

Editorial

Selection and Use of Vaccines for Healthcare Workers

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Exposure to multiple infectious agents with the potential for disease acquisition is a well-recognized risk for healthcare workers (HCWs).¹⁻¹⁵ Important infectious risks may be classified by their route of transmission and include airborne (eg, tuberculosis, influenza, varicella, measles), droplet (eg, pertussis, meningococcal infection, respiratory syncytial virus), skin contact (eg, ectoparasites, *Herpes simplex*, colonization with methicillin-resistant *Staphylococcus aureus*); contact with feces (eg, salmonellosis, hepatitis A virus [HAV], cryptosporidiosis); and parenteral or mucosal exposure to blood or contaminated body fluids (eg, hepatitis B, hepatitis C, human immunodeficiency virus).

Minimizing the risk of disease acquisition is based on strict adherence to three key recommended interventions: handwashing,¹⁶ rapid institution of appropriate isolation precautions for patients with known or suspected communicable diseases,¹⁷ and appropriate immunizations. Other important occupational health interventions include an accessible health service; periodic tuberculin skin tests; evaluation of ill employees with potential communicable diseases, with appropriate treatment and work restrictions; evaluation of employees following infectious disease exposures for postexposure prophylaxis and work restrictions; and education of employees, focusing on general infection control guidelines in addition to Occupational Safety and Health Administration-

mandated training in the prevention of exposure to bloodborne pathogens and tuberculosis.

General recommendations regarding vaccination of HCWs have been published by the Centers for Disease Control and Prevention (CDC),¹ the Advisory Committee for Immunization Practices,^{18,19} the American College of Physicians,²⁰ the American College of Pediatrics,²¹ and infectious disease experts.²²⁻²⁴ It is recommended that all HCWs be immune to mumps, measles, rubella, and varicella. All HCWs with potential exposure to blood or body fluids should be immune to hepatitis B. Influenza vaccine should be offered to all HCWs yearly. Detailed recommendations have been published regarding mumps,²⁵ measles,²⁶ rubella,²⁷ varicella,^{28,29} hepatitis B,³⁰ and influenza³¹ vaccines. Immunization of HCWs should be included by all healthcare facilities as part of a comprehensive occupational health program (Table 1). All new employees should receive a prompt review of their immunization status for vaccine-preventable diseases, and their immunization status also should be reviewed yearly. All HCWs should be included in these recommendations, including employees with direct patient-care responsibilities (eg, nurses, respiratory therapists, physical therapists), physicians, students, employees without direct patient-care responsibilities (eg, environmental service workers, security), contract workers, and

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TABLE 1
VACCINES STRONGLY RECOMMENDED FOR ALL HEALTHCARE WORKERS

Vaccine	Administration*	Demonstration of Immunity	Indication(s)*
Mumps	One dose SC [†] ; no booster	Born before 1957; physician-diagnosed disease [‡] ; positive serology [‡] ; prior receipt of vaccine [‡]	All HCWs
Measles	One dose SC [†] ; second dose at least 1 mo later	Born before 1957 [§] ; physician-diagnosed disease [‡] ; positive serology [‡] ; prior receipt of vaccine [‡] (two doses of live vaccine on or after first birthday)	All HCWs
Rubella	One dose SC [†] ; no booster	Born before 1957 ; physician-diagnosed disease [‡] ; positive serology [‡] ; prior receipt of vaccine [‡]	All HCWs
Varicella	Two doses SC, second dose 4-8 wk apart if ≥ 13 y of age	History of varicella-zoster virus infection; positive serology if history negative or uncertain [‡] ; prior receipt of two doses of vaccine, at least 1 mo apart [‡]	All HCWs
Hepatitis B [¶]	Two doses IM 4 wk apart; third dose 5 mo after second; booster not necessary	Positive serology ^{‡, #, **} ; prior receipt of three doses of vaccine with an appropriate schedule ^{‡, ††}	HCWs with potential blood or body fluid exposure
Influenza	Annual single dose IM with current (either whole- or split-virus) vaccine	Yearly immunization	All HCWs

Abbreviations: HCWs, healthcare workers; IM, intramuscularly; SC, subcutaneously.

* The package insert always should be consulted for specific recommendations regarding storage, administration, precautions, and contraindications.

[†] Measles-mumps-rubella vaccine preferred.

[‡] Written documentation should be required.

[§] During an outbreak, unvaccinated individuals born prior to 1957 should not be assumed to be immune and should be vaccinated.

^{||} Adults born before 1957 may be considered immune, except for women of childbearing age (consideration should be given to serologically testing or immunizing all individuals born before 1957).

[¶] May be indicated for postexposure prophylaxis.

[#] Immunity is indicated by an anti-HBsAg level of ≥ 10 mIU/mL.

^{**} Immunity should be assessed 1-2 mo after the third dose. If not immune, an additional three doses should be provided and immunity reassessed. If still not immune, provide hepatitis B immune globulin as postexposure prophylaxis when indicated.

^{††} If immunity was not assessed 1-6 months after completion of primary series and employee sustains an exposure to blood or a potentially contaminated fluid, the employee should be managed according to current CDC guidelines.

emergency medical personnel. Healthcare workers should be provided vaccines that are recommended for adults, including diphtheria-tetanus,³² and pneumococcal vaccines,³³ or they should be referred to their local medical provider. In special circumstances, healthcare workers or laboratory personnel should be offered immunization with other vaccines (Table 2), including polio,³⁴ quadrivalent meningococcal vaccine,^{35,36} bacille Calmette-Guérin,³⁷ rabies,³⁸ plague,³⁹ typhoid,⁴⁰ and vaccinia (smallpox).⁴¹

How should healthcare facilities decide which vaccines to provide at institutional expense to their employees? We believe that the following guidelines should be used. First, the vaccine should be demonstrated to be effective and safe in adults. Second, HCWs either should be at increased risk for acquiring the vaccine-preventable disease or, if infected, pose a

material risk of transmitting infection to patients. The risk of disease acquisition can be quantitated best by cohort studies demonstrating an increased relative risk of disease acquisition or by case-control studies, using an appropriate control population, that demonstrate an increased odds ratio for infection. Outbreak investigations demonstrate that disease acquisition is possible, but do not allow determination of the degree of population-based risk. Similarly, the risk of an infected HCW transmitting disease to patients may be quantitated by cohort studies using look-back designs, although almost all data are derived from outbreak investigations. Finally, if the first two criteria are fulfilled, the best mechanism of implementing an immunization program should be assessed. Key questions include the desirability of preimmunization or postimmunization serological screening, cost of

TABLE 2
VACCINES AVAILABLE FOR HEALTHCARE WORKERS AND LABORATORY PERSONNEL IN SPECIAL CIRCUMSTANCES

Vaccine	Administration*	Indication(s)*
BCG [†] (for tuberculosis)	One percutaneous dose; no booster recommended	HCWs in locales where (1) multidrug-resistant tuberculosis is prevalent, (2) a strong likelihood of infection exists, and (3) full implementation of infection control precautions have been inadequate in controlling the spread of infection
Meningococcal (A, C, Y, and W135)	One dose; need for boosters unknown	Not routinely indicated; may be useful during type-C outbreaks
Pneumococcal polysaccharide	One dose IM or SC; revaccination recommended for high-risk persons ≥ 6 years after first dose	Adults at increased risk of pneumococcal disease and its complications due to underlying health conditions; adults ≥ 65 years of age
Tetanus-diphtheria [‡]	If not previously primed, two doses IM 4 wk apart; third dose 6-12 mo after second dose; booster as young adult and at age 50	All adults; tetanus prophylaxis still required in wound management
Rabies [‡]	Primary: HDCV or RVA IM on days 0, 7, and 21 or 28, or HDCV ID on days 0, 7, and 21 or 28	Personnel working with rabies virus or infected animals in diagnostic or research activities; postexposure prophylaxis boosters may be required despite primary immunization
Polio	If not previously primed, two doses of eIPV, two doses SC given 4-8 wk apart, followed by a third dose at 6-12 mo after the second dose. If previously primed, one supplemental dose (no boosters needed)	HCWs in close contact with persons who may be excreting wild virus; laboratory personnel handling specimens that may contain wild virus
Typhoid	Depending on vaccine: one dose IM and booster doses every 2 y or two doses SC, 4 or more wk apart, with booster doses every 3 y if exposure continues or four oral doses on alternate days, with revaccination with entire 4-dose series every 5 y	Laboratory personnel who frequently work with <i>Salmonella typhi</i>
Vaccinia	One dose administered with a bifurcated needle, booster dose every 10 y	Personnel who directly handle cultures of, or animals contaminated with, recombinant vaccinia viruses or orthopox viruses (monkeypox, cowpox) that infect humans
Plague	Three doses IM; first dose 1.0 mL; second dose 0.2 mL 1-3 mo after first dose; third dose 0.2 mL 5-6 mo after second dose; boosters 0.2 mL at 1-2 y intervals if exposure continues	Laboratory personnel who frequently work with <i>Yersinia pestis</i>
Hepatitis A	Two doses IM either 6-12 mo apart (VAQTA, Merck & Co, Inc, West Point, PA) or 6 mo apart (Havrix, SmithKline Beecham Biologicals, Philadelphia, PA)	Not routinely indicated for HCWs; persons who work with HAV-infected primates or HAV in a laboratory setting

Abbreviations: BCG, bacille-Calmette-Guérin; eIPV, enhanced inactivated polio vaccine; HAV, hepatitis A virus; HCWs, healthcare workers; HDCV, human diploid cell vaccine; ID, intradermal; IM, intramuscularly; RVA, rabies vaccine adsorbed; SC, subcutaneously.

* The package insert always should be consulted for specific recommendations regarding storage, administration, precautions, and contraindications.

[†] BCG should be used only as a last resort after consultation with local or state health department.

[‡] May be indicated for postexposure prophylaxis.

implementing the program, and comparison of immunization versus other interventions to protect the HCW. Decision and cost-effectiveness analyses may be used to assess scientifically the utility of serological screening and to compare immunization versus other alternative interventions.

The hepatitis B and varicella vaccines clearly have met the previous criteria. Both the hepatitis B and varicella vaccines have been demonstrated to be safe and effective in adults. In the prevaccine era, HCWs were demonstrated to have a three- to fivefold greater risk for hepatitis B markers.^{42,43} Further, this increased risk was associated with the extent and duration of exposure to blood.^{43,44} For varicella, cohort studies have demonstrated frequent exposure of susceptible HCW workers to the varicella-zoster virus, with the need to furlough these employees. Reviews have summarized multiple instances of HCW-to-patient transmission of hepatitis B virus⁴⁵⁻⁴⁹ or varicella-zoster virus.²⁹ Cost-benefit analysis has demonstrated that providing varicella vaccine to susceptible employees is less expensive than furloughing exposed susceptible personnel during the incubation period of varicella.^{50,51}

HEPATITIS A IMMUNIZATION

Should HCWs be immunized against HAV? In this issue, Smith and colleagues⁵² provide the results of a cost-effectiveness study of HAV vaccination in HCWs. Using a Markov model based on the cohort of students currently in medical school, the cost per life-year saved would be \$58,000, and the cost per quality-adjusted life-year saved would be \$47,000. Should HAV vaccine therefore be provided routinely by medical schools or healthcare facilities? French and Belgian researchers have reported in letters that HCWs had higher-than-expected rates of seropositivity to HAV.^{53,54} However, three peer-reviewed studies have reported that HCWs had rates of HAV at or below levels in control populations,⁵⁵⁻⁵⁷ and a cohort study failed to find evidence of patient-to-patient transmission.⁵⁸ Multiple nosocomial outbreaks of HAV have been reported,⁵⁹⁻⁷⁴ most in one of the following settings. First, the source patient was not jaundiced, and hepatitis was inapparent at the time of hospitalization.^{61-65,67,68,71-74} Second, the HAV-infected patient was fecally incontinent or had diarrhea.^{61,63-65,67,68,73} Nosocomial HAV also has been associated with contaminated blood transfusions^{66,69,70} and contaminated food.^{59,60} Risk factors for HAV transmission to personnel have included activities that increase the risk of fecal-oral contamination, including caring for a person with unrecog-

nized HAV infection^{61-65,67,68,71-74}; sharing food, beverages, or cigarettes with patients, their families, or the staff^{64,68,69,74}; nail biting; handling bile without proper precautions⁷⁴; and not washing hands or wearing gloves when providing care to an infected patient.^{69,71,72,74}

PROGRAM EVALUATION

Hospital epidemiologists frequently use the basic tools of epidemiology, including cross-sectional, case-control, and cohort studies. Increasingly, they are using more sophisticated methods including meta-analysis, decision analysis, and cost analysis (cost-effectiveness, cost-utility, or cost-benefit analysis). Cost-analysis techniques require that the following data be available: true costs (rather than charges), frequency of all relevant outcomes, and costs associated with all outcomes including death. All costs must be standardized to a base year, and discounting should be applied to future costs. Discounting takes into account the fact that people are risk-averse and place higher value on immediate benefits compared with temporally remote benefits. Such analyses also should include a sensitivity analysis to determine if varying key assumptions affect the overall result; the use of utility functions (ie, worth the employee places on varying outcomes); and inclusion of quality adjustment for years of life lost. Standards have been published both for performing cost-effectiveness studies⁷⁵⁻⁷⁷ and for evaluating such studies.⁷⁸

Investigators who have evaluated single nosocomial outbreaks, and other commentators, have recommended that healthcare facilities should consider providing HAV vaccine to intensive-care unit staff⁷⁴ or to all HCWs.⁷⁹ Currently, the CDC recommends HAV vaccine only for population groups at increased risk for HAV, which is not understood to include HCWs.⁸⁰ We believe that immunization recommendations should be based on population-based studies and not analysis of case reports. Analyses such as that by Smith and colleagues⁵² are helpful and should be encouraged by policymakers. The use of HAV vaccine as a universal vaccine should be evaluated in a cost-effectiveness study. Given the age distribution of infection and the assumption by Smith and coworkers that HCWs have a low risk of infection, providing vaccine at an earlier age will only improve the cost-effectiveness of immunization. When combined hepatitis A and B vaccines become available, administration and compliance is likely to be improved. Although the cost-effectiveness of providing HAV vaccine to medical students is in range with many other public health interventions, the lack

of increased acquisition risk for HCWs does not justify providing HAV vaccine to HCWs at institutional expense. HCWs should consult with their local medical practitioner regarding the risks and benefits of optional vaccines, including HAV.

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