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CDC Guidance for Evaluating Health-Care Personnel for Hepatitis B Virus Protection and for Administering Postexposure Management

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U.S. Department of Health and Human Services
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CDC Guidance for Evaluating Health-Care Personnel for Hepatitis B Virus Protection and for Administering Postexposure Management

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Summary

This report contains CDC guidance that augments the 2011 recommendations of the Advisory Committee on Immunization Practices (ACIP) for evaluating hepatitis B protection among health-care personnel (HCP) and administering post-exposure prophylaxis. Explicit guidance is provided for persons working, training, or volunteering in health-care settings who have documented hepatitis B (HepB) vaccination years before hire or matriculation (e.g., when HepB vaccination was received as part of routine infant [recommended since 1991] or catch-up adolescent [recommended since 1995] vaccination).

In the United States, 2,890 cases of acute hepatitis B were reported to CDC in 2011, and an estimated 18,800 new cases of hepatitis B occurred after accounting for underreporting of cases and asymptomatic infection. Although the rate of acute hepatitis B virus (HBV) infections have declined approximately 89% during 1990–2011, from 8.5 to 0.9 cases per 100,000 population in the United States, the risk for occupationally acquired HBV among HCP persists, largely from exposures to patients with chronic HBV infection.

ACIP recommends HepB vaccination for unvaccinated or incompletely vaccinated HCP with reasonably anticipated risk for blood or body fluid exposure. ACIP also recommends that vaccinated HCP receive postvaccination serologic testing (antibody to hepatitis B surface antigen [anti-HBs]) 1–2 months after the final dose of vaccine is administered (CDC. Immunization of health-care personnel: recommendations of the Advisory Committee on Immunization Practices [ACIP]. MMWR 2011;60 [No. RR-7]). Increasing numbers of HCP have received routine HepB vaccination either as infants (recommended since 1991) or as catch-up vaccination (recommended since 1995) in adolescence. HepB vaccination results in protective anti-HBs responses among approximately 95% of healthy-term infants. Certain institutions test vaccinated HCP by measuring anti-HBs upon hire or matriculation, even when anti-HBs testing occurs greater than 2 months after vaccination. This guidance can assist clinicians, occupational health and student health providers, infection-control specialists, hospital and health-care training program administrators, and others in selection of an approach for assessing HBV protection for vaccinated HCP. This report emphasizes the importance of administering HepB vaccination for all HCP, provides explicit guidance for evaluating hepatitis B protection among previously vaccinated HCP (particularly those who were vaccinated in infancy or adolescence), and clarifies recommendations for postexposure management of HCP exposed to blood or body fluids.

Introduction

Hepatitis B virus (HBV) has long been recognized as an occupational risk for health-care personnel (HCP), including HCP trainees (*1*,*2*). The virus remains infectious for prolonged periods on environmental surfaces and is transmissible in the absence of visible blood (*1*). HCP do not recognize all exposures to potentially infectious blood or body fluids (*2*) and, even if exposures are recognized, often do not seek postexposure prophylactic management (*3*). In serologic studies conducted in the United States during the 1970s, HCP had a prevalence of HBV infection approximately 10 times greater than the general population (*1*). In 1983, an estimated 17,000 HBV infections occurred among HCP (*4*).

Vaccines to prevent HBV became available in the United States in 1981 and were recommended by the Advisory Committee

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on Immunization Practices (ACIP) for HCP in 1982 (*5*). Although a high proportion of healthy vaccine recipients in clinical trials respond to hepatitis B (HepB) vaccination, the proportion of responders can be lower among the general population, particularly among persons with chronic medical conditions (*6*,*7*). Acute and chronic HBV infections are rare among HCP who respond to HepB vaccination, but HCP who do not respond to vaccination are thought to remain susceptible. Postvaccination serologic testing for antibody to hepatitis B surface antigen (anti-HBs) identifies vaccine nonresponders and guides the need for revaccination, additional testing for chronic HBV infection, and counseling for HCP who remain susceptible after failing to respond to vaccination.

In 1991, ACIP recommended consideration of postvaccination serologic testing for anti-HBs for HCP at risk for needlestick exposures (*8*). In 1997, ACIP recommended postvaccination serologic testing 1–2 months after completion of the HepB vaccine series for HCP who have contact with patients or blood and who are at ongoing risk for injuries with sharp instruments or needlesticks (*9*). Since 1982 (when HepB vaccine was recommended for HCP), major declines have occurred in reports of acute hepatitis B among HCP (*10*). In 2011, ACIP reaffirmed that unvaccinated and incompletely vaccinated HCP at reasonably anticipated risk for blood or body fluid exposure should receive HepB vaccination before potential exposure, and HCP at high risk for exposure should receive postvaccination serologic testing 1–2 months after completion of the vaccine series (*11*).

This report provides CDC guidance for persons working, training, or volunteering in health-care settings who have documented HepB vaccination received years before hire or matriculation (e.g., when HepB vaccination was received as part of routine infant [recommended since 1991] or catch-up adolescent [recommended since 1995] vaccination). No postvaccination serologic testing is recommended after routine infant or adolescent HepB vaccination. Although acute HBV infections have declined substantially since HepB vaccination was introduced in the United States, a risk for occupational exposure to HBV persists (*10*), largely from persons with chronic HBV infection. Because vaccine-induced anti-HBs wanes over time, testing HCP for anti-HBs years after vaccination might not distinguish vaccine nonresponders from responders. Pre-exposure assessment of current or past anti-HBs results upon hire or matriculation, followed by one or more additional doses of HepB vaccine for HCP with anti-HBs <10 mIU/mL, if necessary, helps to ensure that HCP will be protected if they have an exposure to HBV-containing blood or body fluids.

An expert panel convened by CDC acknowledged that the risk for HBV infection for vaccinated HCP can vary widely by setting and profession, and might be low enough in certain settings that assessment of anti-HBs status and appropriate follow-up can be done at the time of exposure to potentially infectious blood or body fluids. This approach relies on HCP recognizing and reporting blood and body fluid exposures and therefore might be applied on the basis of documented low risk, implementation, and cost considerations. Certain HCP occupations have lower risk for occupational blood and body fluid exposures (e.g., occupations involving counseling versus performing procedures), and nontrainees have lower risks for blood and body fluid exposures than trainees. Some settings also will have a lower prevalence of HBV infection in the patient population served than in other settings, which will influence the risk for HCP exposure to hepatitis B surface antigen (HBsAg)-positive blood and body fluids. All health-care institutions should ensure that HCP receive training to recognize and report exposures, have systems in place to facilitate reporting and postexposure assessment, and have prophylaxis readily accessible for timely administration. This report can guide clinicians, occupational health and student health clinicians, infection-control specialists, hospital and health-care training program administrators, and others in selection of an approach for assessing HBV protection for vaccinated HCP.

HCPs are defined as all paid and unpaid persons providing health care, or working or training in health-care settings, who have reasonably anticipated risks for exposure to infectious materials, including blood or body fluids, contaminated medical supplies and equipment, or contaminated environmental surfaces. HCP might include but are not limited to physicians, nurses, nursing assistants, nurse practitioners, physician assistants, therapists, technicians, emergency medical services personnel, dental personnel, pharmacists, laboratory personnel, autopsy personnel, health-care students and trainees, contractual staff not employed by the health-care facility, and persons not directly involved in patient care but with potential exposure to infectious agents that can be transmitted between patients and HCP (e.g., housekeeping, laundry, security, maintenance, and volunteers) (*1*,*11*).

This guidance applies but is not limited to HCP in acute-care hospitals, long-term–care facilities (e.g., nursing homes, skilled nursing facilities, and assisted living facilities), physician's offices, dental offices, rehabilitation centers, urgent-care centers, ambulatory surgical centers, dialysis centers, and outpatient clinics, and to persons who provide home health care and emergency medical services. Although this guidance pertains to HCP, the same principles might be applicable to persons in other professions with reasonably anticipated risk for blood or body fluid exposure (e.g., public safety workers, embalmers, and crime scene cleanup crews).

Recommendations for testing HCP in certain populations at risk for acquisition of HBV infection before matriculation or hire can be found elsewhere and will be reviewed only briefly in this document (*11*–*13*). HCP protection against hepatitis C virus (HCV), human immunodeficiency virus (HIV), and other infections also is covered elsewhere (*1*,*11*,*14*). Postvaccination serologic testing and the need for revaccination specific to HCP with immunocompromising conditions (e.g., HCP who are on dialysis, infected with HIV, hematopoietic stem-cell transplant recipients, and receiving chemotherapy) are addressed in separate recommendations (*15*). Additional guidance on the management of HCP with chronic HBV infection has been published (*13*). A list of frequently used abbreviations is provided (Box).

New or Updated Information Provided in this Guidance

This document examines approaches for assessing HBV protection for vaccinated HCP and offers additional guidance for postexposure evaluation and testing of HCP in consideration of:

- The changing epidemiology of HBV infections in the United States
- The risk for occupational blood or body fluid exposures since introduction of engineering and work-practice controls and the Needlestick Safety and Prevention Act of 2001
- HCP reporting of blood or body fluid exposures
- HepB vaccination coverage among HCP
- Estimates of the proportion of adults with measureable anti-HBs at intervals after vaccination
- Duration of vaccine-induced protection
- Current vaccination and postvaccination serologic testing practices
- Cost-effectiveness of approaches for assessing HBV protection among HCP, and
- Recommendations for administering postexposure management.

Methods

In 2012, CDC identified and convened subject matter experts in the fields of HBV infection, health-care epidemiology, and evidence-based medicine to form an expert panel to address mechanisms for assessing HBV protection for vaccinated HCP.* The expert panel was comprised of professionals from academic medicine (e.g., pediatrics, family medicine, internal medicine, and infectious diseases) and occupational health; federal and state public health professionals with expertise in hepatitis and health-care associated infections; and liaisons from the Society for Healthcare Epidemiology of America (SHEA), Healthcare Infection Control Practices Advisory Committee (HICPAC), American Medical Directors Association (AMDA), American College Health Association (ACHA), American Academy of Family Physicians (AAFP), and the Society for Adolescent Health and Medicine (SAHM). The expert panel convened 21 teleconferences for deliberations during January 19, 2012–January 8, 2013. Materials for teleconference discussion were electronically distributed to members.

The expert panel reviewed relevant published literature identified through PubMed searches, citations, and personal files. Reference lists were reviewed to retrieve additional relevant information. The expert panel considered the changing epidemiology of hepatitis B infections from surveillance reports, which included follow-up with state health departments to obtain additional information on HCP with acute hepatitis B during 2005–2010 reported as having a positive or unknown

BOX. Abbreviations.

ACIP	Advisory Committee on Immunization Practices
anti-HBc	antibody to hepatitis B core antigen
anti-HBs	antibody to hepatitis B surface antigen
ELISA	enzyme-linked immunosorbent assay
HBeAg	hepatitis B e antigen
HBIG	hepatitis B immune globulin
HBsAg	hepatitis B surface antigen
HBV	hepatitis B virus
HBV DNA	hepatitis B virus deoxyribonucleic acid
HCP	health-care personnel
HCV	hepatitis C virus
HepB	hepatitis B vaccine
HIV	human immunodeficiency virus
IDU	injection drug use
IG	immune globulin
IIS	Immunization Information System
IOM	Institute of Medicine
MSM	men who have sex with men
NHIS	National Health Interview Survey
NNDSS	National Notifiable Diseases Surveillance System
OSHA	Occupational Safety and Health Administration
PCR	polymerase chain reaction
QALY	quality-adjusted life-year

*A list of the members of the panel appears on page 20.

HepB vaccination history. The expert panel reviewed previous recommendations from ACIP, HICPAC, and the U.S. Public Health Service; including recommendations defining HCP at risk for occupational exposure, HepB vaccination, and postvaccination serologic testing. The panel also reviewed postexposure prophylaxis (*1*,*5*,*9*,*11*,*13*,*15*,*16*), and results from an electronic survey administered to health-care institutions regarding current practices (see Hepatitis B Vaccination and Postvaccination Testing among HCP). Various members of the expert panel were consulted to address issues throughout the development of these guidelines. Evidence also was summarized in presentations discussed during expert panel teleconferences.

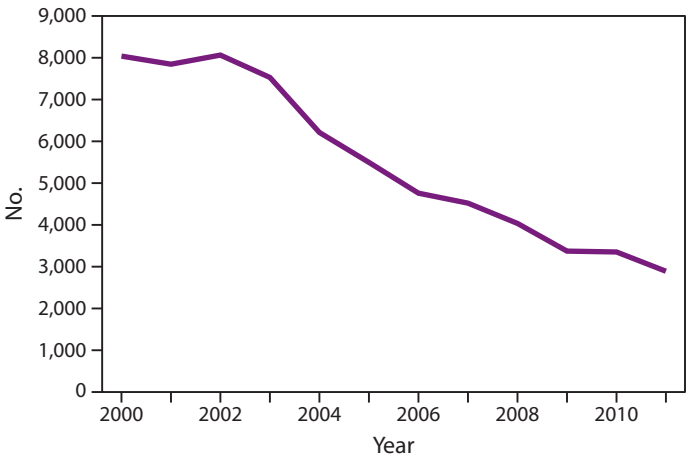
The panel identified two approaches for assessing HBV protection for vaccinated HCP, on the basis of expert opinion, which form the foundation of this guidance. Members of the expert panel critically reviewed earlier drafts of this guidance document, which was developed by CDC, individually and as a group by teleconference. Names and affiliations of persons who provided input in the drafting of these recommendations are included at the beginning of this document and in the acknowledgments section.

Changing Epidemiology of HBV Infection

Hepatitis B is a nationally reportable disease (*17*). In the United States, 2,890 cases of acute hepatitis B were reported to CDC in 2011, and an estimated 18,800 new cases of hepatitis B occurred after accounting for underreporting of cases and asymptomatic infection (Figure 1) (*10*). Among patients with reported cases of acute hepatitis B with information, approximately 55% were hospitalized and 1.3% died from hepatitis B (*10*). Acute HBV infection becomes chronic in 90% of infants, 30% of children aged <5 years, and <1%–12% of adults (*18*). Approximately 25% of persons who become chronically infected during childhood and 15% of those who become chronically infected after childhood die prematurely from cirrhosis or liver cancer (*1*,*15*). An estimated 800,000–1.4 million persons in the United States are living with chronic HBV infection; these persons serve as the main reservoir for HBV (*12*). In contrast to a decline in reports of acute hepatitis B, the prevalence of chronic HBV, which is often asymptomatic, remained relatively stable (Figure 2) (*19*) at 3 per 100,000 persons (95% confidence interval = 2–5 per 100,000) during 2005–2010, as did death certificate-registered deaths (*20*).

A national strategy to eliminate HBV transmission was implemented in 1991 (*16*). A key component was a recommendation for routine vaccination of infants (*16*). As a result, the rate of newly reported acute HBV infections in the United States declined approximately 89% during 1990–2011, from 8.5 to 0.9 cases per 100,000 population (*10*,*11*). The incidence was lowest (0.04 cases per 100,000 population) among persons aged ≤19 years (*10*), the population routinely vaccinated as infants and adolescents. Although HepB vaccine coverage rates in 2011 were high among infants, children, and adolescents (91.1% among children aged 19–35 months and 92.3% among adolescents aged 13–17 years) (*21*,*22*), self-reported ≥3-dose coverage remained considerably lower for adults (35.9% for adults aged 19–49 years in 2011) (*23*).

FIGURE 1. Number* of reported acute hepatitis B cases — National Notifiable Diseases Surveillance System, United States, 2000–2011



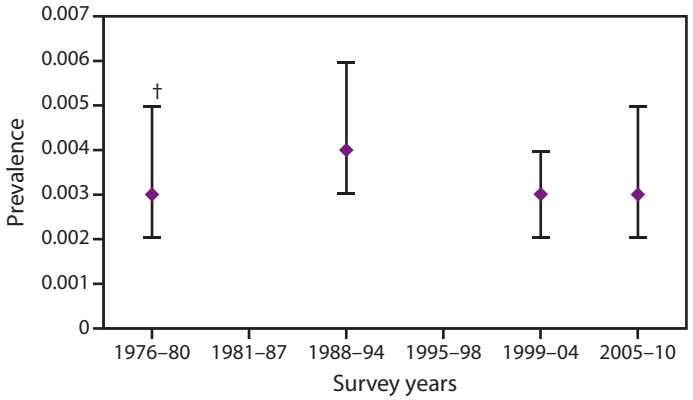
Source: CDC. Viral hepatitis statistics and surveillance. Available at http://www.cdc.gov/hepatitis/statistics/index.htm.

* For 2011, the reported number of cases was 2,890; the estimated number of cases (18,800) was computed after accounting for underreporting and asymptomatic infections.

Occupational Risk for HBV Exposure and Exposure Reporting

Blood from persons with HBV infection contains the highest HBV titers of all body fluids and is the most important vehicle of transmission in the health-care setting (*1*). The following body fluids also are considered potentially infectious: cerebrospinal fluid, synovial fluid, pleural fluid, peritoneal fluid, pericardial fluid, and amniotic fluid (*1*). Although studies have documented HBV in saliva and tears, these body fluids have generally not represented an occupational risk for HBV infection unless they contain blood (*1*). Semen and vaginal secretions have been implicated in the sexual transmission of HBV, but they have not been implicated in occupational transmission from patients to HCP (*1*). The presence of HBsAg, usually an indicator of active HBV infection, also is found in other body fluids (e.g., breast milk, bile, feces, nasopharyngeal washings, and sweat). However, most body fluids are not efficient vehicles of transmission (unless they contain blood) because they contain low quantities of infectious HBV (*1*).

FIGURE 2. Weighted prevalence of chronic hepatitis B* — National Health and Nutrition Examination Survey, United States, 1976–2010



Sources: Wasley A, Kruszon-Moran D, Kuhnert W, et al. The prevalence of hepatitis B virus infection in the United States in the era of vaccination. J Infect Dis 2010;202:192–201. Personal communication. Roberts H, PhD. Atlanta, GA: CDC;2012.

* Chronic Hepatitis B is defined as the presence of both hepatitis B surface antigen (HBsAg) and antibody to hepatitis B core antigen (anti-HBc).

† Represents 95% confidence interval.

Sputum, urine, and vomitus are not considered potentially infectious unless they contain blood (*1*).

HBV is highly infectious, can be transmitted in the absence of visible blood (*1*), and remains infectious on environmental surfaces for at least 7 days (*24*). HBV is transmitted through percutaneous (i.e., needlesticks), mucosal (i.e., direct contact with mucous membranes), or nonintact skin (e.g., psoriasis, eczema, burns, wounds, cuts, and scratches) exposure to infectious blood or body fluids. Although percutaneous exposures are among the most efficient modes of HBV transmission, these exposures might account for only a minority of HBV infections among HCP. In several investigations of HBV outbreaks, most infected HCP could not recall an overt percutaneous exposure (*2*,*25*).

Hepatitis B e antigen (HBeAg) is a marker for high HBV replication and viral load (*15*). Although testing occupational exposure source patients for HBeAg is not practical and is not recommended, the risk for acquiring HBV infection is particularly high in occupational exposures to blood or body fluids from source patients who are HBeAg-positive (*4*). In studies of HCP who sustained injuries from needles contaminated with blood containing HBV, the risk for developing clinical hepatitis if the blood was both HBsAg-positive and HBeAg-positive was 22%–31%; the risk for developing serologic evidence of HBV infection was 37%–62% (*1*,*26*). By comparison, the risk for developing clinical hepatitis from a needle contaminated with HBsAg-positive, HBeAg-negative blood was 1%–6%, and the risk for developing serologic evidence of HBV infection was 23%–37% (*1*,*26*).

The Needlestick Safety and Prevention Act of 2001 directed the Occupational Safety and Health Administration (OSHA) to revise the Occupational Exposure to Bloodborne Pathogens Standard and established in greater detail requirements for employers regarding the identification and use of effective and safer medical devices (*27*). Percutaneous injuries have since decreased from 39.6 injuries per 100 occupied beds in 1999 to 19.5 injuries per 100 occupied beds in 2011 (Figure 3) (*28*). Data since 2002 indicate that 18% of HCP trainees sustain a percutaneous exposure annually, and 54% of percutaneous exposures are reported to occupational health (*3*,*29*–*32*). Reluctance to report exposures to occupational health might be influenced by fear of being reprimanded, concerns regarding confidentiality, and the belief that reporting might be time consuming (*29*,*31*). The annual risk for a mucosal exposure among trainees is 22%, of which 17% are reported to occupational health (*3*,*29*–*32*). The risk for exposure is generally lower among nontrainees and varies by occupation and job duties (*32*,*33*). Surveillance data indicate nurses and physicians account for 41.9% and 22.8%, respectively, of HCP reporting percutaneous exposures (*28*). The purpose of the sharp item that resulted in the exposure was for intramuscular or subcutaneous injection in 30.5% of exposures and was for suturing in 18.7% of exposures (*28*). Medical students account for 44.3% of HCP reporting a mucosal exposure (*28*).

The probability of HBV infection among HCP trainees will vary by the prevalence of HBsAg-positivity of source patients and the approach to assessment (Figure 4). Exposure logs during 2000–2012 representing 7,170 exposures at three health-care systems in the United States indicated that 0.9% of source patients were HBsAg-positive (*34*). This figure likely varies substantially by setting; in some community screening programs among populations considered at higher risk, 11%–25% of persons screened are infected with HBV (*35*).

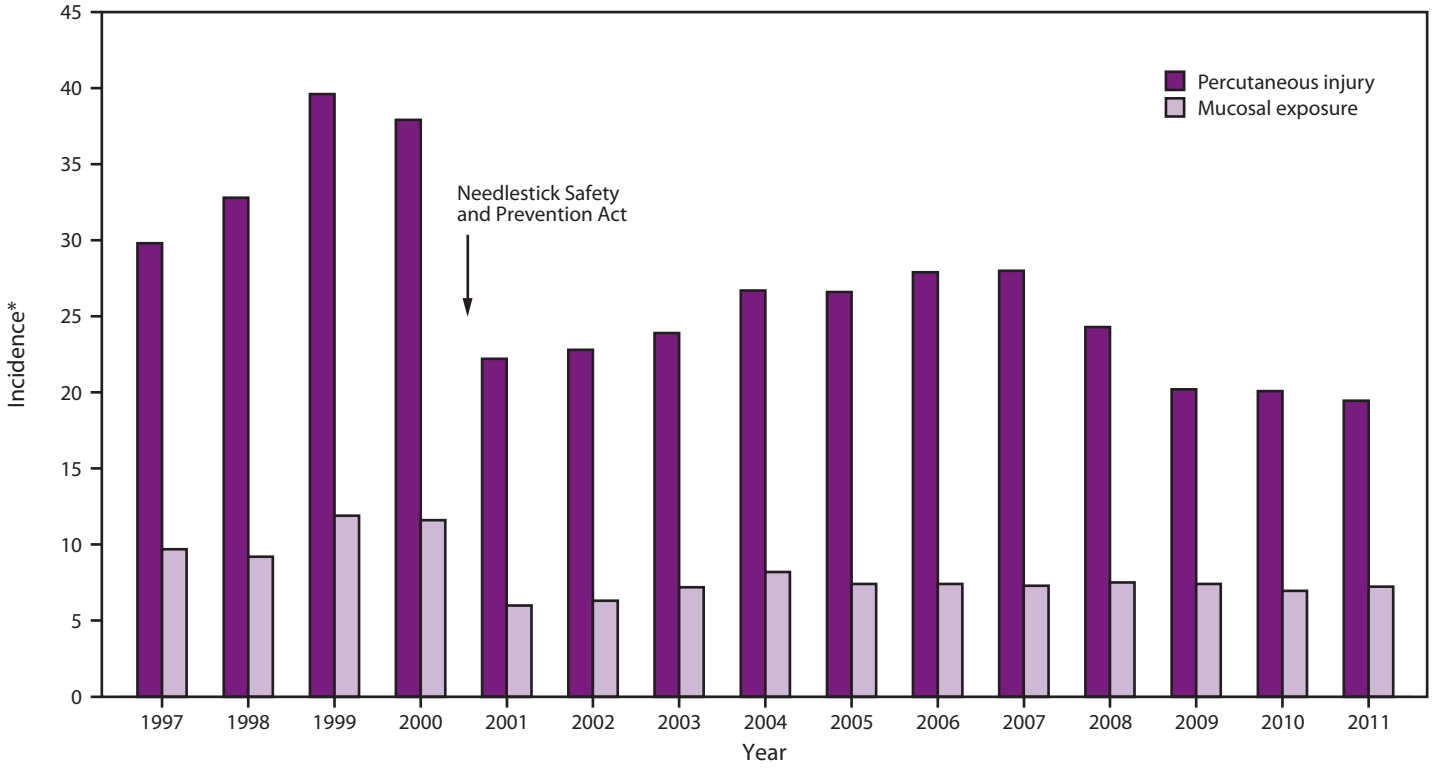
The source patient is identifiable in approximately 95% of exposures (*28*). The source patient might not be identifiable after exposure from an item protruding from a disposal container, an item disposed of in an inappropriate container, or from an item left in an inappropriate place (*28*).

Vaccination

HepB Vaccines

HepB vaccine is available as a single-antigen formulation and also in combination with other vaccines (Table 1) (*15*). Two single-antigen recombinant HBsAg vaccines are available in the United States: Recombivax HB (Merck and Co, Inc.,

FIGURE 3. Incidence* of percutaneous injury† and mucosal exposure§ — Exposure Prevention Information Network, 1997–2011



Source: University of Virginia Health System. International Healthcare Worker Safety Center. Available at http://www.healthsystem.virginia.edu/pub/epinet/home.html.
* Per 100 occupied beds.
† Includes needlesticks, cuts, and bites.
§ Includes contact with mucous membranes or nonintact skin (termed "blood and body fluid exposures" by the Exposure Prevention Information Network [EPINet]).

Whitehouse Station, NJ) and Engerix-B (GlaxoSmithKline Biologicals, Rixensart, Belgium) (*15*). Of the three licensed combination vaccines, one (Twinrix [GlaxoSmithKline Biologicals]) is available for persons aged ≥18 years. Twinrix contains recombinant HBsAg and inactivated hepatitis A virus (*15*).

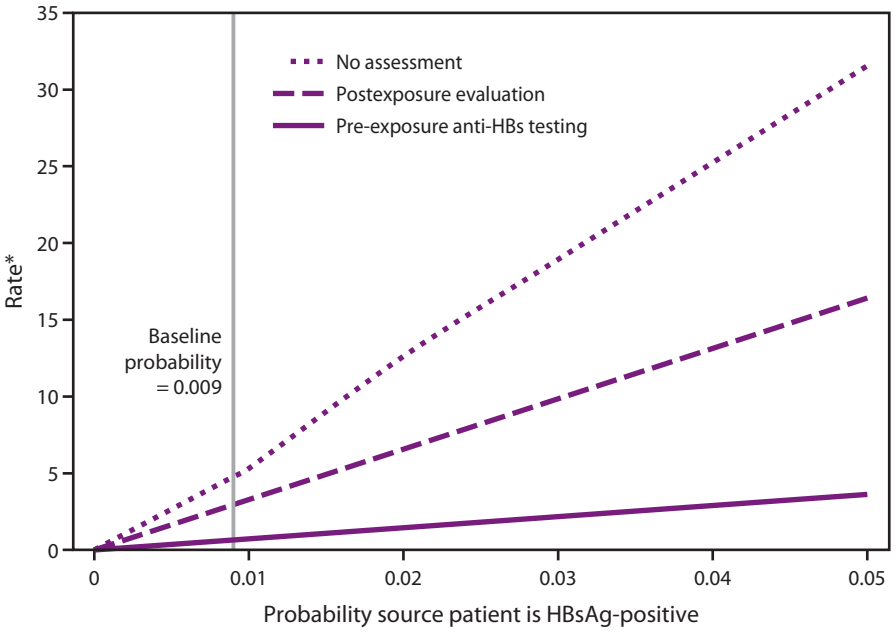
Primary HepB vaccination of adults usually consists of 3 doses of 10 or 20 μg of recombinant HBsAg protein administered intramuscularly into the deltoid muscle on a 0, 1, and 6 month schedule (*15*). Alternative schedules (including a 4-dose schedule at 0, 1, 2, and 12 months) are U.S.-approved for routine vaccination for specific ages and vaccine formulations; vaccination according to these schedules elicits final rates of seroprotection similar to those obtained on a 0, 1, and 6 month schedule (*15*). Obese persons might require adjustment in the needle length for administering HepB vaccine to achieve optimal seroprotection (*11*,*15*).

Vaccine Safety

HepB vaccines have been demonstrated to be safe among persons in all age groups (*15*). During 1982–2004, an estimated 70 million adolescents and adults in the United States received ≥1 dose of HepB vaccine (*15*). The most frequently reported side effects are pain at the injection site (3%–29%) and temperature of >99.9°F (>37.7°C) (1%–6%) (*15*). In placebo-controlled studies, these side effects were reported no more frequently among persons receiving HepB vaccine than among persons receiving placebo (*15*). Administration of additional vaccine doses for nonresponders is not associated with an increase in adverse events (*36*).

Epidemiologic and mechanistic assessment by the Institute of Medicine for 27 adverse events supported a causal association with HepB vaccination only for anaphylaxis in persons who are sensitive to yeast (*37*). HepB vaccination is contraindicated for persons with a history of hypersensitivity to yeast or any vaccine component (*15*). Persons with a history of serious adverse events (e.g., anaphylaxis) after receipt of HepB vaccine should not receive additional doses. As with other vaccines, vaccination of persons with moderate or severe acute illness, with or without fever, should be deferred until illness resolves (*15*). Vaccination is not contraindicated in persons with a history of multiple sclerosis, Guillain-Barré Syndrome, autoimmune disease (e.g., systemic lupus erythematosis and rheumatoid arthritis), or other chronic diseases (*15*). HepB vaccination is not contraindicated for pregnant (*15*,*38*,*39*) or lactating (*1*) women. Available vaccines contain noninfectious HBsAg and do not pose a risk for infection to the fetus (*15*).

FIGURE 4. Hepatitis B virus infection rate among health-care personnel trainees, by prevalence of hepatitis B surface antigen positivity of source patients and approach to assessment



Source: Personal communication. Hoerger TJ, Ludlow-Bradley C. Durham, North Carolina: Research Triangle Institute, International; 2012.
* Per 100,000 population of health-care personnel.

Vaccine Seroprotection

Immunocompetent adults and children who have vaccine-induced anti-HBs levels of ≥10 mIU/mL 1–2 months after having received a complete, ≥3-dose HepB vaccine series are considered seroprotected and deemed vaccine responders (*15*). Vaccine efficacy studies have demonstrated protection against acute and chronic disease in immunocompetent vaccine responders (*40*,*41*). Vaccine-induced seroprotection is a useful surrogate of vaccine efficacy (*42*). Postvaccination seroprotection is achieved in approximately 95% of healthy infants (*43*,*44*), approximately 92% of HCP aged <40 years, and approximately 84% of HCP aged ≥40 years (*6*). Among infants vaccinated at birth, low birthweight is associated with a lower proportion of infants achieving seroprotection (*45*). Among persons vaccinated as adults, smoking, obesity, aging, chronic medical conditions, male sex, genetic factors, and immune suppression are associated with a decrease in proportions seroprotected (*6*,*11*,*36*,*46*–*48*). Although immunogenicity is less among immunocompromised persons, those who achieve and maintain seroprotective antibody levels before exposure to HBV have a high level of protection (*15*).

Persistence of Vaccine-Induced Antibody

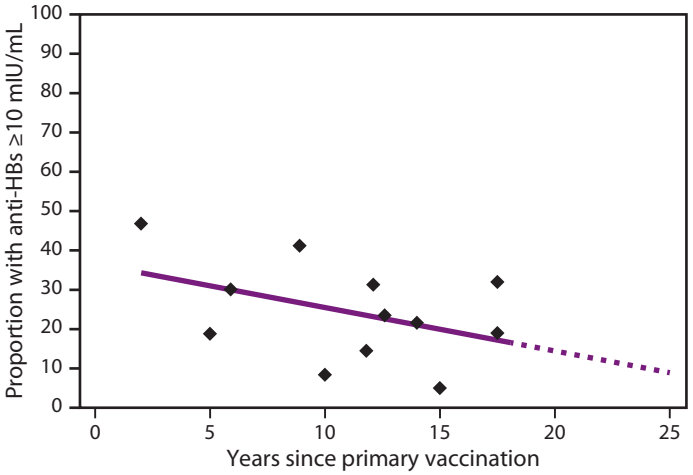
Anti-HBs levels after vaccination decline over time. The persistence of detectable anti-HBs levels varies by age at vaccination. By 18 years after vaccination, approximately 16% of persons vaccinated at age <1 year have detectable antibody levels of ≥10 mIU/mL (*49*–*54*) (Figure 5), compared with 74% for those vaccinated at age ≥1 year (*41*,*54*–*62*). In a study of matriculating health science students, 92.9% of those who had received 3 doses of HepB vaccine had anti-HBs ≥10 mIU/mL (*58*). Median age at receipt of the primary series was 14.5 years (interquartile range: 11.6–20.2 years) and at postvaccination testing was 23.2 years (interquartile range: 22.1–24.8 years) (*58*).

TABLE 1. Recommended dosages of hepatitis B vaccine, by age, immunocompetency, and vaccine type

	Single-antigen vaccine*				Combination vaccine	
	Recombivax HB		Engerix-B		Twinrix†	
Characteristic	Dosage (μg)	Volume (mL)	Dosage (μg)	Volume (mL)	Dosage (μg)	Volume (mL)
Age (yrs)						
11–15	10§	1	NA	NA	NA	NA
11–19	5	0.5	10	0.5	NA	NA
≥20	10	1	20	1	20	1
Hemodialysis patients and other immunocompromised persons						
<20¶	5	0.5	10	0.5	NA	NA
≥20	40**	1	40††	2	NA	NA

Abbreviation: NA = not applicable.
* Single-antigen vaccine is usually administered on a 3-dose schedule at 0, 1, and 6 months. Other schedules are available. See package insert.
† Combined hepatitis A and hepatitis B vaccine is recommended for persons aged ≥18 years at increased risk for both hepatitis B virus and hepatitis A virus infections.
§ Adult formulation administered on a 2-dose schedule.
¶ Higher dosages might be more immunogenic, but no specific recommendations have been made.
** Dialysis formulation administered on a 3-dose schedule at 0, 1, and 6 months.
†† Two 1 mL doses administered at one site on a 4-dose schedule at 0, 1, 2, and 6 months.

FIGURE 5. Serologic evidence of protection, by years since vaccination among persons vaccinated at age <1 year*



Sources: Samandari T, Fiore AE, Negus S, et al. Differences in response to a hepatitis B vaccine booster dose among Alaskan children and adolescents vaccinated during infancy. Pediatrics 2007;120:e373–81. Petersen KM, Bulkow LR, McMahon BJ, et al. Duration of hepatitis B immunity in low risk children receiving hepatitis B vaccinations from birth. Pediatr Infect Dis J 2004;23:650–5. Hammitt LL, Hennessy TW, Fiore AE, et al. Hepatitis B immunity in children vaccinated with recombinant hepatitis B vaccine beginning at birth: a follow-up study at 15 years. Vaccine. 2007;25:6958–64. Dentinger CM, McMahon BJ, Butler JC, et al. Persistence of antibody to hepatitis B and protection from disease among Alaska natives immunized at birth. Pediatr Infect Dis J 2005;24:786–92. Middleman AB, Baker C, Hu DJ, et al. Duration of immunity from hepatitis B vaccine administered soon after birth among 16 to 19 year old youth in the United States. Presented to the Pediatric Academic Societies, Boston, MA, April 29, 2012.
* Includes U.S. studies only.

Response to a Challenge Dose of Vaccine

To assess vaccine response in remotely vaccinated HCP, a challenge dose of HepB vaccine can be used to determine the presence of vaccine-induced immunologic memory through generation of an anamnestic response. The term "booster dose" has been used to refer to a dose of HepB vaccine administered after a primary vaccination series to provide rapid protective immunity against significant infection (i.e., infection resulting in serologic test results positive for HBV and/or clinically significant disease) (*40*). Among persons vaccinated 5.9–17.5 years previously at age <1 year who have anti-HBs levels <10 mIU/mL, approximately 60.0%–97.4% showed a response to a single challenge dose of HepB vaccine demonstrating protective levels of anti-HBs ≥10 mIU/mL (*50–54*). Among persons vaccinated 9–22 years previously at age ≥1 year who have anti-HBs levels <10 mIU/mL, 69.2%–96.4% showed a response to a single challenge dose of HepB vaccine demonstrating protective levels of anti-HBs ≥10 mIU/mL (*41*,*54*,*60*,*62*). The proportion of responders to a challenge dose might vary by population and age at receiving the primary HepB series. HCP with a response ≥10 mIU/mL following a challenge dose are considered protected, regardless of future declines in anti-HBs. Conclusions about the response to a challenge dose are made on the basis of relatively few studies and might change as additional data become available.

Duration of Vaccine Protection among Responders

Among immunocompetent HepB vaccine responders, studies suggest protection against acute symptomatic and chronic hepatitis B infection persists for ≥22 years (*9*,*15*,*40*). Three cohort studies that monitored 1,006 subjects for ≥20 years have been informative (*41*,*63*,*64*). In two of the cohorts from areas with high HBV endemicity, new chronic HBV infections were documented in 0.8% (0 and 1.0%) of 513 (109 and 404) subjects, respectively, who responded or presumably responded to HepB vaccination starting at birth (*63*,*64*). Approximately 20% of subjects had evidence of natural boosting of anti-HBs, presumably from exposure to HBV (*63*,*64*). A third cohort of 493 subjects in an area with intermediate HBV endemicity received HepB vaccination between ages 6 months and ≥50 years (*41*). Among vaccine responders, no acute or chronic HBV was detected, although 1% of subjects experienced subclinical HBV infection without chronic infection during ≥20 years of follow-up (*41*). The significance of subclinical breakthrough HBV infection without chronic HBV and transient HBV infection is unknown.

HepB Vaccination and Postvaccination Testing among HCP

The Bloodborne Pathogens Standard issued in 1991 by OSHA mandates that HepB vaccination be made available at the employer's expense to employees who have reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that might result from the performance of an employee's duties (*27*). HepB vaccination coverage data obtained through the National Health Interview Survey (NHIS) in 2011 demonstrated ≥3-dose coverage of 63.8% among HCP aged ≥19 years (*23*). NHIS 2010 data demonstrated ≥3-dose coverage of 74% for HCP with direct patient contact, and 46% for HCP without direct patient contact (*65*), substantially below the *Healthy People 2020* target of 90% HepB vaccination coverage among HCP (objective no. IID-15.3) (*66*).

Postvaccination serologic testing for anti-HBs is recommended 1–2 months after the last vaccine dose for HCP at risk for occupational percutaneous or mucosal exposures (*11*). During 2012, a survey was administered to 389 California acute care hospitals or centers comprised of more than one hospital to assess current practices for ensuring HCP protection against HBV. Hospitals were identified from a listserv of 580 infection prevention and employee health staff (*67*). Responses

were obtained from 153 listserv subscribers, comprising approximately 39% of hospitals (*67*). Responding hospitals were not representative of all hospitals in the United States (*67*). Of the 153 responding hospitals, most (92 [60.1%]) were nongovernment not-for-profit community hospitals, followed by investor-owned (for-profit) community hospitals (32 [20.9%]), and state and local government community hospitals (13 [8.5%]) (*67*). One fourth (37 [24.2%]) were teaching hospitals (*67*). Responding hospitals had between 35 and 15,421 (median: 1,000) HCP with reasonably anticipated risk for blood or body fluid exposure (*67*). The majority of respondents (71.9%) indicated current practices at their institution consist of measuring anti-HBs on a pre-exposure basis, followed by HepB vaccination if anti-HBs is <10 mIU/mL (*67*). A smaller proportion of respondents (15.7%) indicated their institution follows an approach relying upon postexposure management (*67*). Postvaccination anti-HBs results were known for approximately 69% of HCP at these facilities (*67*).

Revaccination for Vaccine Nonresponse

Revaccination with ≥1dose of HepB vaccine for nonresponse subsequent to the primary series increases the proportion of persons achieving vaccine-induced seroprotection (*15*). Among 178 persons with occupational risk for HBV infection, 47% of those without protective antibody levels after a primary vaccination series developed vaccine-induced seroprotection after one additional dose of HepB vaccine (*6*). An estimated 42% of 86 persons without protective anti-HBs levels after the first revaccination dose and who received 2 additional doses developed protective levels of anti-HBs representing a cumulative response rate of 69% among initial nonresponders after 3 revaccination doses (*6*). Persons who have measurable but low (i.e., 1–9 mIU/mL) levels of anti-HBs after the initial series have better response to revaccination than persons who have no measurable anti-HBs (*36*,*62*,*68*,*69*).

Single dose revaccination with a higher dosage has not been demonstrated to increase the proportion of healthy adult nonresponders (*70*,*71*) or previous responders revaccinated as part of a clinical trial (*62*) who achieve vaccine-induced seroprotection. However, 3-dose revaccination with a higher dosage (40 μg) did improve the proportion of nonresponders achieving anti-HBs levels of ≥10 mIU/mL in one study (100% among 17 persons receiving 40 μg dose versus 62.5% among 18 persons receiving 10 μg dose, p = 0.015, Fisher's exact test) (*70*). Revaccination with >3 doses (i.e., >6 total doses) is not recommended (*11*).

HBV Infection among Vaccinated and Unvaccinated HCP

From 1983 to 2010, the number of HBV infections among HCP declined approximately 98%, from an estimated 17,000 infections to 263 acute HBV infections (considering that occupational history was assessed for 43.6% of cases and using a correction factor of 10.5 to account for underreporting and asymptomatic infection) (*10*). The decrease in acute HBV infection among HCP probably resulted from routine pre-exposure HepB vaccination and reduced risk for exposure through improvements in infection-control practices (*28*,*72*,*73*).

Although few studies have evaluated the vaccination history of persons with acute hepatitis B (*74*), some cases of acute hepatitis B and chronic HBV infection can be expected in unvaccinated persons and among vaccine nonresponders. During 2005–2010, a total of 203 cases of persons with acute hepatitis B among HCP were reported to CDC's National Notifiable Diseases Surveillance System (NNDSS) (*75*). Six of 17 patients with information on the development of chronic HBV infection developed chronic HBV infection (*75*). Follow-up of 67 (76.1%) of 88 HCP initially reported as having a positive or unknown HepB vaccination history indicated that 35 HCP reported vaccination with ≥3 HepB vaccine doses (seven had documentation to support the reported vaccination history) (*75*). Among the 35 HCP reporting vaccination with ≥3 HepB vaccine doses, one HCP demonstrated an immune response (i.e., anti-HBs ≥10 mlU/mL); the remaining 34 were nonresponders or had an unknown response status (*75*). Four of eight HCP with ≥3-dose HepB vaccination with information developed chronic HBV infection; none of the four had complete documentation of ≥3 HepB vaccine doses (*75*). Postvaccination serologic testing was available for only one of seven HCPs with documentation of ≥3-doses of HepB vaccine; this HCP had an anti-HBs level <10 mIU/mL after 4 doses of vaccine (*75*).

Although reported data did not enable identification of the modes of transmission or information on receipt of postexposure prophylaxis, 28 (16.7%) of 168 HCP for whom data were available reported an accidental stick or puncture with a needle or other object contaminated with blood during the 6 weeks through 6 months before illness, possibly representing occupational acquisition of infection (*75*). Unrecognized exposures might have resulted in HBV infections among HCP who did not report an exposure (*2*). Other risk factors for HBV exposure in the 6 weeks through 6 months before illness (i.e., injection drug use, men who have sex with men, multiple sex partners, contact with a hepatitis B case, dialysis patient, receipt of blood transfusion, surgery, acupuncture, and tattoo receipt) were present among 121 (59.6%) of 203 HCP, possibly suggesting their exposures were not occupational (*75*).

Managing HCP Vaccination and Serologic Test Results

Immunization information systems (IIS) provide consolidated vaccination histories for use by vaccination providers in

determining appropriate vaccinations (*76*). Accessing IIS for vaccination records might decrease unnecessary revaccination among HCP who no longer have records of HepB vaccination. IIS do not accept postvaccination anti-HBs test results (*77*). To reduce the cost and inconvenience of repeat anti-HBs testing when HCP are employed by different health-care facilities, CDC recommends that institutions consider systems for long-term management of anti-HBs and other hepatitis B serologic test results. Mechanisms for tracking vaccination and hepatitis B serologic test results in health information technology products could also reduce cost and inconvenience of repeat anti-HBs testing.

Passive Prophylaxis of HBV Exposed Health Care Personnel

Hepatitis B immune globulin

Hepatitis B immune globulin (HBIG) provides passive anti-HBs and temporary (i.e., 3–6 months) protection (*15*). HBIG is prepared from human plasma known to contain a high titer of anti-HBs. HBIG is typically used together with HepB vaccine for postexposure prophylaxis (*15*). For persons who do not respond to HepB vaccine, HBIG administered alone is the primary method of protection after HBV exposure (*15*). The standard adult dose of HBIG is 0.06 mL/kg. HBIG is administered by intramuscular injection; an appropriate muscle mass (i.e., deltoid or gluteal) should be chosen in which to deliver the large volume of HBIG required and a needle length appropriate for the HCP's size should be used. HBIG can be administered simultaneously with HepB vaccine but at a different injection site (*15*).

Safety

The plasma from which HBIG is prepared is screened for HBsAg, HCV, and HIV (*15*). The process used to prepare HBIG inactivates HBV, HCV, and HIV from the final product. No evidence exists that HBV, HCV, or HIV has ever been transmitted by HBIG thar is commercially available in the United States (*15*).

Serious adverse effects from HBIG, when administered as recommended, are rare (*1*). Local pain and tenderness at the injection site, urticaria, and angioedema might occur; anaphylactic reactions, although rare, have been reported following the injection of human immune globulin (IG) preparations (*1*). HBIG is not contraindicated for pregnant (*1*,*78*) or lactating women (*1*).

Efficacy

The effectiveness of HBIG and HepB vaccine in various postexposure settings has been evaluated by prospective studies. For perinatal exposure to a mother positive for both HBsAg and HBeAg, a regimen combining HBIG and initiation of the HepB vaccine series at birth is 85%–95% effective in preventing HBV infection (*79*,*80*). Regimens involving either multiple doses of HBIG alone or the HepB vaccine series alone are 70%–75% effective in preventing HBV infection when administered shortly after exposure (*81*). In the occupational setting, multiple doses of HBIG starting within 1 week following percutaneous exposure to HBsAg-positive blood provide an estimated 75% protection from HBV infection (*82*–*86*). Administration of HBIG might prolong the incubation period of HBV infection among persons who develop infection (*82*,*85*,*87*,*88*). A comparison of the postexposure efficacy of the combination of HBIG and the HepB vaccine series or HBIG alone has not been evaluated in the occupational setting (*1*). Whether the increased efficacy of HBIG added to HepB vaccine observed in the perinatal setting, compared with HBIG alone, applies to adults exposed occupationally remains unknown.

Cost-Effectiveness Considerations

To examine the cost-effectiveness of various strategies for assessing HCP protection from hepatitis B, two economic models that yielded calculations of the incremental cost per quality-adjusted life-year (QALY) saved were developed. One model represented an approach in which anti-HBs is measured on a pre-exposure basis, and HCP with anti-HBs <10 mIU/mL receive an additional dose of HepB vaccine, followed by repeat anti-HBs measurement. If anti-HBs remains <10 mIU/mL after the first revaccination dose, the HCP receives two additional revaccination doses of HepB vaccine followed by repeat anti-HBs measurement. Another model represented a postexposure management approach; at the time of exposure, the HCP is tested for anti-HBs and the source patient is tested simultaneously for HBsAg, and postexposure prophylaxis would be administered on the basis of these results. Results from the two models were compared. A decision-tree analysis was used to combine all parameters and calculate the total intervention costs and probability of infection. In addition, HBV infection-related costs and QALY loss (accounting for acute and asymptomatic infections and a 6% probability of chronic infection) were determined from an existing model (*89*) and were considered for the HCP's remaining lifetime. The intervention time frame included a 1-year analysis and a multiyear analysis covering up to 10 years of exposure. A 3% annual discount rate was used, and all final cost figures were converted to 2010 U.S. dollars using the Medical Consumer Price Index.

The baseline cost-effectiveness models assumed that an ideal 95% of HCP have initial and sustained protection against HBV infection after a primary ≥3-dose HepB vaccine series,

irrespective of the presence of detectable anti-HBs. Ninety-five percent protection was derived from the proportion of persons aged <40 years, including term newborns that have measurable anti-HBs ≥10 mIU/mL soon after a primary vaccination series. Approximately 18–25 years after vaccination, approximately 20% of HCP (vaccinated at age <1 year) or approximately 80% of HCP (vaccinated at age ≥1 year) retain anti-HBs ≥10 mIU/mL. The model did not account for unrecognized exposures, as probability data for unrecognized exposures are not available, or suboptimal vaccine coverage that exists among HCP.

For pre-exposure anti-HBs testing followed by revaccination and retesting, if necessary, compared with doing nothing, the incremental cost per QALY saved was $4,542,467 for trainees and $3,149,183 for nontrainees at year one, and decreased to $893,619 and $796,140, respectively, over 10 years. This approach is expected to result in 3.7 and 1.6 visits to occupational health for trainees and nontrainees, respectively. The expected number of infections is 0.7 per 100,000 and 0.4 per 100,000 for trainees and nontrainees, respectively. For an approach relying upon postexposure management, compared with doing nothing, the incremental cost per QALY saved was $2,270,801 for trainees and $1,610,998 for nontrainees at year one, and decreased to $917,859 and $1,114,364 respectively, over 10 years. The expected number of infections is 3.0 per 100,000 and 1.7 per 100,000 for trainees and nontrainees, respectively. Although an approach relying upon postexposure management might be less costly per QALY saved initially for many institutions, pre-exposure anti-HBs testing with possible revaccination becomes more cost-effective compared with a postexposure approach over time.

Sensitivity analyses demonstrated that cost-effectiveness improves in settings where a greater proportion of source patients are HBsAg-positive and among HCP with higher risk for exposure (e.g., surgeons). Cost-effectiveness can change as new antivirals become available for treatment of HBV infection. Vaccinating previously unvaccinated HCP trainees followed by postvaccination serologic testing, compared with doing nothing, has an incremental cost per QALY saved of $374,646 at year one and $51,537 over 10 years, accounting for direct costs to the health-care system and direct medical costs of hepatitis B-related illness and complications.

Recommendations

Pre-Exposure Management

Education and Infrastructure

At the time of hire or matriculation, health-care providers and health-care institutions should provide training to HCP to improve recognition and encourage timely reporting of blood and body fluid exposures. The possibility that the postexposure evaluation will cause the HCP to have time lost from work should not be a barrier to reporting. Institutions should ensure that HCP have rapid access to postexposure testing and prophylaxis, including HBIG and HepB vaccine.

Serologic Testing for HBV Infection

Testing unvaccinated HCP for HBV infection is not generally indicated for persons being evaluated for hepatitis B protection because of occupational risk. Prevaccination serologic testing is indicated for all persons born in geographic regions with HBsAg prevalence of ≥2% (e.g., much of Eastern Europe, Asia, Africa, the Middle East, and the Pacific Islands) and certain indigenous populations from countries with overall low HBV endemicity (<2%); persons with behavioral exposures to HBV (e.g., men who have sex with men and past or current injection drug users); persons receiving cytotoxic or immunosuppressive therapy; and persons with liver disease of unknown etiology.

HBV endemicity (HBsAg prevalence) can be described as low (<2%), moderate (2%–<8%), and high (≥8%). Because certain persons might have been infected with HBV before they received HepB vaccination, HBsAg testing is recommended regardless of vaccination history for persons born in geographic regions with HBsAg prevalence of ≥2%, U.S.-born persons not vaccinated as infants whose parents were born in regions with high HBV endemicity (HBsAg prevalence) (≥8%), persons who received HepB vaccination as adolescents or adults after the initiation of risk behaviors (*12*), and persons who are HIV-positive or who receive hemodialysis (*11*).

Testing HCP at risk for HBV infection should consist of a serologic assay for HBsAg, in addition to either anti-HBc or anti-HBs (*11*,*12*). For unvaccinated HCP at risk for previous HBV infection, blood should be drawn for testing before the first dose of vaccine is administered.

Vaccination

All HCP whose work-, training-, and volunteer-related activities involve reasonably anticipated risk for exposure to blood or body fluids should be vaccinated with a complete, ≥3-dose HepB vaccine series. OSHA mandates that vaccination be available for employees within 10 days of initial assignment (*27*). HCP trainees should complete the series before the potential for exposure with blood or body fluids, when possible, as higher risk has been reported during professional training (e.g., residency training).

Incompletely vaccinated HCP should receive additional dose(s) to complete the vaccine series (*15*). The vaccine series does not need to be restarted for HCP with an incomplete

series; however, minimum dosing intervals should be heeded (*15*). Minimum dosing intervals are 4 weeks between the first and second dose, 8 weeks between the second and third dose, and 16 weeks between the first and third dose (*15*).

HCP lacking documentation of HepB vaccination should be considered unvaccinated (when documentation for HepB vaccine doses is lacking) or incompletely vaccinated (when documentation for some HepB vaccine doses is lacking) and should receive additional doses to complete a documented HepB series. Health-care institutions are encouraged to seek documentation of "missing" HepB doses in IIS, when feasible, to avoid unnecessary vaccination.

OSHA mandates that HCP who refuse HepB vaccination sign a declination statement (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10052&p_table=STANDARDS). HCP refusing HepB vaccination can obtain vaccination at a later date at no expense if the HCP is still covered under OSHA's Bloodborne Pathogens Standard. Health-care institutions should encourage HepB vaccination among HCP to improve HBV protection and to achieve the *Healthy People 2020* target of 90% vaccination (*66*).

Postvaccination Serologic Testing

HCP who have written documentation of a complete, ≥3-dose HepB vaccine series and subsequent postvaccination anti-HBs ≥10 mIU/mL are considered hepatitis B immune. Immunocompetent persons have long-term protection against HBV and do not need further periodic testing to assess anti-HBs levels (Figure 6).

All HCP recently vaccinated or recently completing HepB vaccination who are at risk for occupational blood or body fluid exposure should undergo anti-HBs testing. Anti-HBs testing should be performed 1–2 months after administration of the last dose of the vaccine series when possible. HCP with documentation of a complete ≥3-dose HepB vaccine series but no documentation of anti-HBs ≥10 mIU/mL who are at risk for occupational blood or body fluid exposure might undergo anti-HBs testing upon hire or matriculation. Testing should use a quantitative method that allows detection of the protective concentration of anti-HBs (≥10 mIU/mL) (e.g., enzyme-linked immunosorbent assay [ELISA]).

- Completely vaccinated HCP with anti-HBs ≥10 mIU/mL are considered hepatitis B immune. Immunocompetent persons have long-term protection and do not need further periodic testing to assess anti-HBs levels.
- Completely vaccinated HCP with anti-HBs <10 mIU/mL should receive an additional dose of HepB vaccine, followed by anti-HBs testing 1–2 months later. HCP whose anti-HBs remains <10 mIU/mL should receive 2 additional vaccine doses (usually 6 doses total), followed by repeat anti-HBs testing 1–2 months after the last dose. Alternatively, it might be more practical for very recently vaccinated HCP with anti-HBs <10 mIU/mL to receive 3 consecutive additional doses of HepB vaccine (usually 6 doses total), followed by anti-HBs testing 1–2 months after the last dose.

Standard Precautions and Advising HCP to Report Exposures

All HCP should adhere to infection-control guidelines and follow Standard Precautions (*90*), including the use of engineering and work-practice controls, to reduce the risk for blood or body fluid exposure. All HCP, including those who have demonstrated protection against HBV, should be advised to immediately report blood or body fluid exposures to occupational health for evaluation of the appropriate measures to prevent transmission of bloodborne pathogens (including HIV, hepatitis C, and hepatitis B).

Postexposure Management

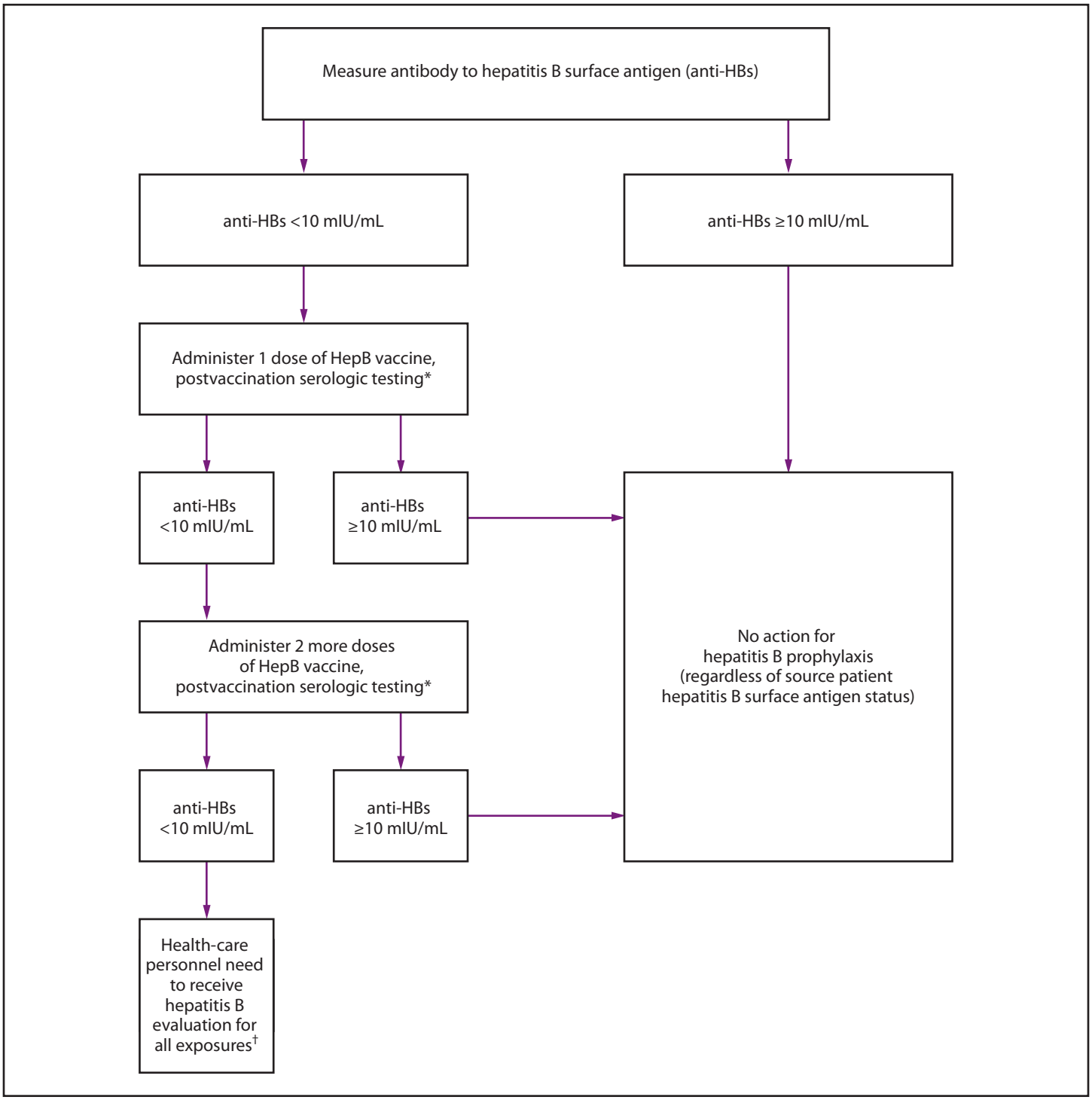
Initial Postexposure Management

Wounds and skin sites that have been in contact with blood or body fluids should be washed with soap and water; mucous membranes should be flushed with water. Using antiseptics (e.g., 2%–4% chlorhexidine) for wound care or expressing fluid by squeezing the wound further have not been shown to reduce the risk for HBV transmission; however, the use of antiseptics is not contraindicated. The application of caustic agents (e.g., bleach) or the injection of antiseptics or disinfectants into the wound is not recommended.

Procedures should be followed for testing known source persons, including obtaining informed consent, in accordance with applicable laws. Source patients determined to be HBsAg-positive should be referred for appropriate management and should be reported to the state or local health department. When a source patient is unknown (e.g., as occurs from a puncture with a needle in the trash), the exposed HCP should be managed as if the source patient were HBsAg-positive. Testing needles and other sharp instruments implicated in an exposure is not recommended, regardless of whether the source patient is known or unknown. The reliability and interpretation of findings in such circumstances are unknown, and testing could be hazardous to persons handling the sharp instrument. Exposures involving human bites should be managed with the knowledge that both the person being bitten and the person who engaged in biting were potentially exposed.

Institutions should ensure that HCP have timely access to postexposure management and prophylaxis, including

FIGURE 6. Pre-exposure evaluation for health-care personnel previously vaccinated with complete, ≥3-dose HepB vaccine series who have not had postvaccination serologic testing*



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

* Should be performed 1–2 months after the last dose of vaccine using a quantitative method that allows detection of the protective concentration of anti-HBs (≥10 mIU/mL) (e.g., enzyme-linked immunosorbent assay [ELISA]).

† A nonresponder is defined as a person with anti-HBs <10 mIU/mL after ≥6 doses of HepB vaccine. Persons who do not have a protective concentration of anti-HBs after revaccination should be tested for HBsAg. If positive, the person should receive appropriate management or vaccination.

TABLE 2. Postexposure management of health-care personnel after occupational percutaneous and mucosal exposure to blood and body fluids, by health-care personnel HepB vaccination and response status

Health-care personnel status	Postexposure testing		Postexposure prophylaxis		Postvaccination serologic testing†
	Source patient (HBsAg)	HCP testing (anti-HBs)	HBIG*	Vaccination	
Documented responder§ after complete series (≥3 doses)	**No action needed**				
Documented nonresponder¶ after 6 doses	Positive/unknown	—**	HBIG x2 separated by 1 month	—	No
	Negative	**No action needed**			
Response unknown after 3 doses	Positive/unknown	<10mIU/mL**	HBIG x1	Initiate revaccination	Yes
	Negative	<10mIU/mL	None		
	Any result	≥10mIU/mL	**No action needed**		
Unvaccinated/incompletely vaccinated or vaccine refusers	Positive/unknown	—**	HBIG x1	Complete vaccination	Yes
	Negative	—	None	Complete vaccination	Yes

Abbreviations: HCP = health-care personnel; HBsAg = hepatitis B surface antigen; anti-HBs = antibody to hepatitis B surface antigen; HBIG = hepatitis B immune globulin.

* HBIG should be administered intramuscularly as soon as possible after exposure when indicated. The effectiveness of HBIG when administered >7 days after percutaneous, mucosal, or nonintact skin exposures is unknown. HBIG dosage is 0.06 mL/kg.

† Should be performed 1–2 months after the last dose of the HepB vaccine series (and 4–6 months after administration of HBIG to avoid detection of passively administered anti-HBs) using a quantitative method that allows detection of the protective concentration of anti-HBs (≥10 mIU/mL).

§ A responder is defined as a person with anti-HBs ≥10 mIU/mL after ≥3 doses of HepB vaccine.

¶ A nonresponder is defined as a person with anti-HBs <10 mIU/mL after ≥6 doses of HepB vaccine.

** HCP who have anti-HBs <10mIU/mL, or who are unvaccinated or incompletely vaccinated, and sustain an exposure to a source patient who is HBsAg-positive or has unknown HBsAg status, should undergo baseline testing for HBV infection as soon as possible after exposure, and follow-up testing approximately 6 months later. Initial baseline tests consist of total anti-HBc; testing at approximately 6 months consists of HBsAg and total anti-HBc.

HBIG and HepB vaccine. For exposed HCP thought to be susceptible to HBV infection, HBIG and HepB vaccine should be administered as soon as possible after an exposure when indicated. The effectiveness of HBIG when administered >7 days after percutaneous, mucosal, or nonintact skin exposures is unknown. HBIG and HepB vaccine can be administered simultaneously at separate injection sites.

Anti-HBs testing of HCP who received HBIG should be performed after anti-HBs from HBIG is no longer detectable (6 months after administration) (*11*). Anti-HBs testing should be performed using a method that allows detection of the protective concentration of anti-HBs (≥10 mIU/mL) (Table 2).

Managing Vaccinated HCP

For vaccinated HCP (who have written documentation of a complete, ≥3-dose HepB vaccine series) with subsequent documented anti-HBs ≥10 mIU/mL, testing the source patient for HBsAg is unnecessary. No postexposure management for HBV is necessary, regardless of the source patient's HBsAg status.

For vaccinated HCP (who have written documentation of HepB vaccination) with anti-HBs <10 mIU/mL after two complete, ≥3-dose HepB vaccine series, the source patient should be tested for HBsAg as soon as possible after the exposure. If the source patient is HBsAg-positive or has unknown HBsAg status, the HCP should receive 2 doses of HBIG (*1*,*11*). The first dose should be administered as soon as possible after the exposure, and the second dose should be administered 1 month later. If the source patient is HBsAg-negative, neither HBIG nor HepB vaccine is necessary.

For vaccinated HCP (who have written documentation of a complete, ≥3-dose HepB vaccine series) without previous anti-HBs testing, the HCP should be tested for anti-HBs and the source patient (if known) should be tested for HBsAg as soon as possible after the exposure. Testing the source patient and the HCP should occur simultaneously; testing the source patient should not be delayed while waiting for the HCP anti-HBs test results, and likewise, testing the HCP should not be delayed while waiting for the source patient HBsAg results.

- If the HCP has anti-HBs <10 mIU/mL and the source patient is HBsAg-positive or has unknown HBsAg status, the HCP should receive 1 dose of HBIG and be revaccinated as soon as possible after the exposure. The HCP should then receive the second 2 doses to complete the second HepB vaccine series (6 doses total when accounting for the original 3-dose series) according to the vaccination schedule. To document the HCP's vaccine response status for future exposures, anti-HBs testing should be performed 1–2 months after the last dose of vaccine.
- If the HCP has anti-HBs <10 mIU/mL and the source patient is HBsAg-negative, the HCP should receive an additional HepB vaccine dose, followed by repeat anti-HBs testing 1–2 months later. HCP whose anti-HBs remains <10 mIU/mL should undergo revaccination with 2 more doses (6 doses total when accounting for the original 3-dose series). To document the HCP's vaccine response status for future exposures, anti-HBs testing should be performed 1–2 months after the last dose of vaccine.
- If the HCP has anti-HBs ≥10 mIU/mL at the time of the exposure, no postexposure HBV management is necessary, regardless of the source patient's HBsAg status.

Managing HCP Who Lack Documentation of Vaccination, are Unvaccinated or Incompletely Vaccinated

For unvaccinated or incompletely vaccinated HCP (including those who refused vaccination), the source patient should be tested for HBsAg as soon as possible after the exposure. Testing unvaccinated or incompletely vaccinated HCP for anti-HBs is not necessary and is potentially misleading, because anti-HBs ≥10 mIU/mL as a correlate of vaccine-induced protection has only been determined for persons who have completed an approved vaccination series (*15*,*42*).

- If the source patient is HBsAg-positive or has unknown HBsAg status, the HCP should receive 1 dose of HBIG and 1 dose of HepB vaccine administered as soon as possible after the exposure. The HCP should complete the HepB vaccine series according to the vaccination schedule. To document the HCP's vaccine response status for future exposures, anti-HBs testing should be performed approximately 1–2 months after the last dose of vaccine. Because anti-HBs testing of HCP who received HBIG should be performed after anti-HBs from HBIG is no longer detectable (6 months after administration), it will likely be necessary to defer anti-HBs testing for a period longer than 1–2 months after the last vaccine dose.
  - HCP with anti-HBs ≥10 mIU/mL after receipt of the primary vaccine series are considered immune. Immunocompetent persons have long-term protection and do not need further periodic testing to assess anti-HBs levels.
  - HCP with anti-HBs <10 mIU/mL after receipt of the primary series should be revaccinated. For these HCP, administration of a second complete 3-dose series on an appropriate schedule, followed by anti-HBs testing 1–2 months after the third dose, usually is more practical than conducting serologic testing after each additional dose of vaccine. To document the HCP's vaccine response status for future exposures, anti-HBs testing should be performed 1–2 months after the last dose of vaccine.
- If the source patient is HBsAg-negative, the HCP should complete the HepB vaccine series according to the vaccination schedule. To document the HCP's vaccine response status for future exposures, anti-HBs testing should be performed approximately 1–2 months after the last dose of vaccine.
  - HCP with anti-HBs ≥10 mIU/mL after receipt of the primary vaccine series are considered immune. Immunocompetent persons have long-term protection and do not need further periodic testing to assess anti-HBs levels.
  - HCP with anti-HBs <10 mIU/mL after receipt of the primary series should be revaccinated. For these HCP, administration of a second complete 3-dose series on an appropriate schedule, followed by anti-HBs testing 1–2 months after the third dose, usually is more practical than conducting serologic testing after each additional dose of vaccine. To document the HCP's vaccine response status for future exposures, anti-HBs testing should be performed 1–2 months after the last dose of vaccine.

Testing of HCP Exposed to an HBsAg-Positive or Unknown Source

HCP who have anti-HBs <10 mIU/mL, or who are unvaccinated or incompletely vaccinated, and who sustain a percutaneous, mucosal, or nonintact skin exposure to a source patient who is HBsAg-positive or has unknown HBsAg status should undergo baseline testing for HBV infection as soon as possible after the exposure, and follow-up testing approximately 6 months later. Testing immediately after the exposure should consist of total anti-HBc, and follow-up testing approximately 6 months later should consist of HBsAg and total anti-HBc.

HCP exposed to a source patient who is HBsAg-positive or has unknown HBsAg status do not need to take special precautions to prevent secondary transmission during the follow-up period; however, they should refrain from donating blood, plasma, organs, tissue, or semen (*1*). The exposed HCP does not need to modify sexual practices or refrain from

becoming pregnant (*1*). If an exposed HCP is breast feeding, she does not need to discontinue (*1*). No modifications to an exposed HCP's patient-care responsibilities are necessary to prevent transmission to patients based solely on exposure to a source patient who is HBsAg-positive or has unknown HBsAg status.

Vaccine Nonresponders

Vaccinated HCP whose anti-HBs remains <10 mIU/mL after revaccination (i.e., after receiving a total of 6 doses) should be tested for HBsAg and anti-HBc to determine infection status. Those determined not to be HBV infected (vaccine nonresponders) should be considered susceptible to HBV infection. No specific work restrictions are recommended for vaccine nonresponders (*91*).

Documentation

Health-care institutions should maintain records, ideally electronic records that are easily retrievable following exposures, of documented vaccination histories and serologic test results for reference in managing occupational exposures, and to provide to other health-care institutions if requested by the HCP. The vaccination information should be entered into an IIS accepting records from adult vaccination, if available. HCP should be provided a copy of HepB vaccination and anti-HBs testing results and encouraged to keep them with their personal health records so they can readily be made available to future employers.

HCP with HBV Infection

HCP who are positive for HBsAg should be counseled how to prevent HBV transmission to others and referred for further evaluation (*92*). Those who perform exposure-prone procedures should be advised regarding the procedures they can perform safely as per updated CDC recommendations for the management of HBsAg-positive health-care providers and students (*11,13*). Chronic hepatitis B infection in itself should not preclude the practice or study of medicine, surgery, dentistry, or allied health professions (*13*).

Future Studies

National surveillance systems to accurately assess the burden of hepatitis B among HCP and health-care facility databases tracking occupational exposures among HCP are important for monitoring the changing epidemiology of occupationally acquired HBV infections and other bloodborne pathogens. Systems and databases could ideally be electronically linked to employee health records and should include results that identify HepB vaccine responders and nonresponders, the nature and HBV status of the exposure source and postexposure management, and the HCP's anti-HBs level. Appropriate safeguards should be in place to protect the privacy of the health information. Data collection should be representative of HCP in a variety of settings (e.g., acute care, long-term care, and dialysis), including settings with frequent staff turnover. Studies assessing HBV transmission among all HCP exposed to an HBsAg-positive source, regardless of vaccination history or anti-HBs levels, approximately 6 months after an exposure will help to inform duration of vaccine protection. Surveillance activities for acute hepatitis B infection should continue to ascertain occupation among cases, in addition to HepB vaccination history. Long-term follow-up studies assessing disease incidence and duration of anti-HBs among persons vaccinated as infants and older adults, including persons who received booster doses subsequent to the primary vaccine series and persons from HBV-endemic areas, also might provide information on duration of vaccine-induced protection. Other subject areas that would benefit from research include efficacy and cost-effectiveness of antiviral agents for postexposure prophylaxis, immunogenicity of higher dosage or new vaccines for revaccinating vaccine nonresponders, and an examination of the future role of postexposure hepatitis B virus deoxyribonucleic acid (HBV DNA) testing.

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Disclosure of Competing Interests

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