presumptive evidence of immunity to mumps. This information should be documented and readily available at the work location. Recently vaccinated HCP do not require any restriction in their work activities.

Presumptive evidence of immunity to mumps for persons who work in health-care facilities includes any of the following:

- written documentation of vaccination with 2 doses of live mumps or MMR vaccine administered at least 28 days apart,**
- laboratory evidence of immunity,††
- laboratory confirmation of disease, or
- birth before 1957.§§

Prevaccination Testing

For HCP who do not have adequate presumptive evidence of mumps immunity, prevaccination antibody screening before MMR vaccination is not necessary (135,175). For HCP who have 2 documented doses of MMR vaccine or other acceptable evidence of immunity to mumps, serologic testing for immunity is not recommended. In the event that a health-care provider who has 2 documented doses of MMR vaccine is tested serologically and determined to have negative or equivocal mumps titer results, it is not recommended that the person receive an additional dose of MMR vaccine. Such persons should be considered immune to mumps. Documented age-appropriate vaccination supersedes the results of subsequent serologic testing. Likewise, during outbreaks of mumps, serologic screening before vaccination is not recommended because rapid vaccination is necessary to halt disease transmission.

Controlling Mumps Outbreaks in Health-Care Settings

Placing patients in droplet precautions and implementing other infection-control measures is important to control the spread of mumps but might fail to prevent all nosocomial transmission, because transmission to other susceptible persons might occur before illness is recognized (208). When a person suspected of having mumps visits a health-care facility, only HCP with adequate presumptive evidence of immunity should be exposed to the person, and in addition to standard precautions, droplet precautions should be followed. The index case-patient should be isolated, and respiratory precautions

(gown and gloves) should be used for patient contact. Negative pressure rooms are not required. The patient should be isolated for 5 days after the onset of parotitis, during which time shedding of virus is likely to occur (209).

If mumps exposures occur in a health-care facility, all contacts should be evaluated for evidence of mumps immunity. HCP with no evidence of mumps immunity who are exposed to patients with mumps should be offered the first dose of MMR vaccine as soon as possible, but vaccine can be administered at any interval following exposure; they should be excluded from duty from day 12 after the first unprotected exposure through day 25 after the most recent exposure. HCP with documentation of 1 vaccine dose may remain at work and should receive the second dose. HCP with mumps should be excluded from work for 5 days from the onset of parotitis (209).

Antibody response to the mumps component of MMR vaccine generally is believed not to develop soon enough to provide effective prophylaxis after exposure to suspected mumps (191,210), but data are insufficient to rule out a prophylactic effect. Nonetheless, the vaccine is not recommended for prophylactic purposes after exposure. However, identifying persons who lack presumptive evidence of mumps immunity during contact investigations provides a good opportunity to offer MMR vaccine to protect against mumps as well as measles and rubella, not only for HCP who are part of an organization's vaccination program, but also for patients and visitors. If an exposed person already is incubating mumps, MMR vaccination will not exacerbate the symptoms. In these circumstances persons should be advised that a mumps-like illness occurring shortly after vaccination is likely to be attributable to natural infection. In such circumstances, specimens should be submitted for viral strain identification to differentiate between vaccine and wild type virus. Immune globulin is not routinely used for postexposure protection from mumps because no evidence exists that it is effective (135).

Rubella

Background

Epidemiology and Risk Factors

Rubella (German measles) is a viral disease characterized by rash, low-grade fever, lymphadenopathy, and malaise (211). Although rubella is considered a benign disease, transient arthralgia and arthritis are observed commonly in infected adults, particularly among postpubertal females. Chronic arthritis has been reported after rubella infection, but such reports are rare, and evidence of an association is weak (212). Other complications that occur infrequently

** The first dose of mumps-containing vaccine should be administered on or after the first birthday; the second dose should be administered no earlier than 28 days after the first dose.

†† Mumps immunoglobulin (IgG) in the serum; equivocal results should be considered negative.

§§ The majority of persons born before 1957 are likely to have been infected naturally between birth and 1977, the year that mumps vaccination was recommended for routine use, and may be presumed immune, even if they have not had clinically recognizable mumps disease. (This might vary depending on current state or local requirements.) For unvaccinated personnel born before 1957 who lack laboratory evidence of mumps immunity or laboratory confirmation of disease, health-care facilities should consider vaccinating personnel with 2 doses of MMR vaccine at the appropriate interval; for unvaccinated personnel born before 1957 who lack laboratory evidence of mumps immunity or laboratory confirmation of disease, health-care facilities should recommend 2 doses of MMR vaccine during an outbreak of mumps.

are thrombocytopenia and encephalitis (211). Infection is asymptomatic in 25%–50% of cases (213). Clinical diagnosis of rubella is unreliable and should not be considered in assessing immune status. Many rash illnesses might mimic rubella infection and many rubella infections are unrecognized. The only reliable evidence of previous rubella infection is the presence of serum rubella IgG antibody (211).

Of primary concern are the effects that rubella can have when a pregnant woman becomes infected, especially during the first trimester, which can result in miscarriages, stillbirths, therapeutic abortions, and congenital rubella syndrome (CRS), a constellation of birth defects that often includes blindness, deafness, mental retardation, and congenital heart defects (211,213). Postnatal rubella is transmitted through direct or droplet contact from nasopharyngeal secretions. The incubation period ranges from 12 to 23 days (214,215). An ill person is most contagious when the rash first appears, but the period of maximal communicability extends from a few days before to 7 days after rash onset (213). Rubella is less contagious than measles.

In the prevaccine era, rubella was an endemic disease globally with larger epidemics that occurred; in the United States, rubella epidemics occurred approximately every 7 years (211). During the 1964–1965 global rubella epidemic, an estimated 12.5 million cases of rubella occurred in the United States, resulting in approximately 2,000 cases of encephalitis, 11,250 fetal deaths attributable to spontaneous or surgical abortions, 2,100 infants who were stillborn or died soon after birth, and 20,000 infants born with CRS. The economic impact of this epidemic in the United States alone was estimated at \$1.5 billion in 1965 dollars (\$10 billion in 2010 dollars) (216).

After the rubella vaccine was licensed in the United States in 1969, reported rubella cases decreased from 57,686 in 1969 to 12,491 in 1976 (216), and CRS cases reported nationwide decreased from 68 in 1970 to 23 in 1976 (217). Declines in rubella age-specific incidence occurred in all age groups, including adolescents and adults, but the greatest declines were among children aged <15 years (216). During 1977–1978, a resurgence of rubella occurred, primarily among older adolescents and young adults, because the initial vaccination strategy targeted children (218). During this resurgence, 62% of reported rubella cases occurred among persons aged >15 years compared with 23% of cases during 1966–1968 (135). As a result of the change in the epidemiologic profile of rubella, in 1977, ACIP modified its recommendations to include the vaccination of susceptible postpubertal girls and women. In 1989, a second MMR vaccination dose was recommended in response to large measles outbreaks nationwide (179). During

2001–2004, the annual numbers of rubella and CRS cases were extremely low, with 23 reported rubella cases in 2001, a total of 18 in 2002, a total of 7 in 2003, and a total of 9 in 2004 (219).

Rubella was declared eliminated from the United States in 2004 (219,220). During 2005–2009, a total of 54 cases of rubella were reported; the majority of the cases occurred among persons aged >20 years. Of the reported cases, 23 (43%) were import-associated; only two outbreaks of rubella were reported during this time, and both involved only three cases (CDC, unpublished data, 2009). Since 2005, only four cases of CRS have been reported, with two cases reported in 2009; three (75%) cases were acquired internationally, and the other had an unknown source (CDC, unpublished data, 2009). Rubella importations are expected to continue in the immediate future.

As of September 2011, only three states (i.e., New York, Oklahoma, and Rhode Island) had laws mandating that all hospital personnel have proof of rubella immunity and did not allow for religious or philosophical exemptions (147). Additional states had requirements for specific types of facilities or for certain employees within those facilities, but they did not have universal laws mandating proof of rubella immunity for all hospital personnel (147).

MMR vaccine coverage in the United States is high; in 2010, an estimated 91.5% of children aged 19–35 months had received 1 dose of MMR vaccine (21); during 2009–2010, a total of 94.8% of kindergarteners had evidence of 2 doses (148); and in 2010, a total of 90.5% of adolescents had evidence of 2 doses (22). Nationally representative data on MMR vaccine coverage of U.S. HCP are not available.

Rubella Transmission and the Costs of Mitigating Rubella Exposures in Health-Care Settings

No documented transmission of rubella to HCP or other hospital staff or patients in U.S. health-care facilities has occurred since elimination was declared. However, in the decades before elimination, rubella transmission was documented in at least 10 U.S. medical settings (221–231) and led to outbreaks with serious consequences, including pregnancy terminations, disruption of hospital routine, absenteeism from work, expensive containment measures, negative publicity, and the threat of litigation (232). In these outbreaks, transmission occurred from HCP to susceptible coworkers and patients, as well as from patients to HCP and other patients. No data are available on whether HCP are at increased risk for acquiring rubella compared with other professions.

Vaccine Effectiveness, Duration of Immunity and Seroprevalence Studies, and Vaccine Safety

Vaccine Effectiveness

Vaccine effectiveness of the RA 27/3 rubella vaccine against clinical rubella is 95% (85%–99% CI) and >99% for clinical laboratory confirmed rubella (211,233). Antibody responses to rubella as part of MMR vaccine are equal (i.e., >99%) to those seen after the single-antigen RA 27/3 rubella vaccine (211,234).

Duration of Immunity and Seroprevalence Studies

In clinical trials, 97%–99% of susceptible persons who received a single dose of the RA 27/3 rubella vaccine when they were aged ≥ 12 months developed antibody (211,235,236). Two studies have demonstrated that vaccine-induced rubella antibodies might wane after 12–15 years (237,238); however, rubella surveillance data do not indicate that rubella and CRS are increasing among vaccinated persons.

National seroprevalence for rubella antibodies among persons aged 6–49 years during 1999–2004 was 91% (239). During 1986–1990, serologic surveys in one hospital indicated that 5% of HCP (including persons born in 1957 or earlier) did not have detectable rubella antibody (240). Earlier studies indicated that up to 14%–19% of U.S. hospital personnel, including young women of childbearing age, lacked detectable rubella antibody (225,241,242). In a recent study on rubella seroprevalence among 477 newly hired HCP at a hospital in North Carolina who were born before 1957, and thus considered immune by age, who could not provide written evidence of immunity to rubella, serologic testing revealed that 14 (3.1%) lacked detectable levels of antibody to rubella (157).

Because of the potential for contact with pregnant women in any type of health-care facility, all HCP should have documented presumptive evidence of immunity to rubella. History of disease is not considered adequate evidence of immunity.

Vaccine Safety

Rubella vaccine is administered in combination with the measles and mumps components as the MMR vaccine in the United States. Monovalent rubella vaccine has been used rarely in the United States in the past 2 decades and is no longer available. After decades of use, evidence demonstrates that MMR vaccine has an excellent safety profile. The most common adverse reactions to the rubella component of the MMR vaccine are transient rashes, which usually appear 7–10 days after vaccination in approximately 5% of vaccinated persons, or transient lymphadenopathy, fever, sore throat, and headache (135,211).

The majority of documented adverse events occur in children. In rare circumstances, MMR vaccination of adults has been associated with the following adverse events: anaphylaxis (approximately 1.0–3.5 occurrences per million doses administered) (134), thrombocytopenia from the measles component or rubella component (rate: three to four cases for every 100,000 doses) (134), and acute arthritis from the rubella component (arthralgia develops among approximately 25% of rubella-susceptible postpubertal females after MMR vaccination, and approximately 10% have acute arthritis-like signs and symptoms from the rubella component of the vaccine) (135). When joint symptoms occur, they generally persist for 1 day–3 weeks and rarely recur (135). Chronic joint symptoms attributable to the rubella component of the MMR vaccine are very rarely reported, if they occur at all.

As a result of the theoretic risk to the fetus, women should be counseled to avoid becoming pregnant for 28 days after receipt of a rubella-containing vaccine (243). However, receipt of rubella-containing vaccine during pregnancy should not be a reason to consider termination of pregnancy; data from 18 years of following to term 321 known rubella-susceptible women who were vaccinated within 3 months before or 3 months after conception indicated that none of the 324 infants born to these mothers had malformations compatible with congenital rubella syndrome, but five had evidence of subclinical rubella infection (244). The estimated risk for serious malformations to fetuses attributable to the mother receiving RA 27/3 vaccine is considered to range from zero to 1.6% (135,244).

Evidence does not support a link between MMR vaccination and any of the following: hearing loss, retinopathy, optic neuritis, Guillain-Barré Syndrome, type 1 diabetes, Crohn's disease, or autism (135,163–169).

A woman can excrete the rubella vaccine virus in breast milk and transmit the virus to her infant, but the infection remains asymptomatic (135). Otherwise, persons who receive MMR or its component vaccines do not transmit measles, rubella, or mumps vaccine viruses (135). No transmission of MMR vaccine virus in a health-care setting has been documented.

Recommendations

Vaccination

All persons who work in health-care facilities should have presumptive evidence of immunity to rubella. Adequate rubella vaccination for HCP consists of 1 dose of MMR vaccine. However, because of the 2-dose vaccination requirements for measles and mumps, the use of the combined MMR vaccine will result in the majority of HCP receiving 2 doses of rubella-containing vaccine, which should provide an additional safeguard

against primary rubella vaccine failure. Recently vaccinated HCP do not require any restriction in their work activities.

Presumptive evidence of immunity to rubella for persons who work in health-care facilities includes any of the following:

- written documentation of vaccination with 1 dose of live rubella or MMR vaccine,
- laboratory evidence of immunity,^{¶¶}
- laboratory confirmation of rubella infection or disease, or
- birth before 1957^{***} (except women of childbearing potential who could become pregnant, although pregnancy in this age group would be exceedingly rare^{†††}).

Prevaccination Testing

For HCP who do not have adequate presumptive evidence of rubella immunity, prevaccination antibody screening before MMR vaccination is not necessary unless the medical facility considers it cost effective (135). For HCP who have 1 documented dose of MMR vaccine or other acceptable evidence of immunity to rubella, serologic testing for immunity is not recommended. In the event that a health-care provider who has at least 1 documented dose of rubella-containing vaccine is tested serologically and determined to have negative or equivocal rubella titer results, receipt of an additional dose of MMR vaccine for prevention of rubella is not recommended. Such persons should be considered immune to rubella. However, if the provider requires a second dose of measles or mumps vaccine, then a second dose of MMR should be administered. Documented age-appropriate vaccination supersedes the results of subsequent serologic testing. Likewise, during outbreaks of rubella, serologic screening before vaccination is not recommended because rapid vaccination is necessary to halt disease transmission.

Controlling Rubella Outbreaks

To prevent transmission of rubella in health-care settings, patients suspected to have rubella should be placed in private rooms. In addition to standard precautions, droplet precautions

should be followed until 7 days after onset of symptoms. Room doors can remain open, and special ventilation is not required.

Any exposed HCP who do not have adequate presumptive evidence of rubella immunity should be excluded from duty beginning 7 days after exposure to rubella and continuing through either 1) 23 days after the most recent exposure or 2) 7 days after rash appears if the provider develops rubella (213–215). Exposed HCP who do not have adequate presumptive evidence of immunity who are vaccinated postexposure should be excluded from duty for 23 days after the most recent exposure to rubella because no evidence exists that postexposure vaccination is effective in preventing rubella infection (244).

Neither rubella-containing vaccine (244) nor immune globulin (IG) (211,244) is effective for postexposure prophylaxis of rubella. Although intramuscular administration of 20 mL of immune globulin within 72 hours of rubella exposure might reduce the risk for rubella, it will not eliminate the risk (135,245); infants with congenital rubella have been born to women who received IG shortly after exposure (213). In addition, administration of IG after exposure to rubella might modify or suppress symptoms and create an unwarranted sense of security with respect to transmission.

If exposure to rubella does not cause infection, postexposure vaccination with MMR vaccine should induce protection against subsequent infection of rubella, as well as measles and mumps. If the exposure results in infection, no evidence indicates that administration of MMR vaccine during the presymptomatic or prodromal stage of illness increases the risk for vaccine-associated adverse events (213).

Pertussis

Background

Epidemiology and Risk Factors

Pertussis is a highly contagious bacterial infection. Secondary attack rates among susceptible household contacts exceed 80% (246,247). Transmission occurs by direct contact with respiratory secretions or large aerosolized droplets from the respiratory tract of infected persons. The incubation period is generally 7–10 days but can be as long as 21 days. The period of communicability starts with the onset of the catarrhal stage and extends into the paroxysmal stage. Symptoms of early pertussis (catarrhal phase) are indistinguishable from other upper respiratory infections.

Vaccinated adolescents and adults, whose immunity from childhood vaccinations wanes 5–10 years after the most recent dose of vaccine (usually administered at age 4–6 years), are an

^{¶¶} Rubella immunoglobulin (IgG) in the serum; equivocal results should be considered negative.

^{***} Depending on current state or local requirements, for unvaccinated personnel born before 1957 who lack laboratory evidence of rubella immunity or laboratory confirmation of infection or disease, health-care facilities should consider vaccinating personnel with one dose of MMR vaccine; for unvaccinated personnel born before 1957 who lack laboratory evidence of rubella immunity or laboratory confirmation of infection or disease, health-care facilities should recommend 1 dose of MMR vaccine during an outbreak of rubella.

^{†††} Because rubella can occur in some persons born before 1957 and because congenital rubella and congenital rubella syndrome can occur in the offspring of women infected with rubella virus during pregnancy, birth before 1957 is not acceptable evidence of rubella immunity for women who could become pregnant.

important source of pertussis infection for susceptible infants. Infants too young to be vaccinated are at greatest risk for severe pertussis, including hospitalization and death. The disease can be transmitted from adults to close contacts, especially unvaccinated children.

Vaccination coverage among infants and children for diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccine remains high. In 2010, coverage for children aged 19–35 months who have received ≥ 4 doses of DTaP/diphtheria and tetanus toxoids and pertussis vaccine (DTP)/diphtheria and tetanus toxoids vaccine (DT) was 84% (21). Among children entering kindergarten for the 2009–2010 school year, DTaP coverage was 93% (148). Vaccination coverage for tetanus toxoid, reduced diphtheria toxoid and acellular pertussis (Tdap) vaccine was 68.7% among adolescents in 2010 and <7% among adults in 2009 (22,248). Tdap vaccination coverage among HCP was 17.0% in 2009 (248).

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

In hospital settings, transmission of pertussis has occurred from hospital visitors to patients, from HCP to patients, and from patients to HCP (249–252). Although of limited size (range: 2–17 patients and 5–13 staff), documented outbreaks were costly and disruptive. In each outbreak, HCP were evaluated for cough illness and required diagnostic testing, prophylactic antibiotics, and exclusion from work.

During outbreaks that occur in hospitals, the risk for contracting pertussis among patients or staff is often difficult to quantify because exposure is not well defined. Serologic studies conducted among hospital staff indicate that exposure to pertussis is much more frequent than suggested by attack rates of clinical disease (246,249–254). In one outbreak, seroprevalence of pertussis agglutinating antibodies among HCP correlated with the degree of patient contact and was highest among pediatric house staff (82%) and ward nurses (71%) and lowest among nurses with administrative responsibilities (35%) (251).

A model to estimate the cost of vaccinating HCP and the net return from preventing nosocomial pertussis was constructed using probabilistic methods and a hypothetical cohort of 1,000 HCP with direct patient contact followed for 10 years (255). Baseline assumptions, determined from data in the literature, included incidence of pertussis in HCP, ratio of identified exposures per HCP case, symptomatic percentage of seroconfirmed pertussis infections in HCP, cost of infection-control measures per exposed person, vaccine efficacy, vaccine coverage, employment turnover rate, adverse events, and cost of vaccine (255). In a 10-year period, the cost of infection

control would be \$388,000 without Tdap vaccination of HCP compared with \$69,000 with such a program (255). Introduction of a vaccination program would result in a net savings as high as \$535,000 and a benefit-cost ratio of 2.38 (i.e., for every dollar spent on the vaccination program, the hospital would save \$2.38 on control measures) (255).

Vaccine Effectiveness, Duration of Immunity, and Vaccine Safety

A prelicensure immunogenicity and safety study in adolescents and adults of a vaccine containing acellular pertussis estimated vaccine efficacy to be 92% (256). Recent postlicensure studies of Tdap demonstrate vaccine effectiveness at 78% and 66% (257,258). Duration of immunity from vaccination has yet to be evaluated. Data from pre- and postlicensure studies support the safety of Tdap in adolescents and adults (259–263).

Since the 2005 Tdap recommendations for HCP, one study tried to determine if postexposure prophylaxis following pertussis exposure was necessary for Tdap-vaccinated HCP (264). During the study period, 116 exposures occurred among 94 HCP. Pertussis infection occurred in 2% of those who received postexposure prophylaxis compared with 10% of those who did not, suggesting a possible benefit of postexposure prophylaxis among Tdap-vaccinated HCP (264). Because Tdap coverage is suboptimal among HCP, and the duration of protection afforded by Tdap is unknown, vaccination status does not change the approach to evaluate the need for postexposure prophylaxis in exposed HCP. Postexposure prophylaxis is necessary for HCP in contact with persons at risk for severe disease. Other HCP either should receive postexposure prophylaxis or be monitored for 21 days after pertussis exposure and treated at the onset of signs and symptoms of pertussis. Recommended postexposure prophylaxis antibiotics for HCP exposed to pertussis include azithromycin, clarithromycin, or erythromycin. HCP are not at greater risk for diphtheria or tetanus than the general population.

Recommendations

Vaccination

Regardless of age, HCP should receive a single dose of Tdap as soon as feasible if they have not previously received Tdap and regardless of the time since their most recent Td vaccination. Vaccinating HCP with Tdap will protect them against pertussis and is expected to reduce transmission to patients, other HCP, household members, and persons in the community. Tdap is not licensed for multiple administrations; therefore, after receipt of Tdap, HCP should receive Td for future booster vaccination against tetanus and diphtheria. Hospitals and ambulatory-care facilities should provide Tdap for HCP and

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 and/or polymerase chain reaction (PCR) assay.

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 $\leq 1,000$ 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 disseminated 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

globulin 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. meningitidis* 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).

HCP Who May Elect to Receive Vaccine to Prevent Meningococcal Disease

HCP with known HIV infection are likely at increased risk for meningococcal disease and may elect vaccination. If these HCP are vaccinated, they should receive a 2-dose vaccine series (307).

Booster Doses

HCP who receive the 2-dose MCV4 vaccine series and/or remain in a group at increased risk should receive a booster dose every 5 years (306).

Postexposure Management of Exposed HCP

Postexposure prophylaxis is advised for all persons who have had intensive, unprotected contact (i.e., without wearing a mask) with infected patients (e.g., via mouth-to-mouth resuscitation, endotracheal intubation, or endotracheal tube management), including HCP who have been vaccinated with either the conjugate or polysaccharide vaccine (3).

Antimicrobial prophylaxis can eradicate carriage of *N. meningitidis* and prevent infections in persons who have unprotected exposure to patients with meningococcal infections (305). Rifampin, ciprofloxacin, and ceftriaxone are effective in eradicating nasopharyngeal carriage of *N. meningitidis*. In areas of the United States where ciprofloxacin-resistant strains of *N. meningitidis* have been detected (as of August 30, 2011, only parts of Minnesota and North Dakota), ciprofloxacin should not be used for chemoprophylaxis (308). Azithromycin can be used as an alternative. Ceftriaxone can be used during pregnancy. Postexposure prophylaxis should be administered within 24 hours of exposure when feasible; postexposure prophylaxis administered >14 days after exposure is of limited or no value (305). HCP not otherwise indicated for vaccination may be recommended to be vaccinated with meningococcal vaccine in the setting of a community or institutional outbreak of meningococcal disease caused by a serogroup contained in the vaccine.

Typhoid Fever

Background

Epidemiology and Risk Factors

The incidence of typhoid fever declined steadily in the United States during 1900–1960 and has since remained low. During 1999–2006, on average, 237 cases were reported annually to the National Typhoid and Paratyphoid Fever Surveillance System (309). The median age of patients was 22 years and 54% were male; 79% reported foreign travel during the 30 days before onset of symptoms. Among international

travelers, the risk for *Salmonella* Typhi infection appears to be highest for those who visit friends and relatives in countries in which typhoid fever is endemic and for those who visit (even for a short time) the most highly endemic areas (e.g., the Indian subcontinent) (310).

Increasing resistance to fluoroquinolones such as ciprofloxacin, which are used to treat multidrug-resistant *S. Typhi*, has been seen particularly among travelers to south and southeast Asia (311). Isolates with decreased susceptibility to ciprofloxacin (DCS) do not qualify as resistant according to current Clinical and Laboratory Standards Institute criteria but are associated with poorer clinical outcomes (311,312). Resistance to nalidixic acid, a quinolone, is a marker for DCS and increased from 19% in 1999 to 59% in 2008 (313). Nine isolates resistant to ciprofloxacin also were seen during this time period (313).

Although overall *S. Typhi* infections have declined in the United States, increased incidence and antimicrobial resistance including resistance to fluoroquinolones have been seen for paratyphoid fever caused by Paratyphi A (314). No vaccines that protect against Paratyphi A infection are available.

Transmission and Exposure in Health-Care Settings

During 1985–1994, seven cases of laboratory-acquired typhoid fever were reported among persons working in microbiology laboratories, only one of whom had been vaccinated (315). Additionally, *S. Typhi* might be transmitted nosocomially via the hands of infected persons (315).

Vaccine Effectiveness, Duration of Immunity, and Vaccine Safety

Two typhoid vaccines are distributed in the United States: oral live-attenuated Ty21a vaccine (one enteric-coated capsule taken on alternate days for a total of four capsules) and the capsular polysaccharide parenteral vaccine (1 0.5 mL intramuscular dose). Both vaccines protect 50%–80% of recipients. To maintain immunity, booster doses of the oral vaccine are required every 5 years, and booster doses of the injected vaccine are required every 2 years. Complication rates are low for both types of *S. Typhi* vaccines. During 1994–1999, serious adverse events requiring hospitalization occurred in an estimated 0.47 to 1.3 per 100,000 doses, and no deaths occurred (310). However, live-attenuated Ty21a vaccine should not be used among immunocompromised persons, including those infected with HIV (316). Theoretic concerns have been raised about the immunogenicity of live, attenuated Ty21a vaccine in persons concurrently receiving antimicrobials (including antimalarial chemoprophylaxis), viral vaccines, or immune globulin (317). A third type of vaccine, a parenteral heat-inactivated vaccine associated with higher reactogenicity, was discontinued in 2000 (310,318).

Recommendations

Vaccination

Microbiologists and others who work frequently with *S. Typhi* should be vaccinated with either of the two licensed and available vaccines. Booster vaccinations should be administered on schedule according to the manufacturers' recommendations.

Controlling the Spread of Typhoid Fever

Personal hygiene, particularly hand hygiene before and after all patient contacts, will minimize risk for transmitting enteric pathogens to patients. However, HCP who contract an acute diarrheal illness accompanied by fever, cramps, or bloody stools are likely to excrete substantial numbers of infective organisms in their feces. Excluding these HCP from care of patients until the illness has been evaluated and treated can prevent transmission (3).

Poliomyelitis

Background

Epidemiology and Risk Factors

In the United States, the last indigenously acquired cases of poliomyelitis caused by wild poliovirus occurred in 1979, and the Americas were certified to be free of indigenous wild poliovirus in 1994 (319,320). With the complete transition from use of oral poliovirus vaccine (OPV) to inactivated poliovirus vaccine (IPV) in 2000, vaccine-associated paralytic poliomyelitis (VAPP) attributable to OPV also has been eliminated (321,322), so the risk for exposure to any live poliovirus in the United States is limited. However, global eradication of poliomyelitis has not yet occurred, so reintroductions of poliovirus into the United States are possible. Two cases of paralytic polio from vaccine-derived poliovirus have occurred since 2000 (one imported case in 2005 and one case in an immunodeficient person in 2008), and evidence of limited circulating vaccine-derived poliovirus in an undervaccinated community was documented in 2005 (323–325).

Transmission and Exposure in Health-Care Settings

Poliovirus can be recovered from infected persons, including from pharyngeal specimens, feces, urine, and (rarely) cerebrospinal fluid. HCP and laboratory workers might be exposed if they come into close contact with infected persons (e.g., travelers returning from areas where polio is endemic) or with specimens that contain poliovirus.

Vaccine Effectiveness, Duration of Immunity, and Vaccine Safety

Both IPV and OPV are highly immunogenic and effective when administered according to their schedules. In studies conducted in the United States, 3 doses of IPV resulted in 100% seroconversion for types 2 and 3 poliovirus and 96%–100% for type 1 (326). Immunity is prolonged and might be lifelong. IPV is well tolerated, and no serious adverse events have been associated with its use. IPV is an inactivated vaccine and does not cause VAPP. IPV is contraindicated in persons with a history of hypersensitivity to any component of the vaccine, including 2-phenoxyethanol, formaldehyde, neomycin, streptomycin, and polymyxin B. OPV is no longer available in the United States.

Recommendations

Vaccination

Because the majority of adults born in the United States are likely immune to polio as a result of vaccination during childhood, poliovirus vaccine is not routinely recommended for persons aged ≥ 18 years. The childhood recommendation for poliovirus vaccine consists of 4 doses at ages 2, 4, and 6–18 months and 4–6 years.

However, vaccination is recommended for HCP who are at greater risk for exposure to polioviruses than the general population, including laboratory workers who handle specimens that might contain polioviruses and HCP who have close contact with patients who might be excreting wild polioviruses, including HCP who travel to work in areas where polioviruses are circulating.

Unvaccinated HCP should receive a 3-dose series of IPV, with dose 2 administered 4–8 weeks after dose 1, and dose 3 administered 6–12 months after dose 2. HCP who have previously completed a routine series of poliovirus vaccine and who are at increased risk can receive a lifetime booster dose of IPV if they remain at increased risk for exposure. Available data do not indicate the need for more than a single lifetime booster dose with IPV for adults.

Controlling the Spread of Poliovirus

Standard precautions always should be practiced when handling biologic specimens. Suspect cases require an immediate investigation including collection of appropriate laboratory specimens and control measures. All suspect or confirmed cases should be reported immediately to the local or state health department.

Other Vaccines Recommended for Adults

Certain vaccines are recommended for adults based on age or other individual risk factors but not because of occupational exposure (327). Vaccine-specific ACIP recommendations should be consulted for details on schedules, indications, contraindications, and precautions for these vaccines.

- **Pneumococcal polysaccharide vaccine (PPSV).** PPSV is recommended for healthy persons aged ≥ 65 years. PPSV is also recommended for persons aged < 65 years with certain underlying medical conditions, including anatomic or functional asplenia, immunocompromise (including HIV infection), chronic lung, heart or kidney disease, and diabetes.
- **Tetanus and diphtheria toxoids (Td).** All adults should have documentation of having received an age-appropriate series of Td-containing vaccine and a routine booster dose every 10 years. Persons without documentation of having received a Td series should receive a 3-dose series. The first dose of the series should be administered as Tdap (see Pertussis).
- **Human papillomavirus (HPV) vaccine.** Either quadrivalent HPV vaccine (Gardasil) or bivalent HPV vaccine (Cervarix) is recommended for females at age 11 or 12 years with catch-up vaccination recommended through age 26 years. Quadrivalent HPV vaccine (Gardasil) may be administered to males aged 9–26 years.
- **Zoster vaccine.** Zoster vaccine contains the same live attenuated varicella zoster virus as varicella vaccine but at a higher concentration (approximately 14 times more vaccine virus per dose). Zoster vaccine is recommended for the prevention of HZ (shingles) in persons aged ≥ 60 years. Transmission of vaccine virus from the recipient to a contact has not been reported. Consequently, limiting or restricting work activities for persons who recently received zoster vaccine is not necessary.
- **Hepatitis A vaccine.** HCP have not been demonstrated to be at increased risk for hepatitis A virus infection because of occupational exposure, including persons exposed to sewage. Hepatitis A vaccine is recommended for person with chronic liver disease, international travelers, and certain other groups at increased risk for exposure to hepatitis A.

Catch-Up and Travel Vaccination

Catch-Up Programs

Managers of health-care facilities should implement catch-up vaccination programs for HCP who already are employed, in addition to developing policies for achieving high vaccination coverage among newly hired HCP. HCP vaccination records could be reviewed annually during the influenza vaccination season or concurrent with annual TB testing. This strategy could help prevent outbreaks of vaccine-preventable diseases. Because education, especially when combined with other interventions such as reminder/recall systems and low or no out-of-pocket costs, enhances the success of many vaccination programs, informational materials should be available to assist in answering questions from HCP regarding the diseases, vaccines, and toxoids as well as the program or policy being implemented (120,328). Conducting educational workshops or seminars several weeks before the initiation of a catch-up vaccination program might promote acceptance of program goals.

Travel

Hospital personnel and other HCP who perform research or health-care work in foreign countries might be at increased risk for acquiring certain diseases that can be prevented by vaccines recommended in the United States (e.g., hepatitis B, influenza, MMR, Tdap, poliovirus, varicella, and meningococcal vaccines) and travel-related vaccines (e.g., hepatitis A, Japanese encephalitis, rabies, typhoid, or yellow fever vaccines) (329). Elevated risks for acquiring these diseases might stem from exposure to patients in health-care settings (e.g., poliomyelitis and meningococcal disease) but also might arise from circumstances unrelated to patient care (e.g., high endemicity of hepatitis A or exposure to arthropod-vector diseases [e.g., yellow fever]). All HCP should seek the advice of a health-care provider familiar with travel medicine at least 4–6 weeks before travel to ensure that they are up to date on routine vaccinations and that they receive vaccinations recommended for their destination (329). Although bacille Calmette-Guérin vaccination is not recommended routinely in the United States, HCP should discuss potential beneficial and other consequences of this vaccination with their health-care provider.

Work Restrictions

Work restrictions for susceptible HCP (i.e., no history of vaccination or documented lack of immunity) exposed to or infected with certain vaccine-preventable diseases can range from restricting individual HCP from patient contact to complete exclusion from duty (Table 5). A furloughed employee should be considered in the same category as an

employee excluded from the facility. Specific recommendations concerning work restrictions in these circumstances have been published previously (3,11).

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TABLE 1. Recommendations for immunization practices and use of immunobiologics applicable to disease prevention among health-care personnel* — Advisory Committee on Immunization Practices (ACIP), June 9, 1989–August 26, 2011

Subject	Publication in <i>MMWR</i>
General recommendations on immunization	2011;60(No. RR-2)
Diphtheria, tetanus, and pertussis	1991;40(No. RR-10) 1997;46(No. RR-7)
Hepatitis B	1991;40;(No. RR-8) [†] 1991;40(No. RR-13) 2001;50(No. RR-11) [†] 2006;55(No. RR-16) 2008;57(No. RR-8) [†]
Influenza [§]	2010;59(No. RR-8) 2011;60:1128–32
Measles, mumps, rubella (MMR)	1998;47(No. RR-8)
Meningococcal disease and outbreaks	2005;54(No. RR-7) 2011;60:72–6
Mumps (see also MMR and Measles)	1989;38:388–92, 397–400 2006;55:629–630
Pertussis, acellular (see also Diphtheria, tetanus, and pertussis)	2006;55(No. RR-3) 2006;55(No. RR-17) 2008;57(No. RR-4) 2011;60:13–15
Poliomyelitis	2000;49(No. RR-5) 2009;58:829–30
Rubella (see also MMR, Measles, and Mumps)	2001;50:1117
Typhoid	1994;43(No. RR-14)
Varicella	2007;56(No. RR-4)

* Persons who provide health care to patients or work in institutions that provide patient care (e.g., physicians, nurses, emergency medical personnel, dental professionals and students, medical and nursing students, laboratory technicians, hospital volunteers, and administrative and support staff in health-care institutions). **Source:** U.S. Department of Health and Human Services. Definition of health-care personnel (HCP). Available at <http://www.hhs.gov/ask/initiatives/vacctoolkit/definition.html>.

[†] This report provides guidance from CDC and is not an ACIP statement.

[§] Each year influenza vaccine recommendations are reviewed and amended to reflect updated information concerning influenza activity in the United States for the preceding influenza season and to provide information on the vaccine available for the upcoming influenza season. These recommendations are published periodically in *MMWR*. The most current published recommendations should be consulted (available at <http://www.cdc.gov/vaccines/pubs/acip-list.htm>).

TABLE 2. Immunizing agents and immunization schedules for health-care personnel (HCP)*

Generic name	Primary schedule and booster(s)	Indications	Major precautions and contraindications	Special considerations
Immunizing agents recommended for all HCP				
Hepatitis B (HB) recombinant vaccine	2 doses 4 weeks apart; third dose 5 months after second; booster doses not necessary; all doses should be administered IM in the deltoid	Preexposure: HCP at risk for exposure to blood or body fluids; postexposure (see Table 4)	On the basis of limited data, no risk for adverse effects to developing fetuses is apparent. Pregnancy should not be considered a contraindication to vaccination of women. Previous anaphylactic reaction to common baker's yeast is a contraindication to vaccination.	The vaccine produces neither therapeutic nor adverse effects in HBV-infected persons. Prevaccination serologic screening is not indicated for persons being vaccinated because of occupational risk but might be indicated for HCP in certain high-risk populations. HCP at high risk for occupational [†] contact with blood or body fluids should be tested 1–2 months after vaccination to determine serologic response.
Hepatitis B immune globulin (HBIG)	0.06 mL/kg IM as soon as possible after exposure, if indicated	Postexposure prophylaxis (see Table 4)	See package insert [§]	
Influenza vaccine (TIV and LAIV)	Annual vaccination with current seasonal vaccine. TIV is available in IM and ID formulations. LAIV is administered intranasally.	All HCP	History of severe (e.g., anaphylactic) hypersensitivity to eggs; prior severe allergic reaction to influenza vaccine	No evidence exists of risk to mother of fetus when the vaccine is administered to a pregnant woman with an underlying high-risk condition. Influenza vaccination is recommended for women who are or will be pregnant during influenza season because of increased risk for hospitalization and death. LAIV is recommended only for healthy, non-pregnant persons aged 2–49 years. Intradermal vaccine is indicated for persons aged 18–64 years. HCP who care for severely immunosuppressed persons who require a protective environment should receive TIV rather than LAIV.
Measles live-virus vaccine	2 doses SC; ≥28 days apart	Vaccination should be recommended for all HCP who lack presumptive evidence of immunity; [¶] vaccination should be considered for those born before 1957.	Pregnancy; immunocompromised persons,** including HIV-infected persons who have evidence of severe immunosuppression; anaphylaxis to gelatin or gelatin-containing products; anaphylaxis to neomycin; and recent administration of immune globulin.	HCP vaccinated during 1963–1967 with a killed measles vaccine alone, killed vaccine followed by live vaccine, or a vaccine of unknown type should be revaccinated with 2 doses of live measles virus vaccine.
Mumps live-virus vaccine	2 doses SC; ≥28 days apart	Vaccination should be recommended for all HCP who lack presumptive evidence of immunity. ^{††} Vaccination should be considered for those born before 1957.	Pregnancy; immunocompromised persons,** including HIV-infected persons who have evidence of severe immunosuppression; anaphylaxis to gelatin or gelatin-containing products; anaphylaxis to neomycin	HCP vaccinated before 1979 with either killed mumps vaccine or mumps vaccine of unknown type should consider revaccination with 2 doses of MMR vaccine.
Rubella live-virus vaccine	1 dose SC; (However, due to the 2-dose requirements for measles and mumps vaccines, the use of MMR vaccine will result in most HCP receiving 2 doses of rubella-containing vaccine.)	Vaccination should be recommended for all HCP who lack presumptive evidence of immunity. ^{§§}	Pregnancy; immunocompromised persons** including HIV-infected persons who have evidence of severe immunosuppression; anaphylaxis to gelatin or gelatin-containing products; anaphylaxis to neomycin	The risk for rubella vaccine-associated malformations in the offspring of women pregnant when vaccinated or who become pregnant within 1 month after vaccination is negligible. ^{¶¶} Such women should be counseled regarding the theoretical basis of concern for the fetus.

See table footnotes on page 41

TABLE 2. (Continued) Immunizing agents and immunization schedules for health-care personnel (HCP)*

Generic name	Primary schedule and booster(s)	Indications	Major precautions and contraindications	Special considerations
Tetanus and diphtheria (toxoids) and acellular pertussis (Tdap)	1 dose IM as soon as feasible if Tdap not already received and regardless of interval from last Td. After receipt of Tdap, receive Td for routine booster every 10 years.	All HCP, regardless of age.	History of serious allergic reaction (i.e., anaphylaxis) to any component of Tdap. Because of the importance of tetanus vaccination, persons with history of anaphylaxis to components in Tdap or Td should be referred to an allergist to determine whether they have a specific allergy to tetanus toxoid and can safely receive tetanus toxoid (TT) vaccine. Persons with history of encephalopathy (e.g., coma or prolonged seizures) not attributable to an identifiable cause within 7 days of administration of a vaccine with pertussis components should receive Td instead of Tdap.	Tetanus prophylaxis in wound management if not yet received Tdap***
Varicella vaccine (varicella zoster virus live-virus vaccine)	2 doses SC 4–8 weeks apart if aged ≥13 years.	All HCP who do not have evidence of immunity defined as: 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 herpes zoster by a health-care provider.	Pregnancy; immunocompromised persons;*** history of anaphylactic reaction after receipt of gelatin or neomycin. Varicella vaccination may be considered for HIV-infected adolescents and adults with CD4+ T-lymphocyte count ≥200 cells/uL. Avoid salicylate use for 6 weeks after vaccination.	Because 71%–93% of adults without a history of varicella are immune, serologic testing before vaccination is likely to be cost-effective.
Varicella-zoster immune globulin	125U/10 kg IM (minimum dose: 125U; maximum dose: 625U)	Persons without evidence of immunity who have contraindications for varicella vaccination and who are at risk for severe disease and complications ^{¶¶¶} known or likely to be susceptible who have direct, nontransient exposure to an infectious hospital staff worker or patient		Serologic testing may help in assessing whether to administer varicella–zoster immune globulin. If use of varicella–zoster immune globulin prevents varicella disease, patient should be vaccinated subsequently. The varicella–zoster immune globulin product currently used in the United States (VariZIG) (Cangene Corp. Winnipeg Canada) can be obtained 24 hours a day from the sole authorized U.S. distributor (FFF Enterprises, Temecula, California) at 1-800-843-7477 or http://www.fffenterprises.com .

Other immunobiologics that might be indicated in certain circumstances for HCP

Quadrivalent meningococcal conjugate vaccine (tetraivalent (A,C,Y,W) for HCP ages 19–54 years, Quadrivalent meningococcal polysaccharide vaccine for HCP age ≥55 years	1 dose; booster dose in 5 years if person remains at increased risk	Clinical and research microbiologists who might routinely be exposed to isolates of <i>Neisseria meningitidis</i>	The safety of the vaccine in pregnant women has not been evaluated; it should not be administered during pregnancy unless the risk for infection is high.
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See table footnotes on page 41

TABLE 2. (Continued) Immunizing agents and immunization schedules for health-care personnel (HCP)*

Generic name	Primary schedule and booster(s)	Indications	Major precautions and contraindications	Special considerations
Typhoid vaccine IM, and oral	IM vaccine: 1 dose, booster every 2 years. Oral vaccine: 4 doses on alternate days. Manufacturer recommends revaccination with the entire 4-dose series every 5 years.	Workers in microbiology laboratories who frequently work with <i>Salmonella typhi</i> .	Severe local or systemic reaction to a previous dose. Ty21a (oral) vaccine should not be administered to immunocompromised persons** or to persons receiving antimicrobial agents.	Vaccination should not be considered an alternative to the use of proper procedures when handling specimens and cultures in the laboratory.
Inactivated poliovirus vaccine (IPV)	For unvaccinated adults, 2 doses should be administered at intervals of 4–8 weeks; a third dose should be administered 6–12 months after the second dose.	Vaccination is recommended for adults at increased risk for exposure to polioviruses including health-care personnel who have close contact with patients who might be excreting polioviruses. Adults who have previously received a complete course of poliovirus vaccine may receive one lifetime booster if they remain at increased risk for exposure.	Hypersensitivity or anaphylactic reactions to IPV or antibiotics contained in IPV. IPV contains trace amounts of streptomycin, polymyxin B, and neomycin.	

Abbreviations: IM = intramuscular; HBV = hepatitis B virus; HBsAg = hepatitis B surface antigen; SC = subcutaneous; HIV = human immunodeficiency virus; MMR = measles, mumps, rubella vaccine; TB = tuberculosis; HAV = hepatitis A virus; IgA = immune globulin A; ID = intradermal; TIV = trivalent inactivated split-virus vaccines; LAIV = live attenuated influenza vaccine; BCG = bacille Calmette-Guérin; OPV = oral poliovirus vaccine.

* Persons who provide health care to patients or work in institutions that provide patient care (e. g., physicians, nurses, emergency medical personnel, dental professionals and students, medical and nursing students, laboratory technicians, hospital volunteers, and administrative and support staff in health-care institutions). **Source:** U.S. Department of Health and Human Services. Definition of health-care personnel (HCP). Available at <http://www.hhs.gov/ask/initiatives/vac toolkit/definition.html>.

† Health-care personnel and public safety workers at high risk for continued percutaneous or mucosal exposure to blood or body fluids include acupuncturists, dentists, dental hygienists, emergency medical technicians, first responders, laboratory technologists/technicians, nurses, nurse practitioners, phlebotomists, physicians, physician assistants, and students entering these professions. **Source:** CDC. A comprehensive immunization strategy to eliminate transmission of hepatitis B virus infection in the United States: recommendations of the Advisory Committee on Immunization Practices. Part II: immunization of adults. *MMWR* 2006;55(No. RR-16).

§ The package insert should be consulted to weigh the risks and benefits of giving HBIG to persons with IgA deficiency, or to persons who have had an anaphylactic reaction to an IgG containing biologic product.

¶ Written documentation of vaccination with 2 doses of live measles or MMR vaccine administered ≥28 days apart, or laboratory evidence of measles immunity, or laboratory confirmation of measles disease, or birth before 1957.

** Persons immunocompromised because of immune deficiency diseases, HIV infection (who should primarily not receive BCG, OPV, and yellow fever vaccines), leukemia, lymphoma or generalized malignancy or immunosuppressed as a result of therapy with corticosteroids, alkylating drugs, antimetabolites, or radiation.

†† Written documentation of vaccination with 2 doses of live mumps or MMR vaccine administered ≥28 days apart, or laboratory evidence of mumps immunity, or laboratory confirmation of mumps disease, or birth before 1957.

§§ Written documentation of vaccination with 1 dose of live rubella or MMR vaccine, or laboratory evidence of immunity, or laboratory confirmation of rubella infection or disease, or birth before 1957, except women of childbearing potential who could become pregnant; though pregnancy in this age group would be exceedingly rare.

¶¶ **Source:** CDC. Revised ACIP recommendation for avoiding pregnancy after receiving a rubella-containing vaccine. *MMWR* 2001;50:1117.

*** **Source:** CDC. Update on adult immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR* 1991;40(No. RR-12).

††† 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., 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.

¶¶¶ For example, immunocompromised patients or pregnant women.

TABLE 3. Summary of recommendations for immunization of health-care personnel* (HCP) with special certain conditions — Advisory Committee on Immunization Practices, United States, 2011

Vaccine	Pregnancy	HIV infection	Severe				Alcoholism and alcoholic cirrhosis
			immunosuppression [†]	Asplenia	Renal failure	Diabetes	
Hepatitis B	R	R	R	R	R	R	R
Influenza	R [§]	R	R	R	R	R	R
Measles, mumps, rubella	C	R [¶]	C	R	R	R	R
Meningococcus	UI	UI	UI	R ^{**}	UI	UI	UI
IPV ^{††}	UI	UI	UI	UI	UI	UI	UI
Pertussis, tetanus, diphtheria	R	R	R	R	R	R	R
Typhoid, inactivated Vi ^{§§}	UI	UI	UI	UI	UI	UI	UI
Typhoid, Ty21a	UI	C	C	UI	UI	UI	UI
Varicella	C	UI ^{¶¶}	C	R	R	R	R

Abbreviations: R = recommended; C = contraindicated; UI = use if indicated; IPV = inactivated poliovirus vaccine.

* Persons who provide health care to patients or work in institutions that provide patient care (e. g., physicians, nurses, emergency medical personnel, dental professionals and students, medical and nursing students, laboratory technicians, hospital volunteers, and administrative and support staff in health-care institutions).
Source: U.S. Department of Health and Human Services. Definition of health-care personnel (HCP). Available at <http://www.hhs.gov/ask/initiatives/vacctoolkit/definition.html>.

[†] Severe immunosuppression can be caused by congenital immunodeficiency, leukemia, lymphoma, generalized malignancy or therapy with alkylating agents, antimetabolites, ionizing radiation, or large amounts of corticosteroids.

[§] Women who are or will be pregnant during the influenza season.

[¶] Contraindicated in HIV-infected persons who have evidence of severe immunosuppression.

^{**} Recommendation is based on the person's underlying condition rather than occupation.

^{††} Vaccination is recommended for unvaccinated HCP who have close contact with patients who may be excreting wild polioviruses. HCP who have had a primary series of oral poliovirus vaccine (OPV) or IPV who are directly involved with the provision of care to patients who may be excreting poliovirus may receive another dose of either IPV or OPV. Any suspected case of poliomyelitis should be investigated immediately. If evidence suggests transmission of poliovirus, control measures to contain further transmission should be instituted immediately.

^{§§} Capsular polysaccharide parenteral vaccine.

^{¶¶} Varicella vaccine may be considered for HIV-infected adults without evidence of immunity and with CD4 T-lymphocyte count ≥ 200 cells/UI.

TABLE 4. Recommended postexposure prophylaxis for percutaneous or permucosal exposure to hepatitis B virus — Advisory Committee on Immunization Practices, United States

Vaccination and antibody response status of exposed person	Treatment		
	Source HBsAg-positive	Source HBsAg-negative	Source not tested or status unknown
Unvaccinated	HBIG x 1; initiate HB vaccine series	Initiate HB vaccine series	Initiate HB vaccine series
Previously vaccinated			
Known responder	No treatment	No treatment	No treatment
Known nonresponder			
After 3 doses	HBIG x 1 and initiate revaccination	No treatment	If known high-risk source, treat as if source were HBsAg-positive
After 6 doses	HBIG x 2 (separated by 1 month)	No treatment	If known high-risk source, treat as if source were HBsAg-positive
Antibody response unknown	Test exposed person for anti-HBs If adequate,* no treatment If inadequate,* HBIG x 1 and vaccine booster	No treatment	Test exposed person for anti-HBs If adequate,* no treatment If inadequate,* initiate revaccination

Abbreviations: HBsAg = Hepatitis B surface antigen; HBIG = hepatitis B immune globulin; anti-HBs = antibody to hepatitis B surface antigen; HB = hepatitis B.

Source: Adapted from CDC. A comprehensive immunization strategy to eliminate transmission of hepatitis B virus infection in the United States: recommendations of the Advisory Committee on Immunization Practices (ACIP). Part II: immunization of adults. *MMWR* 2006;55(No. RR-16).

* A seroprotective (adequate) level of anti-HBs after completion of a vaccination series is defined as anti-HBs ≥ 10 mIU/mL; a response < 10 mIU/mL is inadequate and is not a reliable indicator of protection.

TABLE 5. Advisory Committee on Immunization Practices work restrictions for health-care personnel* (HCP) exposed to or infected with certain vaccine-preventable diseases and conditions

Disease/Condition	Work restriction	Duration
Hepatitis B		
HCP positive for HBsAg (e.g., acute or chronic hepatitis B infection):		
HCP who do not perform exposure-prone invasive procedures	No restriction unless linked epidemiologically to transmission of hepatitis B virus infection	Standard precautions always should be observed
HCP who perform exposure-prone invasive procedures	These HCP should not perform exposure-prone invasive procedures until they have sought counsel from an expert review panel, which should review and recommend the procedures the worker can perform, taking into account the specific procedure as well as the skill and technique of the worker	Per recommendation of expert panel
Upper respiratory infections		
HCP in contact with persons at high risk for complications of influenza [†]	Exclude from duty	<p>Until afebrile ≥ 24 hours (without the use of fever-reducing medicines such as acetaminophen). Those with ongoing respiratory symptoms should be considered for evaluation by occupational health to determine appropriateness of contact with patients. If returning to care for patients in a protective environment (e.g., hematopoietic stem cell transplant patients), consider for temporary reassignment or exclusion from work for 7 days from symptom onset or until the resolution of symptoms, whichever is longer.</p> <p>Those who develop acute respiratory symptoms without fever should be considered for evaluation by occupational health to determine appropriateness of contact with patients and can be allowed to work unless caring for patients in a protective environment; these personnel should be considered for temporary reassignment or exclusion from work for 7 days from symptom onset or until the resolution of all noncough symptoms, whichever is longer. If symptoms such as cough and sneezing are still present, HCP should wear a facemask during patient care activities. The importance of performing frequent hand hygiene (especially before and after each patient contact) should be reinforced.</p>
Measles		
Active	Exclude from duty	4 days after rash appears
Postexposure (HCP without presumptive evidence of measles immunity)	Exclude from duty	5 days after first exposure through 21 days after last exposure and/or 4 days after the rash appears
Mumps		
Active	Exclude from duty	5 days after onset of parotitis
Postexposure (HCP without presumptive evidence of mumps immunity)	Exclude from duty	12 days after first exposure through 25 days after last exposure or 5 days after onset of parotitis
Pertussis		
Active	Exclude from duty	Beginning of catarrhal stage through third week after onset of paroxysms or until 5 days after start of effective antimicrobial therapy
Postexposure		
Symptomatic personnel	Exclude from duty	5 days after start of effective antimicrobial therapy
Asymptomatic personnel – HCP likely to expose a patient at risk for severe pertussis [§]	No restriction from duty; on antimicrobial prophylactic therapy	
Asymptomatic personnel – other HCP	No restriction from duty; can receive postexposure prophylaxis or be monitored for 21 days after pertussis exposure and treated at the onset of signs and symptoms of pertussis	

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TABLE 5. (Continued) Advisory Committee on Immunization Practices work restrictions for health-care personnel* (HCP) exposed to or infected with certain vaccine-preventable diseases and conditions

Disease/Condition	Work restriction	Duration
Rubella		
Active	Exclude from duty	7 days after the rash appears
Postexposure (personnel without evidence of rubella immunity)	Exclude from duty	7 days after first exposure through 23 days after last exposure and/or 7 days after rash appears
Varicella		
Active	Exclude from duty	Until all lesions dry and crust. If only lesions that do not crust (i.e., macules and papules), until no new lesions appear within a 24-hour period
Postexposure (HCP without evidence of varicella immunity)	Exclude from duty unless receipt of the second dose within 3-5 days after exposure	8th day after 1st exposure through 21st day (28th day if varicella-zoster immune globulin administered) after the last exposure; if varicella occurs, until all lesions dry and crust or, if only lesions that do not crust (i.e., macules and papules), until no new lesions appear within a 24-hour period
Herpes zoster		
Localized in immunocompetent person	Cover lesions; restrict from care of high-risk patients [¶]	Until all lesions dry and crust
Disseminated or localized in immunocompromised person until disseminated infection is ruled out	Exclude from duty	Until all lesions dry and crust
Postexposure (HCP without evidence of varicella immunity)		
Disseminated zoster or localized zoster with uncontained/uncovered lesions	Exclude from duty unless receipt of the second dose of varicella vaccine within 3-5 days after exposure	8th day after 1st exposure through 21st day (28th day if varicella-zoster immune globulin administered) after the last exposure; if varicella occurs, until all lesions dry and crust or, if only lesions that do not crust (i.e., macules and papules), until no new lesions appear within a 24-hour period
Localized zoster with contained/covered lesions	For HCP with at least 1 dose of varicella vaccine, no work restrictions. For HCP with no doses of varicella vaccine, restrict from patient contact	8th day after 1st exposure through 21st day (28th day if varicella-zoster immune globulin administered) after the last exposure; if varicella occurs, until all lesions dry and crust or, if only lesions that do not crust (i.e., macules and papules), until no new lesions appear within a 24-hour period

Abbreviation: HBsAg = hepatitis B surface antigen.

Sources: Adapted from CDC. Recommendations for preventing transmission of human immunodeficiency virus and hepatitis B virus to patients during exposure-prone invasive procedures. *MMWR* 1991;40(No. RR-8); CDC. Guideline for isolation precautions in hospitals: recommendations of the Hospital Infection Control Practices Advisory Committee (HICPAC) and the National Center for Infectious Diseases. *Infect Control Hosp Epidemiol* 1996;17:53-80; Williams WW. CDC guideline for infection control in hospital personnel. *Infect Control* 1983;4(Suppl):326-49; CDC. Immunization of health-care workers: recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Hospital Infection Control Practices Advisory Committee (HICPAC). *MMWR* 1997;46(No. RR-18).

* Persons who provide health care to patients or work in institutions that provide patient care (e. g., physicians, nurses, emergency medical personnel, dental professionals and students, medical and nursing students, laboratory technicians, hospital volunteers, and administrative and support staff in health-care institutions). **Source:** U.S. Department of Health and Human Services. Definition of health-care personnel (HCP). Available at <http://www.hhs.gov/ask/initiatives/vacctoolkit/definition.html>.

[†] Includes children aged <5 years, adults aged ≥65 years, pregnant women, American Indians/Alaska Natives, persons aged <19 years who are receiving long-term aspirin therapy, and persons with certain high-risk medical conditions (i.e., asthma, neurologic and neurodevelopmental conditions, chronic lung disease, heart disease, blood disorders, endocrine disorders, kidney disorders, liver disorders, metabolic disorders, weakened immune system due to disease or medication, and morbid obesity).

[§] Includes hospitalized neonates and pregnant women.

[¶] Includes patients who are susceptible to varicella and at increased risk for complications of varicella (i.e., neonates, pregnant women, and immunocompromised persons of any age).

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