

# Hepatitis B Vaccination Coverage Among Health-Care Personnel in the United States

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KATHY K. BYRD, MD, MPH<sup>a</sup>  
PENG-JUN LU, PhD<sup>b</sup>  
TRUDY V. MURPHY, MD<sup>a</sup>

## ABSTRACT

**Objectives.** We compared self-reported hepatitis B (HepB) vaccine coverage among health-care personnel (HCP) with HepB vaccine coverage among the general population and determined trends in vaccination coverage among HCP.

**Methods.** We used the 2010 National Health Interview Survey (NHIS) to determine the weighted proportion of self-reported  $\geq 1$ - and  $\geq 3$ -dose HepB vaccine coverage among HCP aged  $\geq 18$  years. We used logistic regression to determine independent predictors of vaccination and performed a trend analysis to determine changes in coverage from 2004 to 2010 using data from the 2004–2010 NHIS.

**Results.** Overall, 69.5% (95% confidence interval [CI] 67.2, 71.8) and 63.4% (95% CI 60.8, 65.9) of HCP reported receiving  $\geq 1$  and  $\geq 3$  doses of HepB vaccine, respectively, compared with 27.1% (95% CI 26.1, 28.1%) and 23.0% (95% CI 22.1, 24.0) among non-HCP. Among HCP with direct patient contact, 80.7% (95% CI 78.2, 83.1) and 74.0% (95% CI 71.2, 76.8) received  $\geq 1$  and  $\geq 3$  HepB vaccine doses, respectively. Independent predictors of vaccination included direct patient contact, having more than a high school education, influenza vaccination in the past year, and ever having been tested for HIV. There was no significant change in reported coverage from 2004 through 2010.

**Conclusion.** The 2010 HepB vaccine coverage estimate among HCP remained well below the Healthy People 2010 goal of 90%. Efforts to target unvaccinated HCP for preexposure HepB protection should be encouraged.

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<sup>a</sup>Centers for Disease Control and Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Division of Viral Hepatitis, Atlanta, GA

<sup>b</sup>Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases, Immunization Services Division, Atlanta, GA

Address correspondence to: Kathy K. Byrd, MD, MPH, Centers for Disease Control and Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Division of Viral Hepatitis, 1600 Clifton Rd. NE, MS G-37, Atlanta, GA 30333; tel. 404-718-8541; fax 404-718-8595; e-mail <gdn8@cdc.gov>.

Working in health care has long been recognized as a risk for hepatitis B virus (HBV) exposure.<sup>1-4</sup> HBV is transmitted primarily through mucosal or cutaneous exposure to infectious blood or bodily fluids (e.g., sharps injury, non-intact skin, and burns).<sup>5</sup> Studies from the 1980s and 1990s showed that up to 28% of health-care personnel (HCP) had serologic evidence of past or current HBV infection.<sup>1-4</sup> Exposures often go unrecognized, in part because HBV is stable in the environment for at least seven days and can be found in high titers on environmental surfaces even in the absence of visible blood.<sup>6</sup> In previous investigations, most infected HCP could not recall an overt injury or caring for a patient who was known to be HBV infected.<sup>5</sup>

In 1982, a year after the first hepatitis B (HepB) vaccine in the United States was introduced, the Advisory Committee on Immunization Practices (ACIP) recommended a three-dose HepB vaccine series for HCP.<sup>7</sup> In 1991, the Occupational Safety and Health Administration (OSHA) issued a Federal Standard that required employers to offer HepB vaccination at no cost to all occupationally exposed people.<sup>8</sup> The ACIP recommendation, the OSHA Standard, introduction of Universal Precautions (now known as Standard Precautions), and the NeedleStick Safety and Prevention Act of 2001 likely contributed to the decreased HBV incidence among HCP during the past two decades; estimated numbers of incident cases among HCP decreased from 10,000 in 1982 to 304 in 2004.<sup>7-12</sup>

Although the incidence of acute HBV infection has declined among HCP, the risks for exposure persist. For example, in 2005, the risk of needlestick injuries was estimated to be as high as 839 injuries per 1,000 HCP in the hospital setting.<sup>13</sup> In addition, the National Surveillance System for Healthcare Workers estimated that from 1998 to 2007, 12% of source patients who were exposed to bodily fluids were positive for a blood-borne pathogen.<sup>14</sup>

Although the HepB vaccine has been recommended for HCP for more than two decades, vaccine coverage has remained below the Healthy People 2010 coverage goal of 90%.<sup>15</sup> We used the National Health Interview Survey (NHIS) to estimate self-reported HepB vaccine coverage among HCP, determine independent predictors of vaccination, and track trends in vaccination coverage since 2004.

## METHODS

We used the 2010 NHIS to estimate the weighted proportion of self-reported  $\geq 1$ - and  $\geq 3$ -dose HepB vaccine coverage among HCP and the general population aged

$\geq 18$  years. The NHIS is an annual cross-sectional household interview survey of the civilian noninstitutionalized U.S. population. The NHIS collects information on health behaviors, health indicators, and health-care use and access. Details on the NHIS design and sampling procedures have been previously described. In 2010, the final response rate for the core survey sample of adults was 60.8%.<sup>16</sup>

Self-reported vaccination coverage was estimated and stratified by the following sociodemographic and access-to-care variables: age group, sex, race/ethnicity, poverty level, education level, insurance status, number of physician visits in past year, and place of usual health care. Coverage was also stratified by whether a person had ever been tested for human immunodeficiency virus (HIV), had high-risk behavior for incident HBV infection, or had been vaccinated against seasonal influenza in the past year. In addition, because the ACIP recommends that HCP who have a reasonably anticipated risk for exposure to blood or other infectious body fluids should be vaccinated, we also stratified vaccination coverage by whether HCP had direct patient contact.<sup>9</sup>

For estimating vaccination coverage in 2010, we defined HCP status as a “yes” answer to the following question: “Do you currently volunteer or work in a hospital, medical clinic, doctor’s office, dentist’s office, nursing home, or some other health-care facility? This includes part-time and unpaid work in a health-care facility as well as professional nursing care provided in the home.” We considered HCP as having direct patient contact if they answered “yes” to the following question: “Do you provide direct patient care as part of your routine work? By direct patient care, we mean physical or hands-on contact with patients.” People were considered to be vaccinated with  $\geq 1$  dose of HepB vaccine if they responded “yes” to the following question: “Have you ever received the hepatitis B vaccine?” Those who answered “yes” were asked a follow-up question: “Did you receive at least 3 doses of the hepatitis B vaccine, or less than 3 doses?”

We considered people to be vaccinated against seasonal influenza if they answered “yes” to one of the following questions: “During the past 12 months, have you had a flu shot?” or “During the past 12 months, have you had a flu vaccine sprayed in your nose by a doctor or other health professional?” We defined individuals with high-risk behaviors as people who considered themselves at high risk for HIV infection, reported having a sexually transmitted disease other than HIV/acquired immunodeficiency syndrome (AIDS) during the previous five years, or reported any one of the following risk factors: men who have sex with men,

injection of street drugs, having ever traded sex for money or drugs, being HIV-positive, having ever had sex with someone with any of the aforementioned risk factors, and having hemophilia with receipt of clotting factor concentrates. Hemophilia is not considered a risk behavior for HBV transmission; however, we were unable to exclude people with hemophilia because of the format of the survey question.

Subjects were divided into five-year age groups from 25 through 64 years of age. People aged  $\geq 65$  years were placed into one group. People aged 18–24 years were combined into one group because of the small numbers of HCP among this age group. All survey participants with “don’t know,” “refused,” “not ascertained,” or missing responses to any of the aforementioned study variables (<9% of respondents) were excluded from the analysis.

We calculated point estimates and 95% confidence intervals (CIs) of  $\geq 1$ - and  $\geq 3$ -dose HepB vaccine coverage. All analyses were weighted to reflect the age, sex, and race/ethnicity of the U.S. noninstitutionalized civilian population. We used Wald Chi-square tests to assess the statistical significance of the association between vaccination coverage ( $\geq 1$  and  $\geq 3$  doses) and sociodemographic, access-to-care, and other characteristics both by and within HCP status. Because certain sociodemographic and other characteristics have previously been found to be associated with vaccination rates, we conducted a multivariable logistic regression analysis to determine point estimates and 95% CIs of  $\geq 1$ - and  $\geq 3$ -dose HepB vaccine coverage among HCP adjusted for potential confounders, and to determine independent predictors of vaccination. We included all variables from the bivariate analysis in the multivariable regression model. We conducted a separate logistic regression model, which included HCP status as an independent variable, to determine if being an HCP was a predictor of vaccination and to determine the overall adjusted vaccination coverage among HCP; the variable for direct patient contact was excluded from this analysis due to collinearity with HCP status. For all statistical tests, we considered  $p < 0.05$  to be statistically significant, and we used Stata<sup>®</sup> release 11 to calculate vaccination point estimates and to conduct the bivariate and multivariate analyses.<sup>17</sup>

In addition, we calculated point estimates and 95% CIs of  $\geq 1$ -dose HepB vaccine coverage among HCP according to job description, using the standard occupation and industry categories recoded by the Centers for Disease Control and Prevention. The occupation and industry categories include physicians; nurses; others in health diagnosis and treating practitioners groups; clinical laboratorians; other health technolo-

gists; nursing, psychiatric, and home health aides; and other health-care support occupations.<sup>18</sup> Because of the small sample size, we only conducted a descriptive analysis of job description.

We conducted a trend analysis for HepB vaccine coverage from 2004 through 2010 using a t-test for linear trends. Due to a change in the definition of HCP status within NHIS in 2009, we used a different definition for HCP for the trend analysis than what was used to calculate the vaccination point estimates and bivariate and multivariable analyses. We defined HCP for the trend analysis as individuals who were currently employed in a health-care occupation or in a health-care industry setting, based on the standard occupation and industry categories. We considered  $p < 0.05$  to be statistically significant. We used SUDAAN<sup>®</sup> statistical software to conduct the test for linear trends.<sup>19</sup>

## RESULTS

Demographic characteristics and access-to-care variables of the study sample, by HCP status, are shown in Table 1. A total of 24,497 adults aged  $\geq 18$  years were included in the sample, of whom 1,973 (8.1% weighted) were HCP. The median age of HCP was 44 years (range: 18–85 years). Approximately 75.3% of HCP were female and 68.8% were non-Hispanic white. The majority (79.8%) had more than a high school education, were insured (89.0%), and lived at or above the federal poverty level (FPL) (91.4%). About two-thirds (62.4%) of HCP had direct patient contact.

### HepB vaccination coverage and bivariate analysis

Vaccination coverage and results of the bivariate analysis for both HCP and non-HCP are shown in Table 2. Overall, 69.5% (95% CI 67.2, 71.8) and 63.4% (95% CI 60.8, 65.9) of HCP aged  $\geq 18$  years reported receiving  $\geq 1$  and  $\geq 3$  doses of HepB vaccine, respectively, compared with 27.1% (95% CI 26.1, 28.1) and 23.0% (95% CI 22.1, 24.0) of non-HCP ( $p < 0.05$  for both). Ninety-one percent of HCP who received  $\geq 1$  dose of HepB vaccine reported completing the vaccination series (data not shown). Among HCP who had direct patient contact, 80.7% (95% CI 78.2, 83.1) and 74.0% (95% CI 71.2, 76.9) reported receiving  $\geq 1$  and  $\geq 3$  doses of HepB vaccine, respectively (Table 2).

HCP aged 18–24 years reported higher  $\geq 1$ -dose coverage (77.3%) than HCP aged 45–49 years (63.3%) and HCP aged  $\geq 55$  years (range: 36.9%–66.1%) ( $p < 0.05$ ) (Table 2). HCP who were female, had direct patient contact, had more than a high school education, had  $\geq 10$  health-care visits in the past year, were ever tested for HIV, and had high-risk behavior reported higher

**Table 1. Sample characteristics of adults  $\geq 18$  years of age, by health-care personnel status: National Health Interview Survey, 2010**

Characteristic	All adults		Health-care personnel		Non-health-care personnel	
	Sample N	Weighted percent	Sample N	Weighted percent	Sample N	Weighted percent
Total	24,497	100.0	1,973	8.1	22,524	91.9
Age (in years)						
18–24	2,437	12.4	186	11.2	2,251	12.5
25–29	2,132	8.8	204	9.4	1,928	8.8
30–34	2,184	8.5	198	8.9	1,986	8.4
35–39	2,171	8.4	227	10.9	1,944	8.2 <sup>a</sup>
40–44	2,138	9.0	221	12.6	1,917	8.7 <sup>a</sup>
45–49	2,237	9.9	214	10.8	2,023	9.8
50–54	2,221	9.7	220	12.5	2,001	9.5 <sup>a</sup>
55–59	2,026	8.2	180	8.6	1,846	8.2
60–64	1,917	7.7	133	6.5	1,784	7.8
$\geq 65$	5,034	17.3	190	8.6	4,844	18.1
Sex						
Male	10,771	48.1	430	24.7	10,341	50.2 <sup>a</sup>
Female	13,726	51.9	1,543	75.3	12,183	49.8 <sup>a</sup>
Race/ethnicity						
Non-Hispanic white	14,112	68.8	1,153	68.8	12,959	68.8
Non-Hispanic black	3,959	11.6	337	11.9	3,662	11.6
Non-Hispanic other <sup>b</sup>	1,903	6.1	207	8.8	1,696	5.8
Hispanic	4,490	13.5	275	10.5	4,215	13.8
Direct patient contact						
No	NA	NA	736	37.6	NA	NA
Yes	NA	NA	1,236	62.4	NA	NA
Insured						
No	4,545	17.8	247	11.0	4,298	18.3 <sup>a</sup>
Yes	19,884	82.2	1,721	89.0	18,163	81.7 <sup>a</sup>
Education						
$\leq$ High school	10,710	41.5	452	20.2	10,258	43.3 <sup>a</sup>
$\geq$ Some college	13,658	58.5	1,517	79.8	12,168	56.7 <sup>a</sup>
Number of physician visits <sup>c</sup>						
0	4,900	19.5	251	11.6	4,649	20.2
1	3,773	15.8	335	16.4	3,438	15.7
2–3	6,202	25.9	600	30.6	5,602	25.5
4–9	6,109	24.9	541	29.1	5,568	24.6
$\geq 10$	3,446	13.8	244	12.4	3,202	14.0
Poverty level						
<FPL	4,095	14.0	217	8.6	3,878	14.4 <sup>a</sup>
$\geq$ FPL	17,704	86.0	1,579	91.4	16,125	85.6 <sup>a</sup>
Place of usual care						
None	3,057	12.3	152	7.3	2,905	12.8 <sup>a</sup>
Clinic or health center	4,809	17.8	381	16.8	4,428	17.9
Doctor's office or HMO	15,628	66.9	1,367	72.9	14,261	66.3 <sup>a</sup>
Other <sup>d</sup>	868	3.0	68	3.0	800	3.0
High-risk behavior <sup>e</sup>						
No	23,098	94.7	1,837	94.1	21,261	94.8
Yes	1,399	5.3	136	5.9	1,263	5.2
Ever been tested for HIV						
No	14,062	61.1	839	45.2	13,223	62.5 <sup>a</sup>
Yes	9,925	38.9	1,096	54.8	8,829	37.5 <sup>a</sup>

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**Table 1 (continued). Sample characteristics of adults  $\geq 18$  years of age, by health-care personnel status: National Health Interview Survey, 2010**

Characteristic	All adults		Health-care personnel		Non-health-care personnel	
	Sample N	Weighted percent	Sample N	Weighted percent	Sample N	Weighted percent
Received influenza vaccine in past year						
No	9,629	64.4	512	41.2	9,117	66.4 <sup>a</sup>
Yes	5,289	35.6	681	58.8	4,608	33.6 <sup>a</sup>

<sup>a</sup>Wald Chi-square  $p < 0.05$  for difference between health-care personnel and non-health-care personnel. Percentages were rounded to the nearest one-tenth.

<sup>b</sup>Includes American Indian/Alaska Native, Asian, and multiracial people

<sup>c</sup>Includes visits to non-physician health-care professionals

<sup>d</sup>Includes responses of "some other place," hospital emergency room, and hospital outpatient departments

<sup>e</sup>High-risk behaviors include people who considered themselves at high risk for HIV infection, people who reported having a sexually transmitted disease other than HIV/AIDS during the previous five years, and people who reported any one of the following risk factors: hemophilia with receipt of clotting factor concentrates, men who have sex with men, injecting street drugs, trading sex for money or drugs, testing positive for HIV, or having sex with someone with any of these risk factors.

NA = not applicable

FPL = federal poverty level

HMO = health maintenance organization

HIV = human immunodeficiency virus

AIDS = acquired immunodeficiency syndrome

$\geq 1$ -dose coverage than HCP without these characteristics (all  $p < 0.05$ ). Similar characteristics were significantly associated with series completion ( $\geq 3$  doses), except for respondents aged 45–49 and 55–59 years and those reporting high-risk behavior. Being at or above the FPL and being insured were associated with higher  $\geq 3$ -dose coverage.

### HepB vaccination coverage ( $\geq 1$ dose) by health-care job description

The majority of each HCP profession reported receiving  $\geq 1$  HepB vaccine dose. Among physicians ( $n=93$ ) and nurses ( $n=398$ ), 88.8% (95% CI 80.8, 93.8) and 83.5% (95% CI 79.3, 86.9), respectively, reported receiving  $\geq 1$  HepB vaccine dose. Seventy-five percent (95% CI 50.7, 87.2) of clinical laboratory staff ( $n=32$ ) and 76.5% (95% CI 70.3, 81.7) of other health technologists ( $n=231$ ) reported receiving  $\geq 1$  HepB vaccine dose. Coverage for nursing, psychiatric, and home health aides ( $n=424$ ) was 63.5% (95% CI 57.7, 68.9) and for other health-care support occupations ( $n=190$ ) was 66.1% (95% CI 57.1, 74.1) (data not shown).

### Multivariate and trend analysis among HCP

Results of the multivariate analysis for HCP are shown in Table 3. Decreased odds of reported receipt of  $\geq 1$  HepB vaccine dose were seen for HCP aged 60–64 years (adjusted odds ratio [AOR] = 0.37,  $p=0.047$ ). Coverage

of  $\geq 1$  vaccine dose did not differ significantly for most HCP aged  $\leq 59$  years. HCP with direct patient contact (AOR=3.14,  $p < 0.001$ ), those who had more than a high school education (AOR=2.43,  $p < 0.001$ ), those who were ever tested for HIV (AOR=1.61,  $p=0.020$ ), and those who had received seasonal influenza vaccine in the past year (AOR=1.96,  $p=0.001$ ) had greater odds of reported receipt of  $\geq 1$  HepB vaccine dose than HCP without the aforementioned characteristics. Characteristics of HCP who reported  $\geq 3$ -dose coverage were similar except that age was no longer significantly associated with receiving  $\geq 3$  doses, and having high-risk behavior for incident HBV infection was associated with series completion. When HCP status was included as an independent variable within the logistic regression model, being an HCP was associated with both  $\geq 1$ -dose (AOR=5.3,  $p < 0.001$ ) and  $\geq 3$ -dose (AOR=4.95,  $p < 0.001$ ) vaccination (data not shown). There was no significant change in reported  $\geq 1$ - or  $\geq 3$ -dose vaccine coverage among HCP from 2004 to 2010 (test for trend,  $p > 0.05$ ) (Figure).

### DISCUSSION

In 2010, overall self-reported HepB vaccination coverage among HCP aged  $\geq 18$  years was 69.5% and 63.4% for  $\geq 1$  and  $\geq 3$  doses, respectively. HCP with direct patient contact reported higher coverage (80.7% and

**Table 2. Hepatitis B vaccination rates by health-care personnel status: National Health Interview Survey, 2010**

Characteristic	≥ 1 dose hepatitis B vaccine		≥ 3 doses hepatitis B vaccine	
	Health-care personnel		Non-health-care personnel	
	Percent (95% CI)	Percent (95% CI)	Percent (95% CI)	Percent (95% CI)
Total	69.5 (67.2, 71.8)	27.1 (26.1, 28.1) <sup>a</sup>	63.4 (60.8, 65.9)	23.0 (22.1, 24.0) <sup>a</sup>
Age (in years)				
18–24 <sup>a</sup>	77.3 (69.4, 85.1)	54.3 (51.2, 57.4) <sup>a</sup>	66.8 (58.5, 75.2)	47.2 (44.1, 50.2)
25–29	83.0 (76.4, 89.5)	45.2 (42.1, 48.3) <sup>ab</sup>	73.8 (66.3, 81.2)	38.9 (35.7, 42.0) <sup>ab</sup>
30–34	82.0 (75.9, 88.1)	34.0 (31.4, 36.6) <sup>ab</sup>	76.1 (69.3, 82.8)	28.7 (26.1, 31.3) <sup>ab</sup>
35–39	74.5 (67.1, 81.9)	28.9 (26.5, 31.2) <sup>ab</sup>	68.0 (60.3, 75.7)	24.1 (21.9, 26.3) <sup>ab</sup>
40–44	76.0 (69.3, 82.7)	26.5 (24.1, 28.9) <sup>ab</sup>	68.6 (61.4, 75.8)	22.5 (20.3, 24.7) <sup>ab</sup>
45–49	63.3 (55.9, 70.7) <sup>b</sup>	20.6 (18.3, 23.0) <sup>ab</sup>	61.8 (54.2, 69.3)	17.4 (15.3, 19.6) <sup>ab</sup>
50–54	71.3 (64.6, 77.9)	20.5 (18.3, 22.7) <sup>ab</sup>	66.4 (59.7, 73.2)	17.0 (15.0, 19.0) <sup>ab</sup>
55–59	66.1 (58.1, 74.0) <sup>b</sup>	19.7 (17.5, 21.8) <sup>ab</sup>	61.0 (52.7, 69.2)	16.4 (14.4, 18.4) <sup>ab</sup>
60–64	53.0 (43.1, 63.0) <sup>b</sup>	18.1 (16.2, 20.1) <sup>ab</sup>	48.0 (37.7, 58.4) <sup>b</sup>	15.3 (13.4, 17.2) <sup>ab</sup>
≥ 65	36.9 (29.2, 44.6) <sup>b</sup>	10.2 (9.1, 11.3) <sup>ab</sup>	32.4 (24.7, 40.2) <sup>b</sup>	8.3 (7.3, 9.2) <sup>ab</sup>
Sex				
Male	64.9 (59.7, 70.1)	25.4 (24.2, 26.6) <sup>a</sup>	60.4 (54.7, 66.0)	21.3 (20.1, 22.5) <sup>a</sup>
Female	71.0 (68.5, 73.6) <sup>b</sup>	28.9 (27.7, 30.0) <sup>ab</sup>	64.4 (61.6, 67.2)	24.8 (23.6, 25.9) <sup>ab</sup>
Race/ethnicity				
Non-Hispanic white	69.8 (67.0, 72.7)	26.6 (25.5, 27.7) <sup>a</sup>	64.1 (61.0, 67.2)	22.8 (21.7, 23.9) <sup>a</sup>
Non-Hispanic black	67.0 (60.9, 73.3)	30.7 (28.2, 33.1) <sup>ab</sup>	58.6 (52.0, 65.2)	25.7 (23.5, 28.0) <sup>ab</sup>
Non-Hispanic other <sup>c</sup>	76.5 (69.2, 83.9)	34.3 (30.8, 37.8) <sup>ab</sup>	72.0 (64.1, 80.0)	29.0 (25.7, 32.3) <sup>ab</sup>
Hispanic	64.2 (57.2, 71.1)	24.0 (22.0, 26.1) <sup>ab</sup>	57.0 (49.9, 64.1)	19.4 (17.4, 21.3) <sup>ab</sup>
Direct patient contact				
No	51.1 (46.9, 55.3)	NA	45.8 (41.6, 50.0)	NA
Yes	80.7 (78.2, 83.1) <sup>b</sup>	NA	74.0 (71.2, 76.9) <sup>b</sup>	NA
Education				
≤ High school	51.0 (45.3, 56.5)	19.6 (18.4, 20.8) <sup>a</sup>	44.0 (38.5, 49.5)	16.5 (15.4, 17.6) <sup>a</sup>
≥ Some college	74.3 (71.8, 76.8) <sup>b</sup>	33.0 (31.7, 34.3) <sup>ab</sup>	68.4 (65.7, 71.1) <sup>b</sup>	28.1 (26.8, 29.4) <sup>ab</sup>
Federal poverty level				
< FPL	63.8 (55.5, 72.0)	28.8 (26.6, 31.0) <sup>a</sup>	54.1 (45.6, 62.6)	23.9 (21.9, 26.0) <sup>a</sup>
≥ FPL	70.4 (67.8, 73.0)	27.8 (26.7, 28.9) <sup>a</sup>	64.4 (61.6, 67.2) <sup>b</sup>	23.6 (22.6, 24.7) <sup>a</sup>
Insured				
No	63.7 (57.1, 70.4)	26.1 (24.3, 27.9) <sup>a</sup>	54.0 (46.7, 61.3)	20.9 (19.2, 22.6) <sup>a</sup>
Yes	70.2 (67.6, 72.8)	27.3 (26.3, 28.4) <sup>a</sup>	64.5 (61.7, 67.4) <sup>b</sup>	23.5 (22.5, 24.4) <sup>ab</sup>

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**Table 2 (continued). Hepatitis B vaccination rates by health-care personnel status: National Health Interview Survey, 2010**

Characteristic	≥ 1 dose hepatitis B vaccine		≥ 3 doses hepatitis B vaccine	
	Health-care personnel		Non-health-care personnel	
	Percent (95% CI)	Percent (95% CI)	Health-care personnel Percent (95% CI)	Non-health-care personnel Percent (95% CI)
Number of physician visits <sup>d</sup>				
0	63.4 (55.8, 71.0)	23.8 (22.0, 25.6) <sup>a</sup>	58.5 (50.8, 66.3)	19.6 (17.8, 21.4) <sup>a</sup>
1	65.8 (59.7, 71.9)	26.3 (24.4, 28.2) <sup>ab</sup>	59.1 (52.8, 65.4)	23.0 (21.0, 24.9) <sup>ab</sup>
2-3	70.9 (66.4, 75.3)	28.2 (26.5, 29.8) <sup>ab</sup>	65.0 (60.3, 69.6)	23.7 (22.2, 25.3) <sup>ab</sup>
4-9	70.0 (65.4, 74.6)	28.5 (26.9, 30.1) <sup>ab</sup>	62.5 (57.6, 67.4)	24.4 (22.9, 25.9) <sup>ab</sup>
≥ 10	75.5 (69.2, 81.8) <sup>b</sup>	28.8 (26.8, 30.9) <sup>ab</sup>	71.7 (64.8, 78.5) <sup>b</sup>	24.5 (22.5, 26.5) <sup>ab</sup>
Usual place of care				
None	66.3 (57.4, 75.2)	24.6 (22.4, 26.8) <sup>a</sup>	59.6 (50.9, 68.4)	20.4 (18.3, 22.5) <sup>a</sup>
Clinic or health center	71.6 (66.8, 76.3)	29.7 (27.8, 31.6) <sup>ab</sup>	64.5 (59.2, 69.9)	24.4 (22.6, 26.0) <sup>ab</sup>
Doctor's office or HMO	69.2 (66.4, 72.2)	26.9 (25.8, 28.1) <sup>ab</sup>	63.5 (60.3, 66.7)	23.2 (22.1, 24.2) <sup>ab</sup>
Other place <sup>e</sup>	70.6 (57.0, 84.3)	27.2 (22.8, 31.5) <sup>a</sup>	61.6 (47.6, 75.6)	22.1 (18.2, 25.9) <sup>a</sup>
Ever been tested for HIV				
No	60.3 (56.4, 64.2)	20.9 (19.8, 22.1) <sup>a</sup>	54.2 (50.1, 58.3)	17.8 (16.7, 18.8) <sup>a</sup>
Yes	76.9 (73.9, 79.9) <sup>b</sup>	37.9 (36.3, 39.4) <sup>ab</sup>	70.9 (67.6, 74.1) <sup>b</sup>	32.1 (30.5, 33.6) <sup>ab</sup>
High-risk behavior <sup>f</sup>				
No	69.0 (66.6, 71.4)	26.5 (25.5, 27.5) <sup>a</sup>	63.1 (60.4, 65.7)	22.4 (21.5, 23.3) <sup>a</sup>
Yes	77.5 (69.2, 85.9) <sup>b</sup>	39.3 (35.8, 42.8) <sup>ab</sup>	68.1 (58.9, 77.3)	34.0 (30.5, 37.5) <sup>ab</sup>
Received influenza vaccine in past year				
No	25.2 (21.5, 28.9)	73.3 (71.7, 74.9) <sup>a</sup>	31.7 (27.8, 35.7)	76.7 (75.2, 78.2) <sup>a</sup>
Yes	74.8 (71.1, 78.5) <sup>b</sup>	26.7 (25.1, 28.3) <sup>ab</sup>	68.3 (64.3, 72.2) <sup>b</sup>	23.3 (21.8, 47.8) <sup>ab</sup>

<sup>a</sup>Wald Chi-square test  $p < 0.05$  for comparison of health-care personnel and non-health-care personnel for each level of characteristic

<sup>b</sup>Wald Chi-square test  $p < 0.05$  for comparison for each level of characteristic within health-care personnel status to the designated referent

<sup>c</sup>Includes American Indian/Alaska Native, Asian, and multiracial people

<sup>d</sup>Includes visits to non-physician health-care providers

<sup>e</sup>Includes responses of "some other place," hospital emergency room, and hospital outpatient departments

<sup>f</sup>High-risk behaviors include people who considered themselves at high risk for HIV infection, people who reported having a sexually transmitted disease other than HIV/AIDS during the previous five years, and people who reported any one of the following risk factors: hemophilia with receipt of clotting factor concentrates, men who have sex with men, injecting street drugs, trading sex for money or drugs, testing positive for HIV, or having sex with someone with any of these risk factors.

CI = confidence interval

NA = not applicable

FPL = federal poverty level

HMO = health maintenance organization

HIV = human immunodeficiency virus

AIDS = acquired immunodeficiency syndrome

74.0% for  $\geq 1$  and  $\geq 3$  doses, respectively) than HCP without direct patient contact (51.1% and 45.8% for  $\geq 1$  and  $\geq 3$  doses, respectively), but coverage was still below the Healthy People 2010 goal of 90%. Independent predictors of vaccination included direct patient contact, having more than a high school education,

influenza vaccination in the past year, and having ever been tested for HIV. There were no significant gains in coverage from 2004 through 2010.

Although reported HepB vaccination coverage among HCP was suboptimal, vaccination coverage was similar to vaccination coverage for influenza (64%) and

**Table 3. Multivariable logistic regression and adjusted hepatitis B vaccination rates among health-care personnel: National Health Interview Survey, 2010**

Characteristic	$\geq 1$ dose hepatitis B vaccine				$\geq 3$ doses hepatitis B vaccine			
	Adjusted rate		AOR		Adjusted rate		AOR	
	Percent	(95% CI)	AOR	P-value	Percent	(95% CI)	AOR	P-value
Age (in years)								
18–24	70.4	(56.7, 84.1)	Ref.		58.9	(45.8, 72.0)	Ref.	
25–29	81.3	(71.1, 91.5)	2.05	0.243	68.2	(56.9, 79.4)	1.60	0.331
30–34	75.9	(66.5, 85.3)	1.40	0.528	66.2	(56.1, 76.4)	1.45	0.411
35–39	76.3	(68.4, 84.2)	1.44	0.441	68.2	(59.3, 77.2)	1.61	0.239
40–44	75.9	(67.0, 84.8)	1.40	0.514	65.0	(54.2, 75.8)	1.35	0.504
45–49	64.8	(56.5, 73.1)	0.74	0.509	63.0	(54.6, 71.5)	1.23	0.614
50–54	67.5	(59.1, 75.9)	0.85	0.727	64.9	(56.4, 73.5)	1.35	0.439
55–59	67.5	(58.2, 76.7)	0.85	0.737	62.3	(52.7, 72.0)	1.18	0.678
60–64	50.9	(38.9, 62.9)	0.37	0.047	43.9	(32.8, 55.0)	0.49	0.090
$\geq 65$	50.8	(38.0, 63.6)	0.36	0.065	47.1	(34.6, 59.5)	0.56	0.224
Sex								
Male	63.6	(57.1, 70.0)	Ref.		57.3	(50.0, 64.5)	Ref.	
Female	70.4	(67.1, 73.7)	1.48	0.076	63.2	(59.6, 66.8)	1.35	0.167
Race/ethnicity								
Non-Hispanic white	69.3	(65.9, 72.7)	Ref.		62.8	(59.3, 66.4)	Ref.	
Non-Hispanic black	70.7	(62.4, 79.0)	1.09	0.769	62.4	(53.0, 71.7)	0.97	0.924
Non-Hispanic other <sup>a</sup>	60.6	(47.9, 73.2)	0.61	0.180	55.9	(42.9, 69.0)	0.70	0.322
Hispanic	67.8	(59.8, 75.7)	0.91	0.723	57.9	(49.6, 66.2)	0.78	0.274
Direct patient contact								
No	56.2	(51.2, 61.1)	Ref.		48.3	(42.8, 53.7)	Ref.	
Yes	77.3	(73.6, 81.0)	3.14	<0.001	70.4	(66.7, 74.0)	2.90	<0.001
Education								
$\leq$ High school	56.1	(49.1, 63.0)	Ref.		48.5	(41.7, 55.2)	Ref.	
$\geq$ Some college	72.3	(69.0, 75.6)	2.43	<0.001	65.4	(61.7, 69.1)	2.28	<0.001
Federal poverty level								
<FPL	66.4	(54.7, 78.0)	Ref.		54.1	(41.7, 66.5)	Ref.	
$\geq$ FPL	68.9	(66.0, 71.7)	1.16	0.688	62.4	(59.3, 65.4)	1.52	0.192
Insured								
No	62.4	(52.0, 72.8)	Ref.		52.1	(40.6, 63.6)	Ref.	
Yes	69.5	(66.5, 72.5)	1.50	0.202	62.9	(59.6, 66.2)	1.71	0.086
Number of physician visits <sup>b</sup>								
0	62.6	(51.4, 73.7)	Ref.		56.4	(45.4, 67.4)	Ref.	
1	71.8	(64.9, 78.6)	1.71	0.153	64.9	(57.3, 72.6)	1.55	0.200
2–3	71.1	(65.8, 76.4)	1.64	0.154	64.5	(58.9, 70.1)	1.51	0.187
4–9	67.8	(63.0, 72.7)	1.35	0.420	59.5	(54.0, 65.1)	1.17	0.643
$\geq 10$	66.8	(57.0, 76.7)	1.27	0.607	61.4	(51.6, 71.2)	1.29	0.543
Place of usual health care								
None	61.6	(48.6, 74.7)	Ref.		57.5	(44.8, 70.3)	Ref.	
Clinic or health center	73.4	(67.3, 79.4)	1.99	0.093	67.2	(60.9, 73.5)	1.65	0.176
Doctor's office or HMO	68.6	(65.1, 72.0)	1.48	0.317	61.2	(57.6, 64.9)	1.21	0.592
Other place <sup>c</sup>	63.2	(40.2, 86.2)	1.09	0.905	54.1	(29.7, 78.4)	0.84	0.799

continued on p. 506



**Table 3 (continued). Multivariable logistic regression and adjusted hepatitis B vaccination rates among health-care personnel: National Health Interview Survey, 2010**

Characteristic	≥1 dose hepatitis B vaccine				≥3 doses hepatitis B vaccine			
	Adjusted rate		AOR		Adjusted rate		AOR	
	Percent	(95% CI)	AOR	P-value	Percent	(95% CI)	AOR	P-value
Ever tested for HIV								
No	64.6	(59.9, 69.3)	Ref.		57.6	(52.4, 62.8)	Ref.	
Yes	72.7	(68.5, 76.9)	1.61	0.020	65.5	(61.2, 69.9)	1.49	0.035
High-risk behavior <sup>d</sup>								
No	68.1	(65.3, 70.9)	Ref.		61.1	(58.0, 64.1)	Ref.	
Yes	79.7	(69.4, 90.0)	2.14	0.61	74.4	(63.3, 85.5)	2.12	0.041
Received flu vaccine in past year								
No	62.1	(57.2, 67.0)	Ref.		55.3	(50.3, 60.4)	Ref.	
Yes	73.6	(69.6, 77.7)	1.96	0.001	66.5	(62.2, 70.8)	1.76	0.003

<sup>a</sup>Includes American Indian/Alaska Native, Asian, and multiracial people

<sup>b</sup>Includes visits to non-physician health-care providers

<sup>c</sup>Includes responses of "some other place," hospital emergency room, and hospital outpatient departments

<sup>d</sup>High-risk behaviors include people who considered themselves at high risk for HIV infection, people who reported having a sexually transmitted disease other than HIV/AIDS during the previous five years, and people who reported any one of the following risk factors: hemophilia with receipt of clotting factor concentrates, men who have sex with men, injecting street drugs, trading sex for money or drugs, testing positive for HIV, or having sex with someone with any of these risk factors.

AOR = adjusted odds ratio

CI = confidence interval

Ref. = reference group

FPL = federal poverty level

HMO = health maintenance organization

HIV = human immunodeficiency virus

AIDS = acquired immunodeficiency syndrome

tetanus (70%), two other vaccines recommended for HCP in the U.S.<sup>20,21</sup> Suboptimal HepB vaccine coverage in the past was, in part, due to concerns about vaccine side effects, lack of knowledge of the morbidity and mortality associated with HBV infection, and lack of knowledge of the risk of infection.<sup>22-30</sup> In a 2007 study of HepB vaccination among HCP, approximately one-third of unvaccinated HCP refused vaccination based on a belief that they could get HBV from vaccination.<sup>31</sup> Although these barriers to vaccination suggest that additional education about the benefits and safety of vaccination might increase vaccination coverage among HCP, more recent evidence concerning influenza vaccination suggests that increased education does little to improve vaccination among HCP.<sup>32-36</sup>

Having more than a high school education was associated with vaccination, a correlation that has been seen in other studies of adult vaccination.<sup>37</sup> Reported receipt of seasonal influenza vaccination in the past year among HCP was also associated with vaccination, which may indicate a more general acceptance of vaccination and preventive services.

One strategy to improve vaccination coverage

among HCP is employer-mandated vaccination. Institutional requirements for influenza vaccination have led to higher vaccination levels. Miller et al. examined influenza vaccination coverage following institution of vaccination policies within a sample of U.S. hospitals and found that single-season influenza vaccination rates increased approximately 15% after instituting hospital policies requiring receipt or declination of influenza vaccination. Hospitals that instituted adverse consequences for refusal had higher coverage increases.<sup>38</sup> Policies requiring vaccination with tetanus, diphtheria, and acellular pertussis (Tdap) vaccine have also improved Tdap vaccination levels. In 2010, the University of North Carolina (UNC) made employment of HCP with direct patient contact conditional upon Tdap vaccination. UNC achieved a near-100% compliance rate after instituting the policy.<sup>39</sup> While we are unaware of any compulsory institutional policies for HepB vaccination of HCP, such requirements might be more difficult to implement than programs for influenza and Tdap because of the challenges related to documenting three doses of HepB vaccine that can be given during the course of several months or years.

HepB vaccine is routinely administered to people of all ages in multiple settings, and documentation of vaccination might not be available, making it difficult to ascertain whether HCP are protected against HBV infection and if vaccination is indicated. However, documentation of HepB vaccination has increasingly been required of students entering health-care professional training programs; more than 90% of U.S. health professional schools require HepB vaccination for matriculation. This practice may account for higher coverage among HCP aged 18–29 years compared with non-HCP in this age group in our study.<sup>40</sup> Over time, documentation of HepB vaccination might be improved through availability of records from childhood, schools, or immunization registries.

Similar to age-related coverage rates among other groups at high risk for HBV infection, HepB vaccine coverage among HCP in our study was similar for younger HCP.<sup>37</sup> Coverage rates among younger HCP will increasingly be influenced by infant and adolescent HepB vaccination programs, which were implemented during 1991–1999.<sup>41–43</sup> Children who were vaccinated after the recommendations were implemented would have been 19–29 years of age in 2010, when the survey data were collected. Given the assumption that childhood vaccination programs and school matriculation requirements will enhance HepB vaccination coverage among younger HCP, it is reasonable to expect that coverage among HCP will increase in future years.

The 1991 OSHA requirement for employers to offer HepB vaccine at no cost to all workers who are occupationally exposed might also contribute to higher HepB vaccine coverage among HCP.<sup>8</sup> Although this study clearly shows higher vaccination rates among

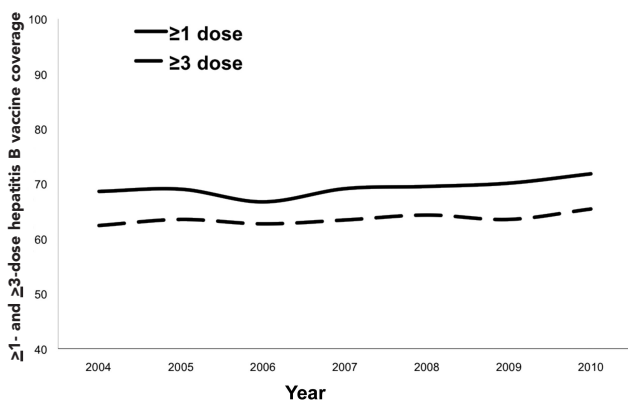
HCP compared with non-HCP, the OSHA requirement might be expected to have had a greater impact on HCP vaccination rates. However, the OSHA requirement to offer HepB vaccine for free to employees does not ensure that employees will seek or accept vaccination; lack of seeking or accepting vaccination may contribute to the modest vaccination rate among HCP seen in this study.

Current ACIP recommendations state: “All unvaccinated people whose work- and training-related activities involve reasonably anticipated risk for exposure to blood or other infectious body fluids should be vaccinated with the complete,  $\geq 3$ -dose HepB vaccine series.”<sup>9</sup> HCP with direct patient contact had higher coverage than HCP without direct patient contact. While the majority of HCP with exposure to bodily fluids are involved in direct patient contact, a substantial percentage (28%) of exposures involved HCP without direct patient contact. During 1995–2007, 4% of reported exposures to bodily fluids were sustained by HCP whose jobs did not involve the routine handling of sharps, such as maintenance staff, housekeeping, and administrative personnel.<sup>15</sup> Because of HBV stability and infectiousness, transmission can occur from exposure of non-intact skin (e.g., from blood spills, contaminated environmental surfaces, or non-patient care-related sharps injuries such as during waste handling), thereby also putting HCP without direct patient contact at risk of exposure.<sup>1</sup>

HCP who had ever been tested for HIV were more likely to be vaccinated. We speculate that the association between ever having been tested for HIV and vaccination might be related to testing after occupational exposures, such as needlestick injuries. HCP who experienced needlestick injuries or other recognized exposures to body fluids might be more prone to seek or accept protection from bloodborne pathogens through vaccination.

Comprehensive strategies are needed to improve vaccination coverage for HCP. Recommended approaches include emphasizing the benefits of vaccination to staff and patients; using the level of vaccination coverage among HCP as a measure of patient safety and quality assurance; instituting electronic tracking of coverage levels by ward, unit, and occupation; targeting interventions to settings in which low vaccine coverage levels are identified; implementing catch-up vaccination programs for HCP who are already employed; and ensuring that newly hired HCP receive necessary vaccinations.<sup>9,44–46</sup> In addition, on descriptive analysis of the study data, home health aides and HCP within other health-care support occupations had the lowest reported HepB vaccination coverage. A strategy to

**Figure. Hepatitis B vaccination coverage among health-care personnel aged  $\geq 18$  years: National Health Interview Survey, 2004–2010**



improve overall coverage among HCP may also include targeting HCP by specific job description.

### Limitations

This study was subject to several limitations. Vaccination status was self-reported and not verified by vaccination records. In two studies, agreement between self-report of adult vaccinations and provider records for influenza and pneumococcal vaccine was relatively high: 89%–92% for influenza and 79% for pneumococcal vaccine.<sup>47–49</sup> Studies assessing the validity of self-reported HepB vaccination through comparison with provider records are not available. One study, however, reported 70% agreement between self-report and serologic evidence of vaccination.<sup>49</sup> Recall bias could have led to over- or underestimation of coverage. Until adult vaccination records are more systematically collected and accessible in health-care settings, however, national surveys of self-reported vaccination status continue to be a viable method of monitoring vaccination coverage among HCP. Lastly, the NHIS is not specifically designed to survey HCP. However, NHIS uses a random, multistage sample designed to represent the civilian noninstitutionalized population of the U.S.; therefore, all noninstitutionalized populations (e.g., HCP and pregnant women) should be well represented.<sup>15</sup>

### CONCLUSION

Despite the availability of a safe and effective vaccine that is available at no cost to most HCP, HepB vaccination coverage is below Healthy People 2010 objectives. Continued efforts are needed to increase HepB coverage among unvaccinated HCP to protect workers and patients.

This study used a publicly available dataset of de-identified data. Therefore, no institutional review board approval was necessary.

### REFERENCES

- Gibas A, Blewett DR, Schoenfeld DA, Dienstag JL. Prevalence and incidence of viral hepatitis in health workers in the prehepatitis B vaccination era. *Am J Epidemiol* 1992;136:603-10.
- Gerberding JL. Incidence and prevalence of human immunodeficiency virus, hepatitis B virus, hepatitis C virus, and cytomegalovirus among health care personnel at risk for blood exposure: final report from a longitudinal study. *J Infect Dis* 1994;170:1410-7.
- Lanphear BP. Trends and patterns in the transmission of bloodborne pathogens to health care workers. *Epidemiol Rev* 1994;16:437-50.
- Beltrami EM, Williams IT, Shapiro CN, Chamberland ME. Risk and management of blood-borne infections in health care workers. *Clin Microbiol Rev* 2000;13:385-407.
- Updated U.S. Public Health Service guidelines for the management of occupational exposures to HBV, HCV, and HIV and recommendations for postexposure prophylaxis. *MMWR Recomm Rep* 2001;50(RR-11):1-52.
- Bond WW, Favero MS, Petersen NJ, Gravelle CR, Ebert JW, Maynard JE. Survival of hepatitis B virus after drying and storage for one week. *Lancet* 1981;1:550-1.
- Recommendation of the Immunization Practices Advisory Committee (ACIP). Inactivated hepatitis B virus vaccine. *MMWR Morb Mortal Wkly Rep* 1982;31(24):317-22, 327-8.
- Department of Labor (US). Bloodborne pathogens: the standard. *Fed Reg* 1991;60:64175-82.
- Shefer A, Atkinson W, Friedman C, Kuhar DT, Motrey G, Bialek SR, et al. Immunization of healthcare personnel. Recommendations of the Advisory Committee on Immunization Practices. *MMWR Recomm Rep* 2011;60(RR-07):1-45.
- Agerton TB, Mahoney FJ, Polish LB, Shapiro CN. Impact of the bloodborne pathogens standard on vaccination of healthcare workers with hepatitis B vaccine. *Infect Control Hosp Epidemiol* 1995;16:287-91.
- Update: universal precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus, and other bloodborne pathogens in health-care settings. *MMWR Morb Mortal Wkly Rep* 1988;37(24):377-82, 387-8.
- Garner JS. Guideline for isolation precautions in hospitals. The Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1996;17:53-80.
- Lee JM, Botteman MF, Xanthakos N, Nicklasson L. Needlestick injuries in the United States. Epidemiologic, economic, and quality of life issues. *AAOHN J* 2005;53:117-33.
- Centers for Disease Control and Prevention (US). The National Surveillance System for Healthcare Workers (NaSH): summary report for blood and body fluid exposure data collected from participating healthcare facilities (June 1995 through December 2007) [cited 2012 Jan 11]. Available from: URL: <http://www.cdc.gov/nhsn/PDFs/NaSH/NaSH-Report-6-2011.pdf>
- Department of Health and Human Services (US). Proposed healthy people 2020 objectives [cited 2012 Jan 11]. Available from: URL: <http://www.healthypeople.gov/hp2020/Objectives/TopicAreas.aspx>
- Centers for Disease Control and Prevention (US). National Health Interview Survey [cited 2011 Dec 15]. Available from: URL: [ftp://ftp.cdc.gov/pub/Health\\_Statistics/NCHS/Dataset\\_Documentation/NHIS/2010/srvydesc.pdf](ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2010/srvydesc.pdf)
- StataCorp. Stata®: Release 11. College Station (TX): StataCorp.; 2009.
- Centers for Disease Control and Prevention (US). Standard Occupational Classification (SOC) and North American Industry Classification (NAICS) [cited 2012 Apr 20]. Available from: URL: [ftp://ftp.cdc.gov/pub/Health\\_Statistics/NCHS/Dataset\\_Documentation/NHIS/2010/samadult\\_layout.pdf](ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2010/samadult_layout.pdf)
- Research Triangle Institute. SUDAAN®: Release 10.1. Research Triangle Park (NC): Research Triangle Institute; 2010.
- Influenza vaccination coverage among health-care personnel—United States, 2010–11 influenza season. *MMWR Morb Mortal Wkly Rep* 2011;60(32):1073-7.
- Lu PJ, Euler GL. Influenza, hepatitis B, and tetanus vaccination coverage among health care personnel in the United States. *Am J Infect Control* 2011;39:488-94.
- Doebbeling BN, Ferguson KJ, Kohout FJ. Predictors of hepatitis B vaccine acceptance in health care workers. *Med Care* 1996;34:58-72.
- Crossley KB, Gerding DN, Petzel RA. Acceptance of hepatitis B vaccine by hospital personnel. *Infect Control* 1985;6:147-9.
- Bodenheimer HC, Fulton JP, Kramer PD. Acceptance of hepatitis B vaccination among hospital workers. *Am J Public Health* 1986;76:252-5.
- Lewy R. Immunizations among hospital personnel. *J Occup Med* 1987;29:433-6.
- Harvard MP, Kaiser DL, Fedson DS. Acceptance of hepatitis B vaccine by medical and surgical residents. *J Gen Intern Med* 1988;3:150-5.
- Hashimoto F, Hunt WC, Brusuelas P. Physician acceptance of the hepatitis B vaccine at a university medical center. *Am J Public Health* 1988;78:973-4.
- Scapa E, Karpuch J, Waron M, Eschar J. Attitude of hospital personnel toward hepatitis B vaccination. *Am J Gastroenterol* 1989;84:400-2.
- Spence MR, Dash GP. Hepatitis B: perceptions, knowledge and vac-

- cine acceptance among registered nurses in high-risk occupations in a university hospital. *Infect Control Hosp Epidemiol* 1990;11:129-33.
30. Murata PJ, Young LC. Physicians' attitudes and behaviors regarding hepatitis B immunization. *J Fam Pract* 1993;36:163-8.
  31. Simard EP, Miller JT, George PA, Wasley A, Alter MJ, Bell BP, et al. Hepatitis B vaccination coverage levels among healthcare workers in the United States. *Infect Control Hosp Epidemiol* 2007;28:783-90.
  32. Heimberger T, Chang HG, Shaikh M, Crotty L, Morse D, Birkhead G. Knowledge and attitudes of healthcare workers about influenza: why are they not getting vaccinated? *Infect Control Hosp Epidemiol* 1995;16:412-5.
  33. Harbarth S, Siegrist CA, Schira JC, Wunderli W, Pittet D. Influenza immunization: improving compliance of healthcare workers. *Infect Control Hosp Epidemiol* 1998;19:337-42.
  34. Dey P, Halder S, Collins S, Benons L, Woodman C. Promoting uptake of influenza vaccination among health care workers: a randomized controlled trial. *J Public Health Med* 2001;23:346-8.
  35. Smedley J, Palmer C, Baird J, Barker M. A survey of the delivery and uptake of influenza vaccine among health care workers. *Occup Med (Lond)* 2002;52:271-6.
  36. Manuel DG, Henry B, Hockin J, Naus M. Health behavior associated with influenza vaccination among healthcare workers in long-term-care facilities. *Infect Control Hosp Epidemiol* 2002;23:609-14.
  37. Lu PJ, Byrd KK, Murphy TV, Weinbaum C. Hepatitis B vaccination coverage among high-risk adults 18-49 years, U.S., 2009. *Vaccine* 2011;29:7049-57.
  38. Miller BL, Ahmed F, Lindley MC, Wortley PM. Increases in vaccination coverage of healthcare personnel following institutional requirements for influenza vaccination: a national survey of U.S. hospitals. *Vaccine* 2011;29:9398-403.
  39. Weber DJ, Consoli SA, Sickbert-Bennett E, Rutala WA. Assessment of a mandatory tetanus, diphtheria, and pertussis vaccination requirement on vaccine uptake over time. *Infect Control Hosp Epidemiol* 2012;33:81-3.
  40. Lindley MC, Lorick SA, Spinner JR, Krull AR, Mootrey GT, Ahmed F, et al. Student vaccination requirements of U.S. health professional schools: a survey. *Ann Intern Med* 2011;154:391-400.
  41. Hepatitis B virus: a comprehensive strategy for eliminating transmission in the United States through universal childhood vaccination: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep* 1991;40(RR-13):1-19.
  42. Update: recommendations to prevent hepatitis B virus transmission—United States. *MMWR Morb Mortal Wkly Rep* 1995;44(30):574-5.
  43. Update: recommendations to prevent hepatitis B virus transmission—United States. *MMWR Morb Mortal Wkly Rep* 1999;48(2):33-4.
  44. Poland GA, Shefer AM, McCauley M, Webster PS, Whitely-Williams PN, Peter G, et al. Standards for adult immunization practice. *Am J Prev Med* 2003;25:144-50.
  45. Lindley MC, Horlick GA, Shefer AM, Shaw FE, Gorji M. Assessing state immunization requirements for healthcare workers and patients. *Am J Prev Med* 2007;32:459-65.
  46. Centers for Disease Control and Prevention (US). Guide to community preventive services [cited 2013 Jun 6]. Available from: URL: <http://www.cdc.gov/epo/communityguide.htm>
  47. MacDonald R, Baken L, Nelson A, Nichol KL. Validation of self-report of influenza and pneumococcal vaccination status in elderly outpatients. *Am J Prev Med* 1999;16:173-7.
  48. Shenson D, Dimartino D, Bolen J, Campbell M, Lu PJ, Singleton JA. Validation of self-reported pneumococcal vaccination in behavioral risk factor surveillance surveys: experience from the Sickness Prevention Achieved through Regional Collaboration (SPARC) program. *Vaccine* 2005;23:1015-20.
  49. Tawk HM, Vickery K, Bisset L, Selby W, Cossart YE; Infection in Endoscopy Study Group. The impact of hepatitis B vaccination in a Western country: recall of vaccination and serological status in Australian adults. *Vaccine* 2006;24:1095-106.