

Immunization of Health-Care Workers

Recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Hospital Infection Control Practices Advisory Committee (HICPAC)

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Immunization of Health-Care Workers: Recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Hospital Infection Control Practices Advisory Committee (HICPAC)

Summary

This report summarizes recommendations of the Advisory Committee on Immunization Practices (ACIP) concerning the use of certain immunizing agents in health-care workers (HCWs) in the United States. It was prepared in consultation with the Hospital Infection Control Practices Advisory Committee (HICPAC) and is consistent with current HICPAC guidelines for infection control in health-care personnel. These recommendations can assist hospital administrators, infection control practitioners, employee health physicians, and HCWs in optimizing infection prevention and control programs. Background information for each vaccine-preventable disease and specific recommendations for use of each vaccine are presented. The diseases are grouped into three categories: a) those for which active immunization is strongly recommended because of special risks for HCWs; b) those for which immunoprophylaxis is or may be indicated in certain circumstances; and c) those for which protection of all adults is recommended. This report reflects current ACIP recommendations at the time of publication. ACIP statements on individual vaccines and disease updates in MMWR should be consulted for more details regarding the epidemiology of the diseases, immunization schedules, vaccine doses, and the safety and efficacy of the vaccines.

INTRODUCTION

Because of their contact with patients or infective material from patients, many health-care workers (HCWs) (e.g., physicians, nurses, emergency medical personnel, dental professionals and students, medical and nursing students, laboratory technicians, hospital volunteers, and administrative staff) are at risk for exposure to and possible transmission of vaccine-preventable diseases. Maintenance of immunity is therefore an essential part of prevention and infection control programs for HCWs. Optimal use of immunizing agents safeguards the health of workers and protects patients from becoming infected through exposure to infected workers (Table 1) (1–15). Consistent immunization programs could substantially reduce both the number of susceptible HCWs in hospitals and health departments and the attendant risks for transmission of vaccine-preventable diseases to other workers and patients (16). In addition to HCWs in hospitals and health departments, these recommendations apply to those in private physicians' offices, nursing homes, schools, and laboratories, and to first responders.

Any medical facility or health department that provides direct patient care is encouraged to formulate a comprehensive immunization policy for all HCWs. The American Hospital Association has endorsed the concept of immunization programs

TABLE 1. Recommendations for immunization practices and use of immunobiologics applicable to disease prevention among health-care workers — Advisory Committee on Immunization Practices (ACIP) statements published as of September 1, 1997

Subject	MMWR Publication
General recommendations on immunization	1994;43(No.RR-1):1-39
Adult immunization	1991;40(No.RR-12):1-94
Altered immunocompetence	1993;42(No.RR-4):1-18
Adverse reactions, contraindications, and precautions	1996;45(No.RR-12):1-35
Bacille Calmette-Guérin vaccine	1996;45(No.RR-4):1-18
Diphtheria, tetanus, and pertussis	1991;40(No.RR-10):1-28 1997;46(No. RR-7)
Hepatitis B	1991;40(No.RR-13):1-25
Hepatitis A	1996;45(No.RR-15):1-30
Influenza*	1997;46(No.RR-9):1-25
Japanese encephalitis	1993;42(No.RR-1):1-15
Measles	1989;38(No.S9):1-18
Measles, mumps, rubella (MMR)	1998;47 (in press)
Meningococcal disease and outbreaks	1997;46(No.RR-5):1-21
Mumps (MMR in press, see Measles above)	1989;38:388-92, 397-400
Pertussis, acellular (see also Diphtheria above) (supplementary statements)	1992;41(No.RR-1):1-10 1992;41(No.RR-15):1-5 1997;46(No.RR-7):1-25
Pneumococcal	1997;46(No.RR-8):1-24
Poliomyelitis	1997;46(No.RR-3):1-25
Rabies	1991;40(No.RR-3):1-19
Rubella (MMR in press, see Measles above)	1990;39(No.RR-15):1-18
Typhoid	1994;43(No.RR-14):1-7
Vaccinia (smallpox)	1991;40(No.RR-14):1-10
Varicella	1996;45(No.RR-11):1-36

*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 annually in the MMWR, usually during May or June.

for both hospital personnel and patients (17). The following recommendations concerning vaccines of importance to HCWs should be considered during policy development (Table 2).

BACKGROUND

Diseases for Which Immunization Is Strongly Recommended

On the basis of documented nosocomial transmission, HCWs are considered to be at significant risk for acquiring or transmitting hepatitis B, influenza, measles, mumps, rubella, and varicella. All of these diseases are vaccine-preventable.

Hepatitis B

Hepatitis B virus (HBV) infection is the major infectious hazard for health-care personnel. During 1993, an estimated 1,450 workers became infected through exposure to blood and serum-derived body fluids, a 90% decrease from the number estimated to have been thus infected during 1985 (18–20). Data indicate that 5%–10% of HBV-infected workers become chronically infected. Persons with chronic HBV infection are at risk for chronic liver disease (i.e., chronic active hepatitis, cirrhosis, and primary hepatocellular carcinoma) and are potentially infectious throughout their lifetimes. An estimated 100–200 health-care personnel have died annually during the past decade because of the chronic consequences of HBV infection (CDC, unpublished data).

The risk for acquiring HBV infection from occupational exposures is dependent on the frequency of percutaneous and permucosal exposures to blood or body fluids containing blood (21–25). Depending on the tasks he or she performs, any health-care or public safety worker may be at high risk for HBV exposure. Workers performing tasks involving exposure to blood or blood-contaminated body fluids should be vaccinated. For public safety workers whose exposure to blood is infrequent, timely postexposure prophylaxis may be considered, rather than routine preexposure vaccination.

In 1987, the Departments of Labor and Health and Human Services issued a Joint Advisory Notice regarding protection of employees against workplace exposure to HBV and human immunodeficiency virus (HIV), and began the process of rulemaking to regulate such exposures (26). The 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 occupationally exposed to blood or other potentially infectious materials (27). Occupational exposure is defined as "...reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of an employee's duties (27)." The Occupational Safety and Health Administration (OSHA) follows current ACIP recommendations for its immunization practices requirements (e.g., preexposure and postexposure antibody testing). These regulations have accelerated and broadened the use of hepatitis B vaccine in HCWs and have ensured maximal efforts to prevent this occupational disease (23).

Prevaccination serologic screening for prior infection is not indicated for persons being vaccinated because of occupational risk. Postvaccination testing for antibody to hepatitis B surface antigen (anti-HBs) response is indicated for HCWs who have blood or patient contact and are at ongoing risk for injuries with sharp instruments or needlesticks (e.g., physicians, nurses, dentists, phlebotomists, medical technicians and students of these professions). Knowledge of antibody response aids in determining appropriate postexposure prophylaxis.

TABLE 2. Immunizing agents and immunization schedules for health-care workers (HCWs)*

Generic name	Primary schedule and booster(s)	Indications	Major precautions and contraindications	Special considerations
IMMUNIZING AGENTS STRONGLY RECOMMENDED FOR HEALTH-CARE WORKERS				
Hepatitis B (HB) recombinant vaccine	Two doses IM 4 weeks apart; third dose 5 months after second; booster doses not necessary.	Preexposure: HCWs at risk for exposure to blood or body fluids. Postexposure: See Table 3.	On the basis of limited data, no risk of adverse effects to developing fetuses is apparent. Pregnancy should <i>not</i> 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 on HBV-infected persons. Prevacination serologic screening is not indicated for persons being vaccinated because of occupational risk. HCWs who have contact with patients or blood 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. A second dose of HBIG should be administered 1 month later if the HB vaccine series has not been started.	Postexposure prophylaxis (Table 3): For persons exposed to blood or body fluids containing HBsAg and who are not immune to HBV infection — 0.06 mL/kg IM as soon as possible (but no later than 7 days after exposure).		
Influenza vaccine (inactivated whole-virus and split-virus vaccines)	Annual vaccination with current vaccine. Administered IM.	HCWs who have contact with patients at high risk for influenza or its complications; HCWs who work in chronic care facilities; HCWs with high-risk medical conditions or who are aged ≥ 65 years.	History of anaphylactic hypersensitivity to egg ingestion.	No evidence exists of risk to mother or fetus when the vaccine is administered to a pregnant woman with an underlying high-risk condition. Influenza vaccination is recommended during second and third trimesters of pregnancy because of increased risk for hospitalization.

Measles live-virus vaccine	One dose SC; second dose at least 1 month later.	HCWs [†] born during or after 1957 who do not have documentation of having received 2 doses of live vaccine on or after the first birthday or a history of physician-diagnosed measles or serologic evidence of immunity. Vaccination should be considered for all HCWs who lack proof of immunity, including those born before 1957.	Pregnancy; immunocompromised persons [§] , including HIV-infected persons who have evidence of severe immunosuppression; anaphylaxis after gelatin ingestion or administration of neomycin; recent administration of immune globulin.	MMR is the vaccine of choice if recipients are likely to be susceptible to rubella and/or mumps as well as to measles. Persons vaccinated during 1963–1967 with a killed measles vaccine alone, killed vaccine followed by live vaccine, or with a vaccine of unknown type should be revaccinated with 2 doses of live measles virus vaccine.
Mumps live-virus vaccine	One dose SC; no booster.	HCWs [†] believed to be susceptible can be vaccinated. Adults born before 1957 can be considered immune.	Pregnancy; immunocompromised persons [§] ; history of anaphylactic reaction after gelatin ingestion or administration of neomycin.	MMR is the vaccine of choice if recipients are likely to be susceptible to measles and rubella as well as to mumps.

*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

[†]All HCWs (i.e., medical or nonmedical, paid or volunteer, full time or part time, student or non-student, with or without patient-care responsibilities) who work in health-care institutions (e.g., inpatient and outpatient, public and private) should be immune to measles, rubella, and varicella.

[§]Persons immunocompromised because of immune deficiency diseases, HIV infection, leukemia, lymphoma or generalized malignancy or immunosuppressed as a result of therapy with corticosteroids, alkylating drugs, antimetabolites, or radiation.

Abbreviations: IM = intramuscular; HBV = hepatitis B virus; HBsAg = hepatitis B surface antigen; SC = subcutaneous; HIV = human immunodeficiency virus; MMR = measles, mumps, rubella vaccine.

TABLE 2. Immunizing agents and immunization schedules for health-care workers (HCWs)* — Continued

Generic name	Primary schedule and booster(s)	Indications	Major precautions and contraindications	Special considerations
Rubella live-virus vaccine	One dose SC; no booster	Indicated for HCWs [†] , both men and women, who do not have documentation of having received live vaccine on or after their first birthday or laboratory evidence of immunity. Adults born before 1957, except women who can become pregnant , can be considered immune.	Pregnancy; immunocompromised persons [†] ; history of anaphylactic reaction after administration of neomycin.	The risk for rubella vaccine-associated malformations in the offspring of women pregnant when vaccinated or who become pregnant within 3 months after vaccination is negligible. Such women should be counseled regarding the theoretical basis of concern for the fetus. MMR is the vaccine of choice if recipients are likely to be susceptible to measles or mumps, as well as to rubella.
Varicella zoster live-virus vaccine	Two 0.5 mL doses SC 4-8 weeks apart if ≥13 years of age.	Indicated for HCWs [†] who do not have either a reliable history of varicella or serologic evidence of immunity.	Pregnancy, immunocompromised persons [§] , history of anaphylactic reaction following receipt of neomycin or gelatin. Avoid salicylate use for 6 weeks after vaccination.	Vaccine is available from the manufacturer for certain patients with acute lymphocytic leukemia (ALL) in remission. Because 71%-93% of persons without a history of varicella are immune, serologic testing before vaccination is likely to be cost-effective.
Varicella-zoster immune globulin (VZIG)	Persons <50 kg: 125 u/10 kg IM; persons ≥50 kg: 625 u [¶] .	Persons known or likely to be susceptible (particularly those at high risk for complications, e.g., pregnant women) who have close and prolonged exposure to a contact case or to an infectious hospital staff worker or patient.		Serologic testing may help in assessing whether to administer VZIG. If use of VZIG prevents varicella disease, patient should be vaccinated subsequently.

BCG VACCINATION

Bacille Calmette Guérin (BCG) Vaccine (Tuberculosis)	One percutaneous dose of 0.3 mL; no booster dose recommended.	Should be considered only for HCWs in areas where multi-drug tuberculosis is prevalent, a strong likelihood of infection exists, and where comprehensive infection control precautions have failed to prevent TB transmission to HCWs.	Should not be administered to immunocompromised persons, [§] pregnant women.	In the United States tuberculosis-control efforts are directed towards early identification, treatment of cases, and preventive therapy with isoniazid.
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OTHER IMMUNOBIOLOGICS THAT ARE OR MAY BE INDICATED FOR HEALTH-CARE WORKERS

Generic name	Primary schedule and booster(s)	Indications	Major precautions and contraindications	Special considerations
Immune globulin (Hepatitis A)	Postexposure —One IM dose of 0.02 mL/kg administered ≤2 weeks after exposure.	Indicated for HCWs exposed to feces of infectious patients.	Contraindicated in persons with IgA deficiency; do not administer within 2 weeks after MMR vaccine, or 3 weeks after varicella vaccine. Delay administration of MMR vaccine for ≥3 months and varicella vaccine ≥5 months after administration of IG.	Administer in large muscle mass (deltoid, gluteal).

* 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.

† All HCWs (i.e., medical or nonmedical, paid or volunteer, full-time or part-time, student or nonstudent, with or without patient-care responsibilities) who work in health-care institutions (i.e., inpatient and outpatient, public and private) should be immune to measles, rubella, and varicella.

§ 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.

¶ Some experts recommend 125 u/10 kg regardless of total body weight.

Abbreviations: IM = intramuscular; HCW = health-care worker; TB = tuberculosis; MMR = measles, mumps, rubella vaccine; HAV = hepatitis A virus; SC = subcutaneous; IgA = immune globulin A.

TABLE 2. Immunizing agents and immunization schedules for health-care workers (HCWs)* — Continued

Generic name	Primary schedule and booster(s)	Indications	Major precautions and contraindications	Special considerations
Hepatitis A vaccine	Two doses of vaccine either 6-12 months apart (HAVRIX®), or 6 months apart (VAQTA®).	Not routinely indicated for HCWs in the United States. Persons who work with HAV-infected primates or with HAV in a research laboratory setting should be vaccinated.	History of anaphylactic hypersensitivity to alum or, for HAVRIX®, the preservative 2-phenoxyethanol. The safety of the vaccine in pregnant women has not been determined; the risk associated with vaccination should be weighed against the risk for hepatitis A in women who may be at high risk for exposure to HAV.	
Meningococcal polysaccharide vaccine (tetravalent A, C, W135, and Y)	One dose in volume and by route specified by manufacturer; need for boosters unknown.	Not routinely indicated for HCWs in the United States.	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.	
Typhoid vaccine, IM, SC, and oral	<i>IM vaccine:</i> One 0.5 mL dose, booster 0.5 mL every 2 years. <i>SC vaccine:</i> two 0.5 mL doses, ≥4 weeks apart, booster 0.5 mL SC or 0.1 ID every 3 years if exposure continues. <i>Oral vaccine:</i> Four doses on alternate days. The manufacturer recommends revaccination with the entire four-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.

Vaccinia vaccine (smallpox)	One dose administered with a bifurcated needle; boosters administered every 10 years.	Laboratory workers who directly handle cultures with vaccinia, recombinant vaccinia viruses, or orthopox viruses that infect humans.	The vaccine is contraindicated in pregnancy, in persons with eczema or a history of eczema, and in immunocompromised persons [†] and their household contacts.	Vaccination may be considered for HCWs who have direct contact with contaminated dressings or other infectious material from volunteers in clinical studies involving recombinant vaccinia virus.
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OTHER VACCINE-PREVENTABLE DISEASES

Tetanus and diphtheria (toxoids [Td])	Two IM doses 4 weeks apart; third dose 6-12 months after second dose; booster every 10 years.	All adults.	Except in the first trimester, pregnancy is not a precaution. History of a neurologic reaction or immediate hypersensitivity reaction after a previous dose. History of severe local (Arthus-type) reaction after a previous dose. Such persons should not receive further routine or emergency doses of Td for 10 years.	Tetanus prophylaxis in wound management [§] .
Pneumococcal polysaccharide vaccine (23 valent).	One dose, 0.5 mL, IM or SC; revaccination recommended for those at highest risk ≥5 years after the first dose.	Adults who are at increased risk of pneumococcal disease and its complications because of underlying health conditions; older adults, especially those age ≥65 who are healthy.	The safety of vaccine in pregnant women has not been evaluated; it should not be administered during pregnancy unless the risk for infection is high. Previous recipients of any type of pneumococcal polysaccharide vaccine who are at highest risk for fatal infection or antibody loss may be revaccinated ≥5 years after the first dose.	

* 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.

[†] Persons immunocompromised because of immune deficiency diseases, HIV infection, leukemia, lymphoma or generalized malignancy or immunosuppressed as a result of therapy with corticosteroids, alkylating drugs, antimetabolites, or radiation.

[§] See (15) CDC. Update on adult immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR 1991;40(No. RR-12):1-94.

Abbreviations: IM = intramuscular; ID = intradermal; SC = subcutaneous.

Vaccine-induced antibodies to HBV decline gradually over time, and $\leq 60\%$ of persons who initially respond to vaccination will lose detectable antibodies over 12 years (28; CDC, unpublished data). Studies among adults have demonstrated that, despite declining serum levels of antibody, vaccine-induced immunity continues to prevent clinical disease or detectable viremic HBV infection (29). Therefore, booster doses are not considered necessary (1). Periodic serologic testing to monitor antibody concentrations after completion of the three-dose series is not recommended. The possible need for booster doses will be assessed as additional data become available.

Asymptomatic HBV infections have been detected in vaccinated persons by means of serologic testing for antibody to hepatitis B core antigen (anti-HBc) (1). However, these infections also provide lasting immunity and are not associated with HBV-related chronic liver disease.

Influenza

During community influenza outbreaks, admitting patients infected with influenza to hospitals has led to nosocomial transmission of the disease (30,31), including transmission from staff to patients (32). Transmission of influenza among medical staff causes absenteeism and considerable disruption of health care (33–36; CDC, unpublished data). In addition, influenza outbreaks have caused morbidity and mortality in nursing homes (36–41). In a recent study of long-term care facilities with uniformly high patient influenza vaccination levels, patients in facilities in which $>60\%$ of the staff had been vaccinated against influenza experienced less influenza-related mortality and illness, compared with patients in facilities with no influenza-vaccinated staff (42).

Measles, Mumps, and Rubella

Measles. Nosocomial measles transmission has been documented in the offices of private physicians, in emergency rooms, and on hospital wards (43–49). Although only 3.5% of all cases of measles reported during 1985–1989 occurred in medical settings, the risk for measles infection in medical personnel is estimated to be thirteenfold that for the general population (45,49–52). During 1990–1991, 1,788 of 37,429 (4.8%) measles cases were reported to have been acquired in medical settings. Of these, 668 (37.4%) occurred among HCWs, 561 (84%) of whom were unvaccinated; 187 (28%) of these HCWs were hospitalized with measles and three died (CDC, unpublished data). Of the 3,659 measles cases reported during 1992–1995, the setting of transmission was known for 2,765; 385 (13.9%) of these cases occurred in medical settings (CDC, unpublished data).

Although birth before 1957 is generally considered acceptable evidence of measles immunity, serologic studies of hospital workers indicate that 5%–9% of those born before 1957 are not immune to measles (53,54). During 1985–1992, 27% of all measles cases among HCWs occurred in persons born before 1957 (CDC, unpublished data).

Mumps. In recent years, a substantial proportion of reported mumps has occurred among unvaccinated adolescents and young adults on college campuses and in the workplace (55–58). Outbreaks of mumps in highly vaccinated populations have been attributed to primary vaccine failure (59,60). During recent years, the overall incidence of mumps has fluctuated only minimally but an increasing proportion of cases has been reported in persons aged ≥ 15 years (61). Mumps transmission in medical set-

tings has been reported nationwide (62, CDC, unpublished data). Programs to ensure that medical personnel are immune to mumps are prudent and are easily linked with measles and rubella control programs (5).

Rubella. Nosocomial rubella outbreaks involving both HCWs and patients have been reported (63). Although vaccination has decreased the overall risk for rubella transmission in all age groups in the United States by $\geq 95\%$, the potential for transmission in hospital and similar settings persists because 10%–15% of young adults are still susceptible (6,64–67). In an ongoing study of rubella vaccination in a health maintenance organization, 7,890 of 92,070 (8.6%) women aged ≥ 29 years were susceptible to rubella (CDC, unpublished data). Although not as infectious as measles, rubella can be transmitted effectively by both males and females. Transmission can occur whenever many susceptible persons congregate in one place. Aggressive rubella vaccination of susceptible men and women with trivalent measles-mumps-rubella (MMR) vaccine can eliminate rubella (as well as measles) transmission (68).

Persons born before 1957 generally are considered to be immune to rubella. However, findings of seroepidemiologic studies indicate that about 6% of HCWs (including persons born in 1957 or earlier) do not have detectable rubella antibody (CDC, unpublished data).

Varicella

Nosocomial transmission of varicella zoster virus (VZV) is well recognized (69–80). Sources for nosocomial exposure of patients and staff have included patients, hospital staff, and visitors (e.g., the children of hospital employees) who are infected with either varicella or zoster. In hospitals, airborne transmission of VZV from persons who had varicella or zoster to susceptible persons who had no direct contact with the index case-patient has occurred (81–85). Although all susceptible hospitalized adults are at risk for severe varicella disease and complications, certain patients are at increased risk: pregnant women, premature infants born to susceptible mothers, infants born at < 28 weeks' gestation or who weigh ≤ 1000 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).

Varicella Control Strategies

Strategies for managing clusters of VZV infections in hospitals include (16,86–94):

- isolating patients who have varicella and other susceptible patients who are exposed to VZV;
- controlling air flow;
- using rapid serologic testing to determine susceptibility;
- furloughing exposed susceptible personnel or screening these persons daily for skin lesions, fever, and systemic symptoms; and
- temporarily reassigning varicella-susceptible personnel to locations remote from patient-care areas.

Appropriate isolation of hospitalized patients who have confirmed or suspected VZV infection can reduce the risk for transmission to personnel (95).

Identification of the few persons who are susceptible to varicella when they begin employment that involves patient contact is recommended. Only personnel who are immune to varicella should care for patients who have confirmed or suspected varicella or zoster.

A reliable history of chickenpox is a valid measure of VZV immunity. Serologic tests have been used to assess the accuracy of reported histories of chickenpox (76,80,93,95–97). Among adults, 97% to 99% of persons with a positive history of varicella are seropositive. In addition, the majority of adults with negative or uncertain histories are seropositive (range: 71%–93%). Persons who do not have a history of varicella or whose history is uncertain can be considered susceptible, or tested serologically to determine their immune status. In health-care institutions, serologic screening of personnel who have a negative or uncertain history of varicella is likely to be cost effective (8).

If susceptible HCWs are exposed to varicella, they are potentially infective 10–21 days after exposure. They must often be furloughed during this period, usually at substantial cost. Persons in whom varicella develops are infective until all lesions dry and crust (16,35,96–98) (see Other Considerations in Vaccination of Health-Care Workers—Work Restrictions for Susceptible Workers After Exposure).

Administration of varicella zoster immune globulin (VZIG) after exposure can be costly. VZIG does not necessarily prevent varicella, and may prolong the incubation period by a week or more, thus extending the time during which personnel should not work.

Breakthrough Infection and Transmission of Vaccine Virus to Contacts

Varicella virus vaccine protects approximately 70%–90% of recipients against infection and 95% of recipients against severe disease for at least 7–10 years after vaccination. Significant protection is long-lasting. Breakthrough infections (i.e., cases of varicella) have occurred among vaccinees after exposure to natural varicella virus. Data from all trials in which vaccinees of all ages were actively followed for up to 9 years indicated that varicella developed in 1%–4.4% of vaccinees per year, depending on vaccine lot and time interval since vaccination (Merck and Company, Inc., unpublished data). Unvaccinated persons who contract varicella generally are febrile and have several hundred vesicular lesions. Among vaccinees who developed varicella, in contrast, the median number of skin lesions was <50 and lesions were less apt to be vesicular. Most vaccinated persons who contracted varicella were afebrile, and the duration of illness was shorter (Merck and Company, Inc., unpublished data; 99, 100).

The rate of transmission of disease from vaccinees who contract varicella is low for vaccinated children, but has not been studied in adults. Ten different trials conducted during 1981–1989 involved 2,141 vaccinated children. Breakthrough infections occurred in 78 children during the 1–8 year follow-up period of active surveillance, resulting in secondary cases in 11 of 90 (12.2%) vaccinated siblings. Among both index and secondary case-patients, illness was mild. Transmission to a susceptible mother from a vaccinated child in whom breakthrough disease occurred also has been reported (Merck and Company, Inc., unpublished data; 101).

Estimates of vaccine efficacy and persistence of antibody in vaccinees are based on research conducted before widespread use of varicella vaccine began to influence the prevalence of natural VZV infection. Thus, the extent to which boosting from exposure to natural virus increases the protection provided by vaccination remains unclear. Whether longer-term immunity may wane as the circulation of natural VZV decreases also is unknown.

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 (102,103). The findings of these studies indicate that healthy vaccinated persons have a minimal risk (estimated to be <1%) for transmitting vaccine virus to their contacts. This risk may be increased in vaccinees in whom a varicella-like rash develops after vaccination. Tertiary transmission of vaccine virus to a second healthy sibling of a vaccinated leukemic child also has occurred (103).

Several options for managing vaccinated HCWs who may be exposed to varicella are available. Routine serologic testing for varicella immunity after administration of two doses of vaccine is not considered necessary because 99% of persons become seropositive after the second dose. Seroconversion, however, does not always result in full protection against disease. Institutional guidelines are needed for management of exposed vaccinees who do not have detectable antibody and for those who develop clinical varicella. A potentially effective strategy to identify persons who remain at risk for varicella is to test vaccinated persons for serologic evidence of immunity immediately after they are exposed to VZV. Prompt, sensitive, and specific serologic results can be obtained at reasonable cost with a commercially available latex agglutination (LA) test. Many other methods also have been used to detect antibody to VZV (8). The LA test, which uses latex particles coated with VZV glycoprotein antigens, can be completed in 15 minutes (104,105). Persons with detectable antibody are unlikely to become infected with varicella. Persons who do not have detectable antibody can be retested in 5–6 days. If an anamnestic response is present, these persons are unlikely to contract the disease. HCWs who do not have antibody when retested may be furloughed. Alternatively, the clinical status of these persons may be monitored daily and they can be furloughed at the onset of manifestations of varicella.

More information is needed concerning risk for transmission of vaccine virus from vaccinees with and without varicella-like rash after vaccination. The risk appears to be minimal, and the benefits of vaccinating susceptible HCWs outweigh this potential risk. As a safeguard, institutions may wish to consider precautions for personnel in whom a rash develops after vaccination and for other vaccinated personnel who will have contact with susceptible persons at high risk for serious complications.

Vaccination should be considered for unvaccinated HCWs who lack documented immunity if they are exposed to varicella. However, because the effectiveness of postexposure vaccination is unknown, persons vaccinated after an exposure should be managed in the manner recommended for unvaccinated persons.

Tuberculosis and Bacille-Calmette-Guérin Vaccination

In the United States, Bacille Calmette-Guérin (BCG) vaccine has not been recommended for general use because the population risk for infection with *Mycobacterium tuberculosis* (TB) is low and the protective efficacy of BCG vaccine uncertain. The im-

mune response to BCG vaccine also interferes with use of the tuberculin skin test to detect *M. tuberculosis* infection (7). TB prevention and control efforts are focused on interrupting transmission from patients who have active infectious TB, skin testing those at high risk for TB, and administering preventive therapy when appropriate. However, in certain situations, BCG vaccination may contribute to the prevention and control of TB when other strategies are inadequate.

Control of TB

The fundamental strategies for the prevention and control of TB include:

- Early detection and effective treatment of patients with active communicable TB (106).
- Preventive therapy for infected persons. Identifying and treating persons who are infected with *M. tuberculosis* can prevent the progression of latent infection to active infectious disease (107).
- Prevention of institutional transmission. The transmission of TB is a recognized risk in health-care settings and is of particular concern in settings where HIV-infected persons work, volunteer, visit, or receive care (108). Effective TB infection-control programs should be implemented in health-care facilities and other institutional settings, (e.g., shelters for homeless persons and correctional facilities) (16,109,110).

Role of BCG Vaccination in Prevention of TB Among HCWs

In a few geographic areas of the United States, increased risks for TB transmission in health-care facilities (compared with risks observed in health-care facilities in other parts of the United States) occur together with an elevated prevalence among TB patients of *M. tuberculosis* strains that are resistant to both isoniazid and rifampin (111–116). Even in such situations, comprehensive application of infection control practices should be the primary strategy used to protect HCWs and others in the facility from infection with *M. tuberculosis*. BCG vaccination of HCWs should not be used as a primary TB control strategy because a) the protective efficacy of the vaccine in HCWs is uncertain; b) even if BCG vaccination is effective for a particular HCW, other persons in the health-care facility (e.g., patients, visitors, and other HCWs) are not protected against possible exposure to and infection with drug-resistant strains of *M. tuberculosis*; and c) BCG vaccination may complicate preventive therapy because of difficulties in distinguishing tuberculin skin test responses caused by infection with *M. tuberculosis* from those caused by the immune response to vaccination.

Hepatitis C and Other Parenterally Transmitted Non-A, Non-B Hepatitis

Hepatitis C virus (HCV) is the etiologic agent in most cases of parenterally transmitted non-A, non-B hepatitis in the United States (117,118). CDC estimates that the annual number of newly acquired HCV infections has ranged from 180,000 in 1984 to 28,000 in 1995. Of these, an estimated 2%–4% occurred among health-care personnel who were occupationally exposed to blood. At least 85% of persons who contract HCV

infection become chronically infected, and chronic hepatitis develops in an average of 70% of all HCV-infected persons (117–119). Up to 10% of parenterally transmitted non-A, non-B hepatitis may be caused by other bloodborne viral agents not yet characterized (non-ABCDE hepatitis) (117,120).

Serologic enzyme immunoassays (EIA) licensed for the detection of antibody to HCV (anti-HCV) have evolved since their introduction in 1990 and a third version is now available which detects anti-HCV in $\geq 95\%$ of patients with HCV infection. Interpretation of EIA results is limited by several factors. These assays do not detect anti-HCV in all infected persons and do not distinguish among acute, chronic, or resolved infection. In 80% to 90% of HCV-infected persons, seroconversion occurs an average of 10–12 weeks after exposure to HCV. These screening assays also yield a high proportion (up to 50%) of falsely positive results when they are used in populations with a low prevalence of HCV infection (118,121). Although no true confirmatory test has been developed, supplemental tests for specificity are available (such as the licensed Recombinant Immunoblot Assay [RIBA™]), and should always be used to verify repeatedly reactive results obtained with screening assays.

The diagnosis of HCV infection also is possible by detecting HCV RNA with polymerase chain reaction (PCR) techniques. Although PCR assays for HCV RNA are available from several commercial laboratories on a research-use basis, results vary considerably between laboratories. In a recent study in which a reference panel containing known HCV RNA-positive and -negative sera was provided to 86 laboratories worldwide (122), only 50% were considered to have performed adequately (i.e., by failing to detect one weak positive sample), and only 16% reported faultless results. Both false-positive and false-negative results can occur from improper collection, handling, and storage of the test samples. In addition, because HCV RNA may be detectable only intermittently during the course of infection, a single negative PCR test result should not be regarded as conclusive. Tests also have been developed to quantify HCV RNA in serum; however, the applicability of these tests in the clinical setting has not been determined.

Most HCV transmission is associated with direct percutaneous exposure to blood, and HCWs are at occupational risk for acquiring this viral infection (123–131). The prevalence of anti-HCV among hospital-based HCWs and surgeons is about 1% (125–128) and 2% among oral surgeons (129,130). In follow-up studies of HCWs who sustained percutaneous exposures to blood from anti-HCV positive patients through unintentional needlesticks or sharps injuries, the average incidence of anti-HCV seroconversion was 1.8% (range: 0%–7%) (132–137). In the only study that used PCR to measure HCV infection by detecting HCV RNA, the incidence of postinjury infection was 10% (136). Although these follow-up studies have not documented transmission associated with mucous membrane or nonintact skin exposures, one case report describes the transmission of HCV from a blood splash to the conjunctiva (138).

Several studies have examined the effectiveness of prophylaxis with immune globulins (IGs) in preventing posttransfusion non-A, non-B hepatitis (139–141). The findings of these studies are difficult to compare and interpret, because of lack of uniformity in diagnostic criteria, mixed sources of donors (volunteer and commercial), and differing study designs (some studies lacked blinding and placebo controls). In some of these studies, IGs appeared to reduce the rate of clinical disease but not overall infection rates. In one study, data indicated that chronic hepatitis was less likely to

develop in patients who received IG (139). None of these data have been reanalyzed since anti-HCV testing became available. In only one study was the first dose of IG administered after, rather than before, the exposure; the value of IG for postexposure prophylaxis is thus difficult to assess. The heterogeneous nature of HCV and its ability to undergo rapid mutation, however, appear to prevent development of an effective neutralizing immune response (142), suggesting that postexposure prophylaxis using IG is likely to be ineffective. Furthermore, IG is now manufactured from plasma that has been screened for anti-HCV. In an experimental study in which IG manufactured from anti-HCV negative plasma was administered to chimpanzees one hour after exposure to HCV, the IG did not prevent infection or disease (143).

The prevention of HCV infection with antiviral agents (e.g., alpha interferon) has not been studied. Although alpha interferon therapy is safe and effective for the treatment of chronic hepatitis C (144), the mechanisms of the effect are poorly understood. Interferon may be effective only in the presence of an established infection (145). Interferon must be administered by injection and may cause side effects. Based on these considerations, antiviral agents are not recommended for postexposure prophylaxis of HCV infection.

In the absence of effective prophylaxis, persons who have been exposed to HCV may benefit from knowing their infection status so they can seek evaluation for chronic liver disease and treatment. Sustained response rates to alpha interferon therapy generally are low (10%–20% in the United States). The occurrence of mild to moderate side effects in most patients has required discontinuation of therapy in up to 15% of patients. No clinical, demographic, serum biochemical, serologic, or histologic features have been identified that reliably predict which patients will sustain a long-term remission in response to alpha interferon therapy.

Several studies indicate that interferon treatment begun early in the course of HCV infection is associated with an increased rate of resolved infection. Onset of HCV infection among HCWs after exposure could be detected earlier by using PCR to detect HCV RNA than by using EIA to measure anti-HCV. However, PCR is not a licensed assay and its accuracy is highly variable. In addition, no data are available which indicate that treatment begun early in the course of chronic HCV infection is less effective than treatment begun during the acute phase of infection. Furthermore, alpha interferon is approved for the treatment of chronic hepatitis C only.

IG or antiviral agents are not recommended for postexposure prophylaxis of hepatitis C. No vaccine against hepatitis C is available. Health-care institutions should consider implementing policies and procedures to monitor HCWs for HCV infection after percutaneous or permucosal exposures to blood (146). At a minimum, such policies should include:

- For the source, baseline serologic testing for anti-HCV;
- For the person exposed to an anti-HCV positive source, baseline and follow-up (e.g., 6 months) serologic testing for anti-HCV and alanine aminotransferase activity;
- Confirmation by supplemental anti-HCV testing of all anti-HCV results reported as repeatedly reactive by EIA;

- Education of HCWs about the risk for and prevention of occupational transmission of all blood borne pathogens, including hepatitis C, using up-to-date and accurate information.

Other Diseases for Which Immunization of Health-Care Workers Is or May Be Indicated

Diseases are included in this section for one of the following reasons:

- Nosocomial transmission occurs, but HCWs are not at increased risk as a result of occupational exposure (i.e., hepatitis A),
- Occupational risk may be high, but protection via active or passive immunization is not available (i.e., pertussis), or
- Vaccines are available but are not routinely recommended for all HCWs or are recommended only in certain situations (i.e., vaccinia and meningococcal vaccines).

Hepatitis A

Occupational exposure generally does not increase HCWs' risk for hepatitis A virus (HAV) infection. When proper infection control practices are followed, nosocomial HAV transmission is rare. Outbreaks caused by transmission of HAV to neonatal intensive care unit staff by infants infected through transfused blood have occasionally been observed (147–149). Transmission of HAV from adult patients to HCWs is usually associated with fecal incontinence in the patients. However, most patients hospitalized with hepatitis A are admitted after onset of jaundice, when they are beyond the point of peak infectivity (150). Serologic surveys among many types of HCWs have not identified an elevated prevalence of HAV infection compared with other occupational populations (151–153).

Two specific prophylactic measures are available for protection against hepatitis A—administration of immune globulin (IG) and hepatitis A vaccine. When administered within 2 weeks after an exposure, IG is >85% effective in preventing hepatitis A (2). Two inactivated hepatitis A vaccines, which can provide long-term preexposure protection, were recently licensed in the United States: HAVRIX® (manufactured by SmithKline Beecham Biologicals) and VAQTA® (manufactured by Merck & Company, Inc.) (2). The efficacy of these vaccines in preventing clinical disease ranges from 94% to 100%. Data indicate that the duration of clinical protection conferred by VAQTA® is at least 3 years, and that conferred by HAVRIX® at least 4 years. Mathematical models of antibody decay indicate that protection conferred by vaccination may last up to 20 years (2).

Meningococcal Disease

Nosocomial transmission of *Neisseria meningitidis* is uncommon. In rare instances, direct contact with respiratory secretions of infected persons (e.g., during mouth-to-mouth resuscitation) has resulted in transmission from patients with meningococemia or meningococcal meningitis to HCWs. Although meningococcal lower respiratory infections are rare, HCWs may be at increased risk for meningococcal in-

fection if exposed to *N. meningitidis*-infected patients with active productive coughs. HCWs can decrease the risk for infection by adhering to precautions to prevent exposure to respiratory droplets (16,95).

Postexposure prophylaxis is advised for persons who have had intensive, unprotected contact (i.e., without wearing a mask) with infected patients (e.g., intubating, resuscitating, or closely examining the oropharynx of patients)(16). Antimicrobial prophylaxis can eradicate carriage of *N. meningitidis* and prevent infections in persons who have unprotected exposure to patients with meningococcal infections (9). Rifampin is effective in eradicating nasopharyngeal carriage of *N. meningitidis*, but is not recommended for pregnant women, because the drug is teratogenic in laboratory animals. Ciprofloxacin and ceftriaxone in single-dose regimens are also effective in reducing nasopharyngeal carriage of *N. meningitidis*, and are reasonable alternatives to the multidose rifampin regimen (9). Ceftriaxone also can be used during pregnancy.

Although useful for controlling outbreaks of serogroup C meningococcal disease, administration of quadrivalent A,C,Y,W-135 meningococcal polysaccharide vaccines is of little benefit for postexposure prophylaxis (9). The serogroups A and C vaccines, which have demonstrated estimated efficacies of 85%–100% in older children and adults, are useful for control of epidemics (9). The decision to implement mass vaccination to prevent serogroup C meningococcal disease depends on whether the occurrence of more than one case of the disease represents an outbreak or an unusual clustering of endemic meningococcal disease. Surveillance for serogroup C disease and calculation of attack rates can be used to identify outbreaks and determine whether use of meningococcal vaccine is warranted. Recommendations for evaluating and managing suspected serogroup C meningococcal disease outbreaks have been published (9).

Pertussis

Pertussis is highly contagious. Secondary attack rates among susceptible household contacts exceed 80% (154,155). Transmission occurs by direct contact with respiratory secretions or large aerosol droplets from the respiratory tract of infected persons. The incubation period is generally 7–10 days. The period of communicability starts with the onset of the catarrhal stage and extends into the paroxysmal stage. Vaccinated adolescents and adults, whose immunity wanes 5–10 years after the last dose of vaccine (usually administered at age 4–6 years), are an important source of pertussis infection for susceptible infants. The disease can be transmitted from adult patients to close contacts, especially unvaccinated children. Such transmission may occur in households and hospitals.

Transmission of pertussis in hospital settings has been documented in several reports (156–159). Transmission has occurred from a hospital visitor, from hospital staff to patients, and from patients to hospital staff. Although of limited size (range: 2–17 patients and 5–13 staff), documented outbreaks were costly and disruptive. In each outbreak, larger numbers of staff were evaluated for cough illness and required nasopharyngeal cultures, serologic tests, 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 during two outbreaks indicate that exposure to pertussis is much more frequent than the attack rates of clinical disease indicate (154,156–159). Seroprevalence of pertussis agglutinating antibodies correlated with the degree of patient contact and was highest among pediatric house staff (82%) and ward nurses (71%), lowest among nurses with administrative responsibilities (35%) (158).

Prevention of pertussis transmission in health-care settings involves diagnosis and early treatment of clinical cases, respiratory isolation of infectious patients who are hospitalized, exclusion from work of staff 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 one of the differential diagnoses for any patient with an acute cough illness of ≥ 7 days duration without another apparent cause, particularly if characterized by paroxysms of coughing, posttussive vomiting, whoop, or apnea. Nasopharyngeal cultures should be obtained if possible.

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 (95). These precautions should remain in effect until patients are clinically improved and have completed at least 5 days of appropriate antimicrobial therapy. HCWs in whom symptoms (i.e., unexplained rhinitis or acute cough) develop after known pertussis exposure may be at risk for transmitting pertussis and should be excluded from work (16)(see Other Considerations in Vaccination of Health-Care Workers—Work Restrictions for Susceptible Workers After Exposure).

One acellular pertussis vaccine is immunogenic in adults, but does not increase risk for adverse events when administered with tetanus and diphtheria (Td) toxoids, as compared with administration of Td alone (160). Recommendations for use of licensed diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccines among infants and young children have been published (161). If acellular pertussis vaccines are licensed for use in adults in the future, booster doses of adult formulations of acellular pertussis vaccines may be recommended to prevent the occurrence and spread of the disease in adults, including HCWs. However, acellular pertussis vaccines combined with diphtheria and tetanus toxoids (DTaP) will need to be reformulated for use in adults, because all infant formulations contain more diphtheria toxoid than is recommended for persons aged ≥ 7 years. Recommendations regarding routine vaccination of adults will require additional studies (e.g., studies of the incidence, severity, and cost of pertussis among adults; studies of the efficacy and safety of adult formulations of DTaP; and studies of the effectiveness and cost-effectiveness of a strategy of adult vaccination, particularly for HCWs).

Typhoid

The incidence of typhoid fever declined steadily in the United States from 1900 to 1960 and has remained at a low level. During 1985–1994, the average number of cases reported annually was 441 (CDC, unpublished data). The median age of persons with cases of typhoid was 24 years; 53% were male. Nearly three quarters of patients infected with *Salmonella typhi* reported foreign travel during the 30 days before onset of symptoms. During this ten year period, several cases of laboratory-acquired typhoid fever were reported among microbiology laboratory workers, only one of

whom had been vaccinated (162). *S. typhi* and other enteric pathogens may be nosocomially transmitted via the hands of personnel who are infected. Generally, personal hygiene, particularly hand washing before and after all patient contacts, will minimize risk for transmitting enteric pathogens to patients. If HCWs contract an acute diarrheal illness accompanied by fever, cramps, or bloody stools, they are likely to be excreting large numbers of infective organisms in their feces. Excluding these workers from care of patients until the illness has been evaluated and treated will prevent transmission (16).

Vaccinia

Vaccinia (smallpox) vaccine is a highly effective immunizing agent that brought about the global eradication of smallpox. In 1976, routine vaccinia vaccination of HCWs in the United States was discontinued. More recently, ACIP recommended use of vaccinia vaccine to protect laboratory workers from orthopoxvirus infection (10). Because studies of recombinant vaccinia virus vaccines have advanced to the stage of clinical trials, some physicians and nurses may now be exposed to vaccinia and recombinant vaccinia viruses. Vaccinia vaccination of these persons should be considered in selected instances (e.g., for HCWs who have direct contact with contaminated dressings or other infectious material).

Other Vaccine-Preventable Diseases

HCWs are not at greater risk for diphtheria, tetanus, and pneumococcal disease than the general population. ACIP recommends that all adults be protected against diphtheria and tetanus, and recommends pneumococcal vaccination of all persons aged ≥ 65 years and of younger persons who have certain medical conditions (see Recommendations).

Immunizing Immunocompromised Health-Care Workers

A physician must assess the degree to which an individual health-care worker is immunocompromised. Severe immunosuppression can be the result of congenital immunodeficiency; HIV infection; leukemia; lymphoma; generalized malignancy; or therapy with alkylating agents, antimetabolites, radiation, or large amounts of corticosteroids. All persons affected by some of these conditions are severely immunocompromised, whereas for other conditions (e.g., HIV infection), disease progression or treatment stage determine the degree of immunocompromise. A determination that an HCW is severely immunocompromised ultimately must be made by his or her physician. Immunocompromised HCWs and their physicians should consider the risk for exposure to a vaccine-preventable disease together with the risks and benefits of vaccination.

Corticosteroid Therapy

The exact amount of systemically absorbed corticosteroids and the duration of administration needed to suppress the immune system of an otherwise healthy person are not well defined. Most experts agree that steroid therapy usually does not contraindicate administration of live virus vaccines such as MMR and its component vaccines when therapy is a) short term (i.e., <14 days) low to moderate dose; b) low to

moderate dose administered daily or on alternate days; c) long-term alternate day treatment with short-acting preparations; d) maintenance physiologic doses (replacement therapy); or e) administered topically (skin or eyes), by aerosol, or by intra-articular, bursal, or tendon injection. Although the immunosuppressive effects of steroid treatment vary, many clinicians consider a steroid dose that is equivalent to or greater than a prednisone dose of 20 mg per day sufficiently immunosuppressive to cause concern about the safety of administering live virus vaccines. Persons who have received systemic corticosteroids in excess of this dose daily or on alternate days for an interval of ≥ 14 days should avoid vaccination with MMR and its component vaccines for at least 1 month after cessation of steroid therapy. Persons who have received prolonged or extensive topical, aerosol, or other local corticosteroid therapy that causes clinical or laboratory evidence of systemic immunosuppression also should not receive MMR, its component vaccines, and varicella vaccine for at least 1 month after cessation of therapy. Persons who receive corticosteroid doses equivalent to ≥ 20 mg per day or prednisone during an interval of < 14 days generally can receive MMR or its component vaccines immediately after cessation of treatment, although some experts prefer waiting until 2 weeks after completion of therapy. Persons who have a disease that, in itself, suppresses the immune response and who are also receiving either systemic or locally administered corticosteroids generally should not receive MMR, its component vaccines, or varicella vaccine.

HIV-Infected Persons

In general, symptomatic HIV-infected persons have suboptimal immunologic responses to vaccines (163–167). The response to both live and killed antigens may decrease as the disease progresses (167). Administration of higher doses of vaccine or more frequent boosters to HIV-infected persons may be considered. However, because neither the initial immune response to higher doses of vaccine nor the persistence of antibody in HIV-infected patients has been systematically evaluated, recommendations cannot be made at this time.

Limited studies of MMR immunization in both asymptomatic and symptomatic HIV-infected patients who did not have evidence of severe immunosuppression documented no serious or unusual adverse events after vaccination (168). HIV-infected persons are at increased risk for severe complications if infected with measles. Therefore, MMR vaccine is recommended for all asymptomatic HIV-infected HCWs who do not have evidence of severe immunosuppression. Administration of MMR to HIV-infected HCWs who are symptomatic but do not have evidence of severe immunosuppression also should be considered. However, measles vaccine is not recommended for HIV-infected persons who have evidence of severe immunosuppression because a) a case of progressive measles pneumonia has been reported after administration of MMR vaccine to a person with AIDS and severe immunosuppression (169), b) the incidence of measles in the United States is currently very low (170), c) vaccination-related morbidity has been reported in severely immunocompromised persons who were not HIV-infected (171), and d) a diminished antibody response to measles vaccination occurs among severely immunocompromised HIV-infected persons (172).

RECOMMENDATIONS

Recommendations for administration of vaccines and other immunobiologic agents to HCWs are organized in three broad disease categories:

- those for which active immunization is strongly recommended because of special risks for HCWs (i.e., hepatitis B, influenza, measles, mumps, rubella, and varicella);
- those for which active and/or passive immunization of HCWs may be indicated in certain circumstances (i.e., tuberculosis, hepatitis A, meningococcal disease, typhoid fever, and vaccinia) or in the future (i.e., pertussis); and
- those for which immunization of all adults is recommended (i.e., tetanus, diphtheria, and pneumococcal disease).

Immunization Is Strongly Recommended

ACIP strongly recommends that all HCWs be vaccinated against (or have documented immunity to) hepatitis B, influenza, measles, mumps, rubella, and varicella (Table 2). Specific recommendations for use of vaccines and other immunobiologics to prevent these diseases among HCWs follow.

Hepatitis B

Any HCW who performs tasks involving contact with blood, blood-contaminated body fluids, other body fluids, or sharps should be vaccinated. Hepatitis B vaccine should always be administered by the intramuscular route in the deltoid muscle with a needle 1–1.5 inches long.

Among health-care professionals, risks for percutaneous and permucosal exposures to blood vary during the training and working career of each person but are often highest during the professional training period. Therefore, vaccination should be completed during training in schools of medicine, dentistry, nursing, laboratory technology, and other allied health professions, before trainees have contact with blood. In addition, the OSHA Federal Standard requires employers to offer hepatitis B vaccine free of charge to employees who are occupationally exposed to blood or other potentially infectious materials (27).

Prevaccination serologic screening for previous infection is not indicated for persons being vaccinated because of occupational risk unless the hospital or health-care organization considers screening cost-effective. Postexposure prophylaxis with hepatitis B immune globulin (HBIG) (passive immunization) and/or vaccine (active immunization) should be used when indicated (e.g., after percutaneous or mucous membrane exposure to blood known or suspected to be HBsAg-positive [Table 3]).

Needlestick or other percutaneous exposures of unvaccinated persons should lead to initiation of the hepatitis B vaccine series. Postexposure prophylaxis should be considered for any percutaneous, ocular, or mucous membrane exposure to blood in the workplace and is determined by the HBsAg status of the source and the vaccination and vaccine-response status of the exposed person (Table 3) (1, 18).

If the source of exposure is HBsAg-positive and the exposed person is unvaccinated, HBIG also should be administered as soon as possible after exposure

TABLE 3. Recommended postexposure prophylaxis for percutaneous or permucosal exposure to hepatitis B virus, United States

Vaccination and anti-body response status of exposed person	Treatment when source is		
	HBsAg* positive	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 non-responder	HBIG x 2 or HBIG x 1 and initiate revaccination	No treatment	If known high-risk source, treat as if source were HBsAg positive
Antibody response unknown	Test exposed person for anti-HBs** 1. If adequate [¶] , no treatment 2. If inadequate [¶] , HBIG x 1 and vaccine booster	No treatment	Test exposed person for anti-HBs 1. If adequate [¶] , no treatment 2. If inadequate [¶] , initiate revaccination

*Hepatitis B surface antigen.

[†]Hepatitis B immune globulin; dose 0.06 mL/kg intramuscularly.

[§]Hepatitis B vaccine.

[¶]Responder is defined as a person with adequate levels of serum antibody to hepatitis B surface antigen (i.e., anti-HBs \geq 10 mIU/mL); inadequate response to vaccination defined as serum anti-HBs < 10 mIU/mL.

**Antibody to hepatitis B surface antigen.

(preferably within 24 hours) and the vaccine series started. The effectiveness of HBIG when administered >7 days after percutaneous or permucosal exposures is unknown. If the exposed person had an adequate antibody response (\geq 10 mIU/mL) documented after vaccination, no testing or treatment is needed, although administration of a booster dose of vaccine can be considered.

One to 2 months after completion of the 3-dose vaccination series, HCWs who have contact with patients or blood and are at ongoing risk for injuries with sharp instruments or needlesticks should be tested for antibody to hepatitis B surface antigen (anti-HBs). Persons who do not respond to the primary vaccine series should complete a second three-dose vaccine series or be evaluated to determine if they are HBsAg-positive. Revaccinated persons should be retested at the completion of the second vaccine series. Persons who prove to be HBsAg-positive should be counseled accordingly (1,16,121,173). Primary non-responders to vaccination who are HBsAg-negative should be considered susceptible to HBV infection and should be counseled regarding precautions to prevent HBV infection and the need to obtain HBIG prophylaxis for any known or probable parenteral exposure to HBsAg-positive blood (Table 3). Booster doses of hepatitis B vaccine are not considered necessary, and periodic serologic testing to monitor antibody concentrations after completion of the vaccine series is not recommended.

Influenza

To reduce staff illnesses and absenteeism during the influenza season and to reduce the spread of influenza to and from workers and patients, the following HCWs should be vaccinated in the fall of each year:

- Persons who attend patients at high risk for complications of influenza (whether the care is provided at home or in a health-care facility) (3);
- Persons aged ≥ 65 years; and
- Persons with certain chronic medical conditions (e.g., persons who have chronic disorders of the cardiovascular or pulmonary systems; persons who required medical follow-up or hospitalization within the preceding year because of chronic metabolic disease [including diabetes], renal dysfunction, hemoglobinopathies, or immunosuppression [including HIV infection]).
- Pregnant women who will be in the second or third trimester of pregnancy during influenza season.

Measles, Mumps, and Rubella

Persons who work within medical facilities should be immune to measles and rubella. Immunity to mumps is highly desirable for all HCWs. Because any HCW (i.e., medical or nonmedical, paid or volunteer, full time or part time, student or nonstudent, with or without patient-care responsibilities) who is susceptible can, if exposed, contract and transmit measles or rubella, all medical institutions (e.g., inpatient and outpatient, public and private) should ensure that those who work within their facilities* are immune to measles and rubella. Likewise, HCWs have a responsibility to avoid causing harm to patients by preventing transmission of these diseases.

Persons born in 1957 or later can be considered immune to measles, mumps, or rubella[†] only if they have documentation of a) physician-diagnosed measles or mumps disease; or b) laboratory evidence of measles, mumps, or rubella immunity (persons who have an "indeterminate" level of immunity upon testing should be considered nonimmune); or c) appropriate vaccination against measles, mumps, and rubella (i.e., administration on or after the first birthday of two doses of live measles vaccine separated by ≥ 28 days, at least one dose of live mumps vaccine, and at least one dose of live rubella vaccine).

Although birth before 1957 generally is considered acceptable evidence of measles and rubella immunity, health-care facilities should consider recommending a dose of MMR vaccine to unvaccinated workers born before 1957 who are in either of the following categories: a) those who do not have a history of measles disease or laboratory evidence of measles immunity, and b) those who lack laboratory evidence of rubella immunity. Rubella vaccination or laboratory evidence of rubella immunity is particularly important for female HCWs born before 1957 who can become pregnant.

*A possible exception might be an outpatient facility that deals exclusively with elderly patients considered at low risk for measles.

[†]Birth before 1957 is not acceptable evidence of rubella immunity for women who can become pregnant because rubella can occur in some unvaccinated persons born before 1957 and because congenital rubella syndrome can occur in offspring of women infected with rubella during pregnancy.

Serologic screening need not be done before vaccinating against measles and rubella unless the health-care facility considers it cost-effective (174–176). Serologic testing is not necessary for persons who have documentation of appropriate vaccination or other acceptable evidence of immunity to measles and rubella. Serologic testing before vaccination is appropriate only if tested persons identified as nonimmune are subsequently vaccinated in a timely manner, and should **not** be done if the return and timely vaccination of those screened cannot be ensured (176). Likewise, during outbreaks of measles, rubella, or mumps, serologic screening before vaccination is not recommended because rapid vaccination is necessary to halt disease transmission.

Measles-mumps-rubella (MMR) trivalent vaccine is the vaccine of choice. If the recipient has acceptable evidence of immunity to one or more of the components, monovalent or bivalent vaccines may be used. MMR or its component vaccines should not be administered to women known to be pregnant. For theoretical reasons, a risk to the fetus from administration of live virus vaccines cannot be excluded. Therefore, women should be counseled to avoid pregnancy for 30 days after administration of monovalent measles or mumps vaccines and for 3 months after administration of MMR or other rubella-containing vaccines. Routine precautions for vaccinating postpubertal women with MMR or its component vaccines include a) asking if they are or may be pregnant, b) not vaccinating those who say they are or may be pregnant, and c) vaccinating those who state that they are not pregnant after the potential risk to the fetus is explained. If a pregnant woman is vaccinated or if a woman becomes pregnant within 3 months after vaccination, she should be counseled about the theoretical basis of concern for the fetus, but MMR vaccination during pregnancy should not ordinarily be a reason to consider termination of pregnancy. Rubella-susceptible women from whom vaccine is withheld because they state they are or may be pregnant should be counseled about the potential risk for congenital rubella syndrome and the importance of being vaccinated as soon as they are no longer pregnant. Measles vaccine is not recommended for HIV-infected persons with evidence of severe immunosuppression (see Vaccination of HIV-Infected Persons).

Varicella

All HCWs should ensure that they are immune to varicella. Varicella immunization is particularly recommended for susceptible HCWs who have close contact with persons at high risk for serious complications, including a) premature infants born to susceptible mothers, b) infants who are born at <28 weeks of gestation or who weigh $\leq 1,000$ g at birth (regardless of maternal immune status), c) pregnant women, and d) immunocompromised persons.

Serologic screening for varicella immunity need not be done before vaccinating unless the health-care institution considers it cost-effective. Routine postvaccination testing of HCWs for antibodies to varicella is not recommended because $\geq 90\%$ of vaccinees are seropositive after the second dose of vaccine.

Hospitals should develop guidelines for management of vaccinated HCWs who are exposed to natural varicella. Seroconversion after varicella vaccination does not always result in full protection against disease. Therefore, the following measures should be considered for HCWs who are exposed to natural varicella: a) serologic testing for varicella antibody immediately after VZV exposure; b) retesting 5–6 days later

to determine if an anamnestic response is present; and c) possible furlough or re-assignment of personnel who do not have detectable varicella antibody. Whether postexposure vaccination protects adults is not known.

Hospitals also should develop guidelines for managing HCWs after varicella vaccination because of the risk for transmission of vaccine virus. Institutions may wish to consider precautions for personnel in whom a rash develops after vaccination and for other vaccinated HCWs who will have contact with susceptible persons at high risk for serious complications.

Hepatitis C and Other Parenterally Transmitted Non-A, Non-B Hepatitis

No vaccine or other immunoprophylactic measures are available for hepatitis C or other parenterally transmitted non-A, non-B hepatitis. HCWs should follow recommended practices for preventing transmission of all blood borne pathogens (see Background—Hepatitis C and other Parenterally Transmitted Non-A, Non-B Hepatitis).

Other Diseases for Which Immunoprophylaxis Is or May Be Indicated

ACIP does not recommend routine immunization of HCWs against tuberculosis, hepatitis A, pertussis, meningococcal disease, typhoid fever, or vaccinia. However, immunoprophylaxis for these diseases may be indicated for HCWs in certain circumstances.

Tuberculosis and BCG Vaccination of Health-Care Workers in High-Risk Settings

BCG vaccination of HCWs should be considered on an individual basis in health-care settings where **all** of the following conditions are met:

- a high percentage of TB patients are infected with *M. tuberculosis* strains that are resistant to both isoniazid and rifampin; and
- transmission of such drug-resistant *M. tuberculosis* strains to HCWs is likely; and,
- comprehensive TB infection-control precautions have been implemented and have not been successful.

Vaccination with BCG should not be required for employment or for assignment in specific work areas.

BCG is not recommended for use in HIV-infected persons or persons who are otherwise immunocompromised. In health-care settings where there is a high risk for transmission of *M. tuberculosis* strains resistant to both isoniazid and rifampin, employees and volunteers who are infected with HIV or are otherwise immunocompromised should be fully informed about the risk for acquiring TB infection and disease and the even greater risk for development of active TB disease associated with immunosuppression.

HCWs considered for BCG vaccination should be counseled regarding the risks and benefits of both BCG vaccination and preventive therapy. They should be informed about the variable findings of research regarding the efficacy of BCG vaccination, the interference of BCG vaccination with diagnosis of newly acquired *M. tuberculosis* infection, and the possible serious complications of BCG vaccine in immunocompromised persons, especially those infected with HIV. They also should be informed about the lack of data regarding the efficacy of preventive therapy for *M. tuberculosis* infections caused by strains resistant to isoniazid and rifampin and the risks for drug toxicity associated with multidrug preventive-therapy regimens. If requested by the employee, employers should offer (but not compel) a work assignment in which an immunocompromised HCW would have the lowest possible risk for infection with *M. tuberculosis*.

HCWs who contract TB are a source of infection for other health-care personnel and patients. Immunocompromised persons are at increased risk for developing active disease after exposure to TB; therefore, managers of health-care facilities should develop written policies to limit activities that might result in exposure of immunocompromised employees to persons with active cases of TB.

BCG vaccination is not recommended for HCWs in low-risk settings. In most areas of the United States, most *M. tuberculosis* isolates (approximately 90%) are fully susceptible to isoniazid or rifampin or both, and the risk for TB transmission in health-care facilities is very low if adequate infection control practices are maintained.

Hepatitis A

Routine preexposure hepatitis A vaccination of HCWs and routine IG prophylaxis for hospital personnel providing care to patients with hepatitis A are not indicated. Rather, sound hygienic practices should be emphasized. Staff education should emphasize precautions regarding direct contact with potentially infective materials (e.g., hand washing).

In documented outbreaks of hepatitis A, administration of IG to persons who have close contact with infected patients (e.g., HCWs, other patients) is recommended. A single intramuscular dose (0.02 mL per kg) of IG is recommended as soon as possible and ≤ 2 weeks after exposure (2). The usefulness of hepatitis A vaccine in controlling outbreaks in health-care settings has not been investigated.

The following vaccination schedules are recommended for the vaccines available in the United States:

- HAVRIX®: for persons aged >18 years, two doses, the second administered 6–12 months after the first.
- VAQTA® : for persons aged >17 years, two doses, the second administered 6 months after the first.

Meningococcal Disease

Routine vaccination of civilians, including HCWs, is not recommended. HCWs who have intensive contact with oropharyngeal secretions of infected patients, and who do not use proper precautions (95) should receive antimicrobial prophylaxis with rifampin (or sulfonamides, if the organisms isolated are sulfonamide-sensitive). Ciprofloxacin and ceftriaxone are reasonable alternative drugs; ceftriaxone can be ad-

ministered to pregnant women. Vaccination with quadrivalent polysaccharide vaccine should be used to control outbreaks of serogroup C meningococcal disease. Surveillance for serogroup C disease and calculation of attack rates can be used to identify outbreaks and determine whether use of meningococcal vaccine is warranted.

Pertussis

Pertussis vaccines (whole-cell and acellular) are licensed for use only among children aged 6 weeks through 6 years. If acellular pertussis vaccines are licensed for use in adults in the future, booster doses of adult formulations may be recommended to prevent the occurrence and spread of the disease in HCWs.

Typhoid

Workers in microbiology laboratories who frequently work with *S. typhi* should be vaccinated with any one of the three typhoid vaccines distributed in the United States: oral live-attenuated Ty21a vaccine (one enteric-coated capsule taken on alternate days to a total of four capsules), the parenteral heat-phenol inactivated vaccine (two 0.5 mL subcutaneous doses, separated by ≥ 4 weeks), or the capsular polysaccharide parenteral vaccine (one 0.5 mL intramuscular dose). Under conditions of continued or repeated exposure to *S. typhi*, booster doses are required to maintain immunity, every 5 years if the oral vaccine is used, every 3 years if the heat-phenol inactivated parenteral vaccine is used, and every 2 years if the capsular polysaccharide vaccine is used. Live-attenuated Ty21a vaccine should not be used among immunocompromised persons, including those infected with HIV (13).

Vaccinia

Vaccinia vaccine is recommended only for the few persons who work with orthopoxviruses (e.g., laboratory workers who directly handle cultures or animals contaminated or infected with vaccinia, recombinant vaccinia viruses, or other orthopoxviruses that replicate readily in humans [e.g., monkeypox, cowpox, and others]). Other HCWs (e.g., physicians and nurses) whose contact with these viruses is limited to contaminated materials (e.g., dressings) and who adhere to appropriate infection control measures are at lower risk for accidental infection than laboratory workers, but may be considered for vaccination. When indicated, vaccinia vaccine should be administered every 10 years (10). Vaccinia vaccine should not be administered to immunocompromised persons (including persons infected with HIV), persons who have eczema or a history of eczema, or to pregnant women (10).

Other Vaccine-Preventable Diseases

Health-care workers are not at substantially increased risk than the general adult population for acquiring diphtheria, pneumococcal disease, or tetanus. Therefore, they should seek these immunizations from their primary care provider, according to ACIP recommendations (12,14).

Tetanus and Diphtheria

Primary vaccination of previously unvaccinated adults consists of three doses of adult tetanus-diphtheria toxoid (Td): 4–6 weeks should separate the first and second

doses; the third dose should be administered 6–12 months after the second (12). After primary vaccination, a tetanus-diphtheria (Td) booster is recommended for all persons every 10 years. HCWs should be encouraged to receive recommended Td booster doses.

Pneumococcal Disease

Persons for whom pneumococcal vaccine is recommended include:

- Persons aged ≥ 65 years.
- Persons aged ≥ 2 and < 65 years who, because they have certain chronic illnesses, are at increased risk for pneumococcal disease, its complications, or severe disease if they become infected. Included are those who have chronic cardiovascular disease (i.e., congestive heart failure [CHF] or cardiomyopathies), chronic pulmonary disease (i.e., chronic obstructive pulmonary disease [COPD] or emphysema, but not asthma), diabetes mellitus, alcoholism, chronic liver disease (cirrhosis), or cerebrospinal fluid leaks.
- Persons ≥ 2 and < 65 years of age with functional or anatomic asplenia (e.g., sickle cell disease, splenectomy).
- Persons ≥ 2 and < 65 years of age living in special environments or social settings where an increased risk exists for invasive pneumococcal disease or its complications (e.g., Alaska Natives and certain American Indian populations).
- Immunocompromised persons ≥ 2 years of age, including
 - persons infected with HIV and persons who have leukemia, lymphoma, Hodgkin's disease, multiple myeloma, generalized malignancy, chronic renal failure, nephrotic syndrome;
 - persons with other conditions associated with immunosuppression (e.g., organ or bone marrow transplantation); and
 - persons receiving immunosuppressive chemotherapy, including long-term systemic corticosteroids.

Immunization of Immunocompromised Health-Care Workers

ACIP has published recommendations for immunization of immunocompromised persons (177). ACIP recommendations for use of individual vaccines or immune globulins also should be consulted for additional information regarding the epidemiology of the diseases and the safety and the efficacy of the vaccines or immune globulin preparations. Specific recommendations for use of vaccines depend upon the type of immunocompromising condition (Table 4).

Killed or inactivated vaccines do not represent a danger to immunocompromised HCWs and generally should be administered as recommended for workers who are not immunocompromised. Additional vaccines, particularly bacterial polysaccharide vaccines (i.e., *Haemophilus influenzae* type b [Hib] vaccine, pneumococcal vaccine, and meningococcal vaccine), are recommended for persons whose immune function is compromised by anatomic or functional asplenia and certain other conditions. Fre-

TABLE 4. Summary of ACIP recommendations concerning immunization of health-care workers with special conditions

Vaccine	Pregnancy	HIV Infection	Severe Immuno-suppression*	Asplenia	Renal Failure	Diabetes	Alcoholism and Alcoholic Cirrhosis
BCG	C	C	C	UI	UI	UI	UI
Hepatitis A	UI	UI	UI	UI	UI	UI	R [†]
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
Poliovirus vaccine, inactivated (IPV)**	UI	UI	UI	UI	UI	UI	UI
Poliovirus vaccine, live, oral (OPV)**	UI	C	C	UI	UI	UI	UI
Pneumococcus [†]	UI	R	R	R	R	R	R
Rabies	UI	UI	UI	UI	UI	UI	UI
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	C	C	R	R	R	R
Vaccinia	C	C	C	UI	UI	UI	UI

* 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.

[†] Recommendation is based on the person's underlying condition rather than occupation.

[§] Women who will be in the second or third trimester of pregnancy during the influenza season.

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

** Vaccination is recommended for unvaccinated health-care workers who have close contact with patients who may be excreting wild polioviruses. Primary vaccination with IPV is recommended because the risk for vaccine-associated paralysis after administration of OPV is higher among adults than among children. Health care workers who have had a primary series of 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 wild poliovirus, control measures to contain further transmission should be instituted immediately, including an OPV vaccination campaign.

^{††} Capsular polysaccharide parenteral vaccine.

Abbreviations: R=Recommended; C= Contraindicated; UI=Use if indicated.

quently, the immune response of immunocompromised persons to these vaccine antigens is not as good as that of nonimmunocompromised persons; higher doses or more frequent boosters may be required. Even with these modifications, the immune response may be suboptimal.

HIV-Infected Persons

Specific recommendations for vaccination of HIV-infected persons have been developed (Table 4). In general, live virus or live bacterial vaccines should not be administered to HIV-infected persons. However, asymptomatic HCWs need not be tested for HIV infection before administering live virus vaccines.

The following recommendations apply to all HCWs infected with HIV:

- MMR vaccine is recommended for all asymptomatic HIV-infected HCWs who do not have evidence of severe immunosuppression. Administration of MMR to HIV-infected HCWs who are symptomatic, but who do not have evidence of severe immunosuppression, should be considered. Measles vaccine is not recommended for HIV-infected persons with evidence of severe immunosuppression.
- Enhanced inactivated poliovirus vaccine (IPV) is the **only** poliovirus vaccine recommended for HIV-infected persons (11). Live oral poliovirus vaccine (OPV) **should not** be administered to immunocompromised persons.
- Influenza and pneumococcal vaccines are indicated for all HIV-infected persons (influenza vaccination for persons aged ≥ 6 months and pneumococcal vaccination for persons aged ≥ 2 years).

OTHER CONSIDERATIONS IN VACCINATION OF HEALTH-CARE WORKERS

Other considerations important to appropriate immunoprophylaxis of HCWs include maintenance of complete immunization records, policies for catch-up vaccination of HCWs, work restrictions for susceptible employees who are exposed to vaccine-preventable diseases, and control of outbreaks of vaccine-preventable disease in health-care settings. Additional vaccines not routinely recommended for HCWs in the United States may be indicated for those who travel to certain other regions of the world to perform research or health-care work (e.g., as medical volunteers in a humanitarian effort).

Immunization Records

An immunization record should be maintained for each HCW. The record should reflect documented disease and vaccination histories as well as immunizing agents administered during employment. At each immunization encounter, the record should be updated and the HCW encouraged to maintain the record as appropriate (15).

Catch-Up Vaccination Programs

Managers of health-care facilities should consider implementing catch-up vaccination programs for HCWs who are already employed, in addition to policies to ensure

that newly hired HCWs receive necessary vaccinations. This strategy will help prevent outbreaks of vaccine preventable diseases (see Outbreak Control). Because education enhances the success of many immunization programs, reference materials should be available to assist in answering questions regarding the diseases, vaccines, and toxoids, and the program or policy being implemented. Conducting educational workshops or seminars several weeks before the initiation of the program may be necessary to ensure acceptance of program goals.

Work Restrictions for Susceptible Workers After Exposure

Postexposure work restrictions ranging from restriction of contact with high-risk patients to complete exclusion from duty are appropriate for HCWs who are not immune to certain vaccine-preventable diseases (Table 5). Recommendations concerning work restrictions in these circumstances have been published (16,35,178).

Outbreak Control

Hospitals should develop comprehensive policies and protocols for management and control of outbreaks of vaccine-preventable disease. Outbreaks of vaccine-preventable diseases are costly and disruptive. Outbreak prevention, by ensuring that all HCWs who have direct contact with patients are fully immunized, is the most effective and cost-effective control strategy. Disease-specific outbreak control measures are described in published ACIP recommendations (Table 1) (1-15) and infection control references (16,35,95, 178-180).

Vaccines Indicated for Foreign Travel

Hospital and other HCWs who perform research or health-care work in foreign countries may be at increased risk for acquiring certain diseases (e.g, hepatitis A, poliomyelitis, Japanese encephalitis, meningococcal disease, plague, rabies, typhoid, or yellow fever). Vaccinations against those diseases should be considered when indicated for foreign travel (181). Elevated risks for acquiring these diseases may stem from exposure to patients in health-care settings (e.g., poliomyelitis, meningococcal disease), but may also arise from circumstances unrelated to patient care (e.g, high endemicity of hepatitis A or exposure to arthropod disease vectors [yellow fever]).

TABLE 5. Work restrictions* for health-care workers (HCWs) exposed to or infected with certain vaccine-preventable diseases

Disease/Problem	Work Restriction	Duration
Diphtheria		
Active	Exclude from duty.	Until antimicrobial therapy is completed and 2 nasopharyngeal cultures obtained ≥ 24 hours apart are negative.
Postexposure (Susceptible HCWs; previously vaccinated HCWs who have not had a Td booster dose within the previous 5 years)	Exclude from duty.	Same as active diphtheria
Asymptomatic carriers	Exclude from duty.	Same as active diphtheria.
Hepatitis A		
	Restrict from patient contact and food handling.	7 days after onset of jaundice.
Hepatitis B		
HCWs with acute or chronic antigenemia:		
-HCWs who do not perform exposure-prone invasive procedures (21)	Standard precautions should always be observed. No restriction unless epidemiologically linked to transmission of infection.	Universal precautions should always be observed.
-HCWs who perform exposure-prone invasive procedures	These HCWs 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 (30).	Until HBeAg [†] is negative.
Upper respiratory infections		
(Persons at high risk for complications of influenza as defined by ACIP [3])	During particular seasons (e.g., during winter when influenza and/or RSV are prevalent), consider excluding personnel with acute febrile upper respiratory infections (including influenza) from care of high-risk patients.	Until acute symptoms resolve.
Measles		
Active	Exclude from duty	7 days after rash appears.
Postexposure (Susceptible personnel)	Exclude from duty.	5th day after 1st exposure through 21st day after last exposure and/or 7 days after the rash appears.

TABLE 5. Work restrictions* for health-care workers (HCWs) exposed to or infected with certain vaccine-preventable diseases — Continued

Disease/Problem	Work Restriction	Duration
Mumps		
Active	Exclude from duty	9 days after onset of parotitis.
Postexposure (Susceptible personnel)	Exclude from duty.	12th day after 1st exposure through 26th day after last exposure or 9 days after onset of parotitis.
Pertussis		
Active	Exclude from duty	Beginning of catarrhal stage through 3rd week after onset of paroxysms or until 5 days after start of effective antimicrobial therapy.
Postexposure <i>Symptomatic personnel</i>	Exclude from duty	5 days after start of effective antimicrobial therapy.
<i>Asymptomatic personnel</i>	No restriction, on antimicrobial prophylactic therapy.	
Rubella		
Active	Exclude from duty	5 days after the rash appears.
Postexposure (Susceptible personnel)	Exclude from duty.	7th day after 1st exposure through 21st day after last exposure and/or 5 days after rash appears.
Varicella		
Active	Exclude from duty	Until all lesions dry and crust.
Postexposure (Susceptible personnel)	Exclude from duty	10th day after 1st exposure through 21st day (28th day if VZIG administered) after the last exposure; if varicella occurs, until all lesions dry and crust.
Zoster		
(Localized in normal person)	Cover lesions; restrict from care of high-risk patients [§] .	Same as varicella.
Postexposure (Susceptible personnel)	Restrict from patient contact.	

* Adapted from:

- (173) CDC. Recommendations for preventing transmission of human immunodeficiency virus and hepatitis B virus to patients during exposure-prone invasive procedures. *MMWR* 1991;40(RR-8):1-8.

- (95) 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.

- (178) Williams WW: CDC guideline for infection control in hospital personnel. *Infect Control* 1983;4(Suppl):326-49.

† HBeAg = Hepatitis B e antigen.

§ Patients who are susceptible to varicella and at increased risk for complications of varicella (i.e., neonates and immunocompromised persons of any age.)

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