

ORIGINAL ARTICLE

Hepatitis B Vaccination Coverage Levels Among Healthcare Workers in the United States, 2002-2003

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BACKGROUND. Hepatitis B virus (HBV) infection is a well recognized risk for healthcare workers (HCWs), and routine vaccination of HCWs has been recommended since 1982. By 1995, the level of vaccination coverage among HCWs was only 67%.

OBJECTIVE. To obtain an accurate estimate of hepatitis B vaccination coverage levels among HCWs and to describe the hospital characteristics and hepatitis B vaccination policies associated with various coverage levels.

DESIGN. Cross-sectional survey.

METHODS. A representative sample of 425 of 6,116 American Hospital Association member hospitals was selected to participate, using probability-proportional-to-size methods during 2002-2003. The data collected included information regarding each hospital's hepatitis B vaccination policies. Vaccination coverage levels were estimated from a systematic sample of 25 HCWs from each hospital whose medical records were reviewed for demographic and vaccination data. The main outcome measure was hepatitis B vaccination coverage levels.

RESULTS. Among at-risk HCWs, 75% had received 3 or more doses of the hepatitis B vaccine, corresponding to an estimated 2.5 million vaccinated hospital-based HCWs. The coverage level was 81% among staff physicians and nurses. Compared with nurses, coverage was significantly lower among phlebotomists (71.1%) and nurses' aides and/or other patient care staff (70.9%; $P < .05$). Hepatitis B vaccination coverage was highest among white HCWs (79.5%) and lowest among black HCWs (67.6%; $P < .05$). Compared with HCWs who worked in hospitals that required vaccination only of HCWs with identified risk for exposure to blood or other potentially infectious material, hepatitis B vaccination coverage was significantly lower among HCWs who worked in hospitals that required vaccination of HCWs without identified risk for exposure to blood or other potentially infectious material (76.6% vs 62.4%; $P < .05$).

CONCLUSIONS. In the United States, an estimated 75% of HCWs have been vaccinated against hepatitis B. Important differences in coverage levels exist among various demographic groups. Hospitals need to identify methods to improve hepatitis B vaccination coverage levels and should consider developing targeted vaccination programs directed at unvaccinated, at-risk HCWs who have frequent or potential exposure to blood or other potentially infectious material.

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Occupational exposure to hepatitis B virus (HBV) is a well recognized risk for healthcare workers (HCWs).¹⁻⁶ Hepatitis B virus is transmitted through percutaneous or permucosal exposures to blood, which occur in the healthcare setting most often as needle sticks or other sharp device injuries, and HCWs sustain an estimated 400,000 percutaneous injuries annually.⁷ Occupational exposures to HBV have historically accounted for as many as 4.5% of the acute hepatitis B cases reported in the United States. In recent years this proportion has decreased to 0.5%.⁸

In 1982, a safe and effective vaccine against HBV infection was licensed for use in the United States, and the Advisory Committee on Immunization Practices recommended vac-

ination for HCWs who were occupationally exposed to blood.⁹ In 1991, the Occupational Safety and Health Administration issued a regulation requiring employers to offer hepatitis B vaccination free of charge to all employees with reasonably anticipated occupational exposure to blood or other potentially infectious material.¹⁰ Studies of hepatitis B vaccination coverage levels among hospital-based HCWs demonstrated coverage to be 51% in 1992 and 66.5% in 1995.^{11,12} The Centers for Disease Control and Prevention (CDC) has set a Healthy People 2010 goal of achieving 98% hepatitis B vaccination coverage among HCWs, providing a benchmark for the elimination of occupationally acquired HBV infection in the United States.¹³ We conducted a cross-sectional survey

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of a nationally representative sample of hospitals to estimate hepatitis B vaccination coverage levels among HCWs and to describe the hospital characteristics and hepatitis B vaccination policies associated with various vaccination coverage levels.

METHODS

Sampling and Data Collection

Hospitals that responded to the 1999 American Hospital Association (AHA) annual survey were eligible to participate in the current survey. The AHA is a professional organization that represents 6,116 hospitals in the United States; these hospitals employ 4.4 million HCWs.¹⁴ A sample of 7,900 HCWs employed at AHA hospitals was needed to calculate a precise point estimate for national hepatitis B vaccination coverage and to have 80% power to detect a 2% difference in vaccination coverage levels for different vaccination policy parameters and facility parameters. Given an anticipated hospital survey response rate of 80%, the necessary sample size was 10,625 HCWs. It was determined that each hospital selected for the survey could reasonably provide data on 25 HCWs, thus a sample of 425 hospitals was selected from the AHA database. The hospitals were chosen to reflect the known distribution of HCWs by facility type, with 85% of the HCW sample drawn from medical-surgical hospitals and 15% drawn from specialty hospitals. Probability-proportional-to-size sampling was used to select the hospitals, and the hospitals (ie, the primary sampling units) were divided into 10 strata. The 10 strata consisted of 5 strata of medical-surgical hospitals categorized according to the number of beds (0-99 beds, 100-199, 200-399, 400-699, and 700 or more), and an additional 5 strata made up of psychiatric hospitals, military hospitals, Veterans Administration hospitals, Indian Health Service hospitals, and all other nonpsychiatric hospitals. The probability of a hospital being selected for inclusion in the survey was proportional to the number of beds in the hospital and, therefore, to the number of HCWs employed.¹⁵⁻¹⁷

At each of the 425 hospitals selected for the survey, 2 questionnaires were mailed to an infection control or occupational health staff member for completion: one to collect data on hospital characteristics and vaccination policies and another to collect data on hepatitis B vaccination coverage levels among HCWs. Data collected for the questionnaire about hospital characteristics and policies included information about hepatitis B vaccination and testing policies and the characteristics of the hospital's vaccination tracking system. To estimate hepatitis B vaccination coverage levels, each participating hospital was requested to provide a sample of medical records from 25 HCWs. If the HCWs' medical records were kept electronically, hospital staff members were instructed to take a random sample from all records. If the HCWs' records were kept on paper, hospital staff members were instructed to use a random starting point from which

to systematically sample HCWs' medical records to obtain an unbiased sample. This method of sample selection has been used for numerous vaccination coverage surveys and is described elsewhere.^{12,15} Data collected from each record included demographic characteristics, job category, blood exposure category (ie, frequent exposure, potential exposure, or no exposure, as defined by job category and duty location), and number of doses of hepatitis B vaccine received. The study was approved by the institutional review board of the CDC. The CDC mailed the survey forms to eligible hospitals and coordinated their responses from 2002 through 2003.

Statistical Analysis

Statistical analyses were conducted with SAS software for Windows (SAS Institute) and Sudaan software (Research Triangle Institute). Sampling weights were calculated on the basis of the selection probabilities, adjusted for nonresponse, and applied to the hospital-level data and the HCW-level data such that the sum of their respective weights equaled the nationwide number of AHA hospitals and HCWs employed in those hospitals.

HCWs were considered to have been vaccinated if they had received 3 or more doses of hepatitis B vaccine. Analyses were restricted to HCWs who had frequent or potential exposure to blood or other potentially infectious material. If an HCW's medical record indicated a contraindication to vaccination or evidence of prior or current HBV infection, that HCW was excluded from analyses.

Hepatitis B vaccination coverage levels were calculated by dividing the weighted number of vaccinated HCWs by the weighted number of HCWs in that category (eg, type of hospital, job category, age, and race or ethnicity). Descriptive statistics were calculated, and 95% confidence intervals (CIs) were calculated with the Taylor expansion method. Proportions were compared by use of the χ^2 test.¹⁸ *P* values of .05 or less were considered statistically significant. Adjustments were not made for multiple comparisons.

A multivariate logistic regression model was fitted to the data to evaluate the association between an individual HCW's hepatitis B vaccination status (ie, "yes" or "no" with respect to whether an HCW had received at least 3 doses of vaccine) and both hospital policies and individual HCW characteristics. Hospital-level variables were repeated for HCWs in each hospital, since each HCW would be subject to the same policies in that specific hospital. Independent variables were included in the final model on the basis of either their epidemiologic plausibility, their statistical significance as assessed by the Wald χ^2 test statistic (variables with a *P* value of .05 or less were included), or their relative contribution to the fit of the model as assessed by the Hosmer-Lemeshow test.^{19,20} Associations were assessed by evaluating the adjusted odds ratios (ORs) calculated by the model.

TABLE 1. Hepatitis B Vaccination Coverage Levels Among Healthcare Workers (HCWs), by Hospital Characteristics

Variable	Prevalence of hepatitis B vaccination, % (95% CI)	Weighted no. of hospitals
Hospital type		
General medical surgical		
0-99 beds	74.0 (68.3-78.9)	2,017
100-199 beds	76.9 (71.8-81.3)	1,108
200-399 beds	75.5 (69.3-80.7)	1,094
400-699 beds	72.9 (67.1-78.0)	321
≥700 beds	78.2 (71.6-83.7)	74
Psychiatric	75.6 (60.4-86.3)	256
All other nonpsychiatric	68.7 (45.9-85.0)	486
Military	83.8 (66.1-93.2)	30
Veterans Administration	73.1 (61.3-82.3)	143
Indian Health Service	71.3 (56.9-82.3)	39
Metropolitan statistical area		
<100,000 population	76.0 (71.6-80.1)	2,667
≥100,000 population	74.7 (71.5-77.7)	2,899
Vaccination policy		
Requires vaccination for HCWs with regular or potential exposure to blood or other potentially infectious material		
Yes	75.0 (71.5-78.6)	3,411
No	75.1 (71.6-78.6)	2,273
Requires vaccination for HCWs without identified risk for exposure to blood or other potentially infectious material		
Yes	62.4 (50.8-73.8)	456
No	76.6 (74.1-79.1) ^a	5,189
Offers vaccine free of charge to HCWs without identified risk for exposure to blood or other potentially infectious material		
Yes	72.0 (68.5-75.6)	3,733
No	80.3 (76.9-83.7) ^a	1,963
Performs postvaccination testing of HCWs with regular exposure to blood or other potentially infectious material		
Yes	75.5 (72.9-78.0)	4,599
No	70.0 (55.2-84.8)	1,102
Provides HCWs with educational materials on the risks of hepatitis B and the benefits of vaccination		
Yes	75.0 (72.3-77.6)	5,654
No	58.9 (47.2-70.8) ^a	57
Tracking system characteristic		
Able to send appointment cards for additional dose(s) of vaccine		
Yes	76.8 (73.7-79.9)	3,833
No	70.5 (64.7-76.3) ^a	1,217
Able to identify staff due for dose 2 or 3 of vaccine		
Yes	76.7 (73.9-79.6)	4,545
No	65.8 (56.6-75.0) ^a	540
Able to identify unvaccinated staff eligible for vaccination		
Yes	76.3 (72.7-79.9)	3,292
No	73.1 (68.3-77.9)	1,533
Able to calculate percentage of staff who refused vaccination or are immune		
Yes	74.5 (70.3-78.8)	2,775
No	75.2 (71.5-78.9)	2,031

NOTE. Some categories have different sums because of missing values. CI, confidence interval.

^a $P < .05$, by the χ^2 test for difference in proportions.

TABLE 2. Hepatitis B Vaccination Coverage Levels Among Healthcare Workers (HCWs), by Demographic Characteristics

Characteristic	Prevalence of hepatitis B vaccination, % (95% CI)	Estimated no. of vaccinated HCWs	Estimated total no. of HCWs
All HCWs	75.0 (72.3-77.5)	2,499,536	3,331,436
Sex			
Female	76.1 (73.5-78.6)	1,789,353	2,349,945
Male	73.3 (69.3-76.9)	550,153	750,845
Age			
<20-29 years	72.7 (68.3-77.2)	428,613	588,992
30-39 years	76.2 (72.6-79.5)	677,608	889,072
40-49 years	76.8 (73.5-79.7)	754,358	982,586
50-59 years	76.2 (72.6-79.4)	464,529	610,009
60-69 years	69.4 (62.5-75.5)	105,835	152,520
≥70 years	56.9 (33.7-77.6)	7,748	13,596
Race or ethnicity			
White	79.5 (76.8-81.9)	1,409,742	1,772,673
Black	67.6 (57.6-76.1) ^a	205,194	303,706
Hispanic	75.3 (66.3-82.5)	151,293	201,003
Asian	74.3 (64.7-82.1)	126,379	93,923
Other or unknown	68.7 (64.4-72.8) ^a	576,366	838,216
Job category			
Nurse	80.9 (77.9-83.6)	1,064,112	1,314,658
Phlebotomist or medical technician	71.1 (62.5-78.4) ^b	141,692	199,293
Nurses' aide or other patient care staff	70.9 (67.3-74.4) ^b	736,744	1,037,833
Physician	81.6 (75.2-86.7)	128,353	157,251
Maintenance or housekeeping staff	72.0 (66.7-76.8) ^b	205,316	285,101
Administrative (security, clerical, or dietary staff)	66.4 (60.6-71.7) ^b	213,075	320,910

NOTE. CI, confidence interval.

^a $P < .05$ for comparison with white HCWs, by the χ^2 test for difference in proportions.

^b $P < .05$ for comparison with nurses, by the χ^2 test for difference in proportions.

RESULTS

A total of 300 (70.5%) of the 425 hospitals surveyed responded to the survey, and vaccination data were collected on 7,011 (65.9%) of 10,625 HCWs. Response rates were similar by strata. There were no significant differences in hospital characteristics when participating and nonparticipating hospitals were compared (data not shown).

Hospital Characteristics

Among medical-surgical hospitals, vaccination coverage levels were similar (median, 75.3% [range, 72.9%-78.2%]). Compared with medical-surgical hospitals, vaccination coverage levels were slightly higher among HCWs in military hospitals (83.8%) and similar among HCWs in Veterans Administration hospitals (73.1%) and Indian Health Service hospitals (71.3%) (Table 1).

Hepatitis B vaccination coverage was similar in both hospitals that did and hospitals that did not require vaccination of HCWs who had regular or potential occupational exposure to blood or other potentially infectious material (Table 1). However, coverage was significantly lower in hospitals that required vaccination of HCWs who did not have an identified

risk for occupational exposure to blood or other potentially infectious material, compared with hospitals that did not have such a requirement (62.4% vs 76.6%; $P < .05$) (Table 1). Similarly, coverage was significantly lower in hospitals that offered hepatitis B vaccination free of charge to HCWs who did not have an identified risk for exposure, compared with hospitals that did not have such a policy (72.0% vs 80.3%; $P < .05$).

Most hospitals (90%) reported having a vaccination tracking system. Vaccination coverage was significantly higher among HCWs in hospitals that had tracking systems that could send appointment cards, compared with HCWs in hospitals with tracking systems that could not (76.8% vs 70.5%; $P < .05$) (Table 1). Other vaccination and testing policies and tracking system characteristics significantly associated with coverage levels can be found in Table 1.

HCW Characteristics

Among HCWs with frequent or potential exposure to blood or other potentially infectious material, 75.0% (95% CI, 72.3%-77.5%) had received 3 or more doses of the hepatitis B vaccine, corresponding to an estimated 2.5 million vaccinated, hospital-based HCWs in the United States (Table 2). The few

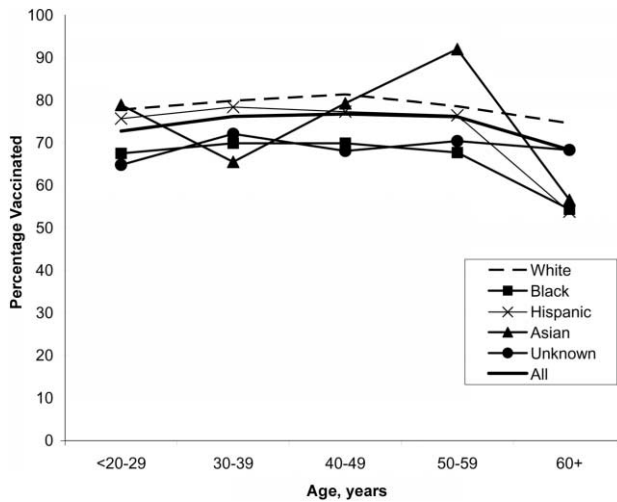


FIGURE 1. Hepatitis B vaccination coverage levels among health-care workers, by race or ethnicity and age group.

HCWs ($n = 401$) who had received 1 or 2 doses of the hepatitis B vaccine were excluded from analyses. Exclusion of these HCWs did not impact the overall or stratified estimates.

Among the 5,276 HCWs who were reported to have frequent or potential exposure in the survey, 70.8% were female; hepatitis B vaccination coverage was similar among female and male HCWs (Table 2). Vaccination coverage was similar among HCWs 20-59 years of age, and HCWs in this age group accounted for the majority of survey respondents (94.8%).

The hepatitis B vaccination coverage level was highest among white HCWs (79.5%), and they constituted the majority of the HCWs in the survey (58%) (Table 2). Hepatitis B vaccination coverage among black HCWs was significantly lower than that among white HCWs (67.6% vs 79.5%; $P < .05$). For almost every age group, black HCWs had lower coverage, compared with other racial or ethnic groups (Figure 1).

The hepatitis B vaccination coverage level was highest among nurses (80.9%) and staff physicians (81.6%) (Table 2). Coverage was 71.1% among phlebotomists and medical technicians and 70.9% among nurses' aides and other patient care staff; coverage for both groups was significantly lower than that among nurses ($P < .05$). By job and age group, coverage was high among nurses and staff physicians of all ages (Figure 2).

More than two-thirds of survey participants were nurses, nurses' aides, or other patient care technicians. Among them, notable differences in coverage levels were observed by race or ethnicity: 84.6% of white nurses had been vaccinated, compared with 62.6% of black nurses ($P < .01$), and similar differences in coverage were observed among nurses' aides and other patient care staff (data not shown).

For the majority of unvaccinated HCWs ($n = 1,323$), no specific reason for the lack of vaccination was recorded in the medical record. Some unvaccinated HCWs (28%) had a

signed refusal in their medical record, while very few HCWs (1%) had a documented contraindication to vaccination. Compared with vaccinated HCWs, those who refused vaccination were more likely to be older than 50 years of age, black, nurses' aides or other patient care staff, maintenance or housekeeping staff, and/or administrative staff. The HCWs who refused vaccination were distributed throughout all hospital strata.

Individual HCW characteristics included in the final multivariate logistic regression model were age, race or ethnicity, and job category. The hospital policy variables included were a vaccination requirement for HCWs with regular exposure to blood or other potentially infectious material, a vaccination requirement for HCWs without identified risk for exposure to blood or other potentially infectious material, and offering vaccination to HCWs who did not have identified risk for exposure to blood or other potentially infectious material. Finally, several variables describing the characteristics of a hospital's tracking systems were included: the ability to send appointment cards, to identify staff who are due for additional doses, to identify unvaccinated staff eligible for vaccination, and to calculate the percentage of staff who refused vaccination or were immune.

Multivariate analyses revealed that black HCWs were significantly less likely to have received hepatitis B vaccine, compared with white HCWs (OR, 0.5 [95% CI, 0.3-0.8]) (Table 3). Compared with nurses, HCWs in all job categories except physicians were significantly less likely to have been vaccinated. No tracking system characteristics were found to be associated with coverage. Hospital policies, such as requiring vaccination of HCWs who did not have exposure to blood or other potentially infectious material (OR, 0.6 [95% CI, 0.3-0.9]) and offering hepatitis B vaccination to this same

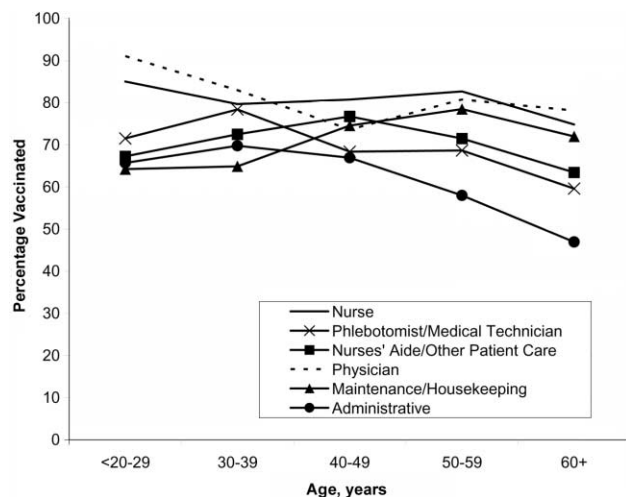


FIGURE 2. Hepatitis B vaccination coverage levels among health-care workers, by job category and age group.

TABLE 3. Multivariate Analysis of Factors Associated With Healthcare Worker Hepatitis B Vaccination Status

Variable	Adjusted odds ratio (95% CI)
Age	
30-59 years	1.0
<20-29 years	0.9 (0.7-1.1)
60- \geq 70 years	0.7 (0.5-1.0)
Race or ethnicity	
White	1.0
Black	0.5 (0.3-0.8)
Hispanic	0.8 (0.5-1.3)
Asian	0.8 (0.5-1.3)
Other or unknown	0.5 (0.4-0.6)
Job category	
Nurse	1.0
Phlebotomist or medical technician	0.6 (0.4-0.9)
Nurses' aide or other patient care staff	0.6 (0.5-0.8)
Physician	1.0 (0.7-1.7)
Maintenance or housekeeping staff	0.6 (0.3-0.6)
Administrative staff	0.5 (0.3-0.6)
Vaccination policy	
Requires hepatitis B vaccination for HCWs with regular exposure to blood or other potentially infectious material	1.1 (0.8-1.4)
Requires vaccination for HCWs without identified risk for exposure to blood or other potentially infectious material	0.6 (0.3-0.9)
Offers vaccination free of charge for HCWs without identified risk for exposure to blood or other potentially infectious material	0.6 (0.5-0.8)
Tracking system characteristic	
Able to send appointment cards for additional dose(s) of vaccine	1.1 (0.8-1.6)
Able to identify staff who are due for dose 2 or 3 of vaccine	1.1 (0.8-1.7)
Able to identify unvaccinated staff who are eligible for vaccination	1.4 (1.0-1.9)
Able to calculate percentage of staff who refused vaccination or are immune	0.8 (0.6-1.1)

NOTE. CI, confidence interval.

group of HCWs (OR, 0.6 [95% CI, 0.5-0.8]), were inversely associated with vaccination.

DISCUSSION

To our knowledge, this survey of hepatitis B vaccination coverage levels among HCWs provides the first national estimates of coverage since 1995. The survey allowed for national estimates because of its large sample size and robust stratified random sample design. The results indicate that an estimated 75% of HCWs (or 2.5 million HCWs) with frequent or potential exposure to blood or other potentially infectious material working in US hospitals during 2002-2003 were vaccinated against hepatitis B. Race was found to be the strongest determinant of vaccination; after adjusting for other demographic and hospital variables for all categories of HCWs, black HCWs remained significantly less likely to be vaccinated, compared with white HCWs. This disparity has been previously reported among HCWs, and among children and adults in the general population in coverage studies of other vaccines.^{12,21-23}

Few hospital-level characteristics were associated with vaccination coverage. The majority of hospitals had policies in place that required vaccination for HCWs with occupational exposure to blood or other potentially infectious material. HCWs were less likely to be vaccinated if they were employed in hospitals that had policies either requiring or offering hepatitis B vaccination to HCWs without occupational exposure to blood or other potentially infectious material. The reasons for this finding are unclear. It is possible that such policies might divert attention and resources from vaccination of HCWs who are at occupational risk for HBV infection.

The overall estimate of hepatitis B vaccination coverage in this survey was consistent with that obtained from the 2001 National Health Interview Survey (NHIS). Although the NHIS was not specifically designed to survey HCWs and does not include validation of self-reported vaccination status, receipt of 1 or more doses of hepatitis B vaccine was reported by 78.5% of persons who identified themselves as HCWs (CDC, unpublished data). In comparison with a methodologically similar survey from 1995, the results of the current study

indicate that hepatitis B vaccination coverage among HCWs increased from 66.5% to 75%. Improvements in coverage were evident among physicians, nurses, and nurses' aides; coverage among phlebotomists and medical technicians decreased.¹²

Of the 1,323 unvaccinated HCWs in the survey who had frequent or potential exposure to blood or other potentially infectious material, almost one-third had refused vaccination. Although their reasons for refusing vaccination were not readily available in their medical records, a previous study conducted among hospital-based HCWs found that the reason most often cited for refusing was fear of getting hepatitis B from the vaccination.²⁴ Other studies have also found influenza vaccine coverage to be quite low among HCWs.²⁵ The unvaccinated HCWs identified by this and other surveys represent missed opportunities for vaccination and underscore the need for efforts to increase adult vaccination coverage nationwide. HCWs represent a high-risk population whose access to vaccination services is likely to be better than that of other high-risk adults. Further studies to evaluate reasons for refusal and strategies to increase vaccination acceptance are warranted.

This cross-sectional survey has potential limitations. HCW education and income levels, as well as length of practice, were not evaluated, and these are characteristics that may influence vaccination status.²⁶ A large proportion of HCW medical records (23.5%) were missing data on race or ethnicity. However, coverage rates were not significantly different when the records missing information on race or ethnicity were excluded from the analysis. Finally, some misclassification of the risk of exposure could have occurred, as risk of exposure was based on job title and duty location. However, any misclassification would have been nondifferential, given that staff at 300 different hospitals abstracted the relevant data, and hence it is unlikely to result in appreciable bias.

Nationally, the incidence of acute hepatitis B is at a historic low. Overall, a 70% decrease in the incidence of acute hepatitis B has been observed since 1991.⁸ Since the initial recommendation for vaccination of HCWs in 1982, the estimated number of annual infections among HCWs has decreased from 10,000 to 304 in 2004 (CDC, unpublished data). However, a number of recent outbreaks of patient-to-patient transmission of HBV and hepatitis C virus indicate the continued transmission of HBV and hepatitis C virus in the healthcare setting and demonstrate the continued risk of healthcare-related exposure to bloodborne pathogens.²⁷⁻²⁹

The elimination of HBV transmission to HCWs is achievable through vaccination. HCWs are an accessible population of adults demonstrated to be at high risk for HBV infection for whom hepatitis B vaccination has been recommended for over 20 years. Despite vaccination being provided at no cost and administered in the workplace, an estimated one-quarter of HCWs who have frequent or potential exposure to blood or other potentially infectious material remain unvaccinated. Efforts should be made to determine the reasons for refusing

vaccination and to increase hepatitis B vaccination coverage levels among all HCWs, especially those at greatest risk for exposure to blood or other potentially infectious material. Hospitals also need to identify successful vaccination strategies focused on exposed, but unvaccinated, HCWs.

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