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Determinants of Hepatitis B Vaccination among Adults in the United States: NHANES 1999-2006

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Abstract

Purpose: The primary objective of this study was to estimate the prevalence of vaccination and HBV infection status of adults and to evaluate the trend in self reported vaccination and seroprevalence for Hepatitis B for this population. Additionally, this study sought to assess the association between vaccination rates, seroprevalence (HBsAg, anti-HBc, and anti-HBs), demographic (age, gender, location of birth, race/ethnicity), and socioeconomic (annual household income, education level, insurance coverage and access to care, marital status) characteristics.

Methods: Eight years, 1999-2006, of the National Health and Nutrition Examination Survey (NHANES) data were used. NHANES participants aged 20-59 years who contributed data via the household interview and laboratory component were eligible for this study. Two sources of vaccination status were available. The vaccination status was identified through self-report. Those who answered yes to "less than three doses" and "at least three doses" were classified as vaccinated. Vaccination status was also verified through serologic markers. All analyses were weighted to consider the complex weighting scheme and adjusted to the 2000 US census population. Vaccination rates were calculated for both low and high risk populations. 95% confidence intervals (95% CI) of each estimate were also calculated. The association between potential predictors of vaccination (demographic variables, socioeconomic status, high risk, and health care access and utilization variables) and vaccination status was assessed using bivariate analysis. We used logistic regression model to obtain odds ratios and their 95% confidence intervals for the association between predictor variables and vaccination status after adjusting for all potential confounding factors.

Results: Vaccinated adults were more likely to be female, younger (20-29), Non-Hispanic white, married, born in the United States, have some education beyond high school, have a household income greater than $20000, health insurance coverage, a source of usual medical care, report a health status of good or higher, be non-smokers, and have no history of alcohol abuse. High risk adults comprised about 16% of adults who had received at least one dose of the Hepatitis B vaccine. Unvaccinated adults were more likely to be male, over the age of 40, Non-Hispanic white, born in the United States, married, have some education beyond high school, have a household income greater than $20,000, live in a household of 6 or fewer people, have health insurance coverage, and a source of usual care. When comparing the self reported vaccination status with serologic status, almost half of the adults who reported receiving all three doses of the vaccine tested negative for immunity. For all adults the prevalence increased from 23.4% to 39.1%. Compared to adults in 1999-2000, adults were twice as likely to report vaccination in 2005-2006 (OR=2.1 95% CI [1.77, 2.49]).

Conclusions: Although, hepatitis B vaccination rates are rising, only 32% of high risk adults are vaccinated. The rise in vaccination rates in young adults is mostly related to childhood immunization strategies and not strategies aimed at adults. Older males, those with less than high school education, without health insurance coverage and a source of usual care were least likely to be vaccinated. More targeted interventions are needed to educate and vaccinate the adult population and to create a means for identifying those at risk and those already vaccinated.

Determinants of Hepatitis B Vaccination among Adults in the United States: NHANES 1999-2006

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INTRODUCTION

Hepatitis B is a potentially life-threatening liver infection caused by the hepatitis B virus (HBV) and a major global health problem. An estimated two billion people globally have been infected with HBV, and more than 350 million have chronic liver infections.[1] In the United States, there are approximately 1.3 million people living with chronic HBV.[2] During 2006, a total of 4,713 acute, symptomatic cases of hepatitis B were reported.[2] While the overall incidence has declined 81% since 1990, asymptomatic infections and underreporting accounted for an estimated 46,000 new infections in 2006. HBV puts chronic carriers at high risk of death from cirrhosis and hepatocellular carcinoma.

HBV is transmitted by percutaneous or mucosal exposure to the blood or body fluids of an infected person.[2] This occurs most often through intravenous drug use (IDU), sexual contact, or contact from an infected mother to her infant during delivery. HBV can also be transmitted through nonsexual interpersonal contact over an extended period. For example, household contacts of a person with chronic HBV infection are at higher risk of contracting the virus.[2]

The two primary sources of HBV infection for infants and children are perinatal transmission from infected mothers and horizontal transmission from contact with infected household members.[3] Adolescents are at risk for HBV infection primarily through high-risk sexual activity and injection-drug use. Among adults, HBV transmission occurs principally among unvaccinated adults with risk behaviors for HBV transmission (e.g., heterosexuals with

multiple sex partners, injection-drug users [IDUs], and men who have sex with men [MSM]) and horizontal transmission.

No treatment is currently recommended for acute hepatitis B.[4] Supportive care is the primary therapy. Those with chronic HBV infection require regular medical evaluation and monitoring to determine if the disease is progressing and to identify liver damage or hepatocelluar carcinoma. For chronic infection, several antiviral drugs are available. However, because of expense and possible needs for hospitalization, prevention has emerged as a more practical approach.

The current form of the hepatitis B vaccine has been used in the United States since 1986.[9] Before 1991, the vaccine was recommended only for people who were identified to be at a high risk for acquiring the infection. Adults at increased risk for infection include health care workers, dialysis patients, household contacts and sex partners of persons with chronic HBV infection, recipients of certain blood products, persons with a recent history of multiple sex partners or an STD, MSM, and injection-drug users.[2] Despite these recommendations, coverage remained low among adults at risk for HBV infection remained low.[5,6] In 1991, recommendations for vaccination of unvaccinated adults at high risk for HBV infection became part of the national strategy adopted by Advisory Committee on Immunization Practices (ACIP) to eliminate HBV transmission in the United States.[9] Immunization strategies for infants, children, and adolescents have been successful.[3,6] Hepatitis B vaccine has been integrated into the childhood vaccination schedule, and infant vaccination coverage levels now are comparable to those of other childhood vaccines.[6]

For adults, ongoing HBV transmission occurs primarily among unvaccinated adults with risk behaviors for HBV transmission. While studies have shown a slight increase in vaccination

coverage among this population between 2000 and 2004, it is attributed to the 35% decline in acute hepatitis B incidence that occurred during this period.[7] Incidence of acute hepatitis B remains highest among adults, who accounted for approximately 95% of an estimated 51,000 new HBV infections in 2005.[3] Acceptance of vaccination is high among adults who are offered vaccination. The low adult vaccination coverage reflects the lack of hepatitis B vaccination services and missed vaccination opportunities in settings in which a large proportion of adults at risk for HBV infection. [8]

OBJECTIVES

Hepatitis B incidence among adults is expected to decline during the next decade as cohorts of those vaccinated in infancy, childhood, and adolescence reach adulthood.[9] However, new implementation strategies are needed to protect unvaccinated adults at risk for HBV infection. In order to meet Healthy People 2010 objectives related to Hepatitis B vaccination among adults with high risk behaviors, an analysis of the factors that affect vaccination rates should be completed. The primary objective of this study was to estimate the prevalence of vaccination and HBV infection status of adults and to evaluate the trend in self reported vaccination and seroprevalence for Hepatitis B for this population. Additionally, this study sought to assess the association between vaccination rates, seroprevalence (HBsAg, anti-HBc, and anti-HBs), demographic (age, gender, location of birth, race/ethnicity), and socioeconomic (annual household income, education level, insurance coverage and access to care, marital status) characteristics.

METHODS

Eight years, 1999-2006, of the National Health and Nutrition Examination Survey (NHANES) data were used. The National Center for Health Statistics (NCHS), Division of

Health Examination Statistics (DHES), part of the Centers for Disease Control and Prevention (CDC), conducts the surveys. NHANES is a program of studies designed to assess the health and nutritional status of adults and children in the United States. The survey is unique in that it combines interviews and physical examinations. The NHANES interview includes demographic, socioeconomic, dietary, and health-related questions. The examination component consists of medical, dental, physiological measurements, and laboratory tests administered by highly trained medical personnel.

The NHANES survey design is a stratified, multistage probability sample that is weighted to represent the civilian non-institutionalized U.S. population.[10-13] The sample for the survey is selected to represent the U.S. population of all ages. To produce reliable statistics, NHANES over-samples of low-income persons, adolescents 12–19 years, persons 60+ years of age, African Americans, and Mexican Americans.[14-17]

Study population

NHANES participants aged 20-59 years who contributed data via the household interview and laboratory component were eligible for this study. Participants in this age range were asked questions related to sexual practices and illegal drug use. Participants were not included in this study if they had missing data related to immunization status, sexual behavior, drug use, and HBV serology data. The final analytic sample consisted of 7273 participants representing 99,263,120 Americans. The unweighted sample sizes of adults analyzed were 1431 for 1999-2000, 2037 for 2001-2002, 1856 for 2003-2004, and 1949 for 2005-2006.

Laboratory analysis

Blood specimens were processed, stored, and shipped to the Division of Viral Hepatitis, National Center for Infectious Diseases, National Centers for Disease Control and Prevention.

Details on the serologic methods used by NHANES are discussed extensively elsewhere.[18-21] Briefly, the Hepatitis B core antibody (anti-HBc) Ortho HBc ELISA Test System detects prior exposure. The Hepatitis B surface antigen (HBsAg) AUSZYME Monoclonal test is a solid-phase "sandwich" enzyme immunoassay is used to detect current infection with HBV. The Hepatitis B surface antibody (anti-HBs) test used the AUSAB EIA which detects exposure to the antigen or vaccine.

Hepatitis C virus (anti-HCV) was measured using direct solid-phase enzyme immunoassay with the anti-HCV screening ELISA. For HIV status, specimens were tested using the Synthetic Peptide Enzyme Immunoassay (EIA) (Genetic Systems HIV-1/HIV-2 Peptide EIA) for the detection of antibody to human immunodeficiency virus type 1 or type 2 (HIV-1 and HIV-2) or both (Bio-Rad Laboratories, Hercules, CA). Blood and urine specimens were processed, stored, and shipped to the Division of AIDS, STD, and TB, National Center for HIV, STD, and TB Prevention, National Centers for Disease Control and Prevention.[18-21]

Determinants

The Advisory Committee on Immunization Practices (ACIP) recommends routine pre-exposure vaccination for populations at higher risk for HBV as described in Table 1.[22] The NHANES data used in this study is capable of capturing the majority of high-risk groups related to sexual practice (more than one sexual partner within 30 days prior to the interview, MSM/homosexual or bisexual men), illegal drug use (ever used intravenous drugs), recent history of sexually transmitted infections (genital herpes, genital warts, gonorrhea, chlamydia, HIV, and chronic liver disease (Hepatitis C). Since questions regarding sexual orientation were not asked until 2001, males who responded homosexual or bisexual were coded as high risk in addition to answers provided for lifetime sexual history with males. Participants were

categorized as higher risk of HBV if they met at least one of these definitions through self-report or laboratory data (HCV, HIV). Participants who did not meet the criteria for higher risk were categorized as being lower risk for contracting HBV.

Table 1. Individuals classified as being at higher risk for HBV[22]

- Susceptible sex partners of hepatitis B surface antigen (HBsAg)-positive persons
- **Sexually active persons who are not in a long-term, mutually monogamous relationship (e.g., >1 sex partner during the previous 6 months)**
- **Persons seeking evaluation or treatment for a sexually transmitted disease**
- **Men who have sex with men**
- **Injection drug users**
- Susceptible household contacts of HBsAg-positive persons
- Healthcare and public safety workers at risk for exposure to blood or blood-contaminated body fluids
- Persons with end-stage renal disease, including predialysis, hemodialysis, peritoneal dialysis, and home dialysis patients
- Residents and staff of facilities for developmentally disabled persons
- Travelers to regions with intermediate or high rates of endemic HBV infection
- **Persons with chronic liver disease**
- **Persons with HIV infection**
- All other persons seeking protection from HBV infection — acknowledgment of a specific risk factor is not a requirement for vaccination

Note: Boldface indicate which risk factors are captured by NHANES

Outcome variable

Two sources of vaccination status were available. The vaccination status was identified through self-report to the question "Have you ever received the 3-dose series of the hepatitis B vaccine?".[14-17] The questionnaire provided a description of the vaccine. Those who answered yes to "less than three doses" and "at least three doses" were classified as vaccinated. Vaccination status was also verified through serologic markers. Table 2 provides interpretations for hepatitis B serologic markers. Blood specimens were analyzed for HBsAg, anti-HBc, and anti-HBs. Serologic status was classified as vaccinated (immune due to Hepatitis B vaccination), unvaccinated (susceptible), and history of Hepatitis B infection (immune due to natural infection). Since NHANES does not test for the presence of IgM antibody to hepatitis B core

antigen (IgM anti-HBc), it is not possible to determine if participants are acutely or chronically infected.

Table 2. Interpretation of hepatitis B serologic test results[23]

Tests	Results	Interpretation
HBsAg	negative	Susceptible or loss of anti-HBs over time after vaccinated
anti-HBc	negative	
anti-HBs	negative	
HBsAg	negative	Immune due to natural infection
anti-HBc	positive	
anti-HBs	positive	
HBsAg	negative	Immune due to hepatitis B vaccination
anti-HBc	negative	
anti-HBs	positive	
HBsAg	positive	Acutely infected
anti-HBc	positive	
IgM anti-HBc	positive	
anti-HBs	negative	
HBsAg	positive	Chronically infected
anti-HBc	positive	
IgM anti-HBc	negative	
anti-HBs	negative	
HBsAg	negative	Interpretation unclear; four possibilities:
anti-HBc	positive	1. Resolved infection (most common)
anti-HBs	negative	2. False-positive anti-HBc, thus susceptible
		3. "Low level" chronic infection
		4. Resolving acute infection

Potential confounders

Based on our literature review[1-9], we evaluated the following variables for confounding: age, gender, race/ethnicity, location of birth, education level, marital status, age at first intercourse, sexual orientation, household size, annual household income, insurance status, health care access, health status, history of alcohol abuse, and current tobacco use. Age was categorized as 20-29, 30-39, 40-49, and 50-59. Race/ethnicity was coded as non-Hispanic white, non-Hispanic black, Hispanic, and other. Location of birth was categorized as US-born, Mexico-born, and other. Education level was classified as less than high school, completed high school,

and more than high school. Marital status was classified as never married, married, previously married, and living with partner.

Household size was grouped as 1-3 people, 4-6 people, and 7 or more people. For health care access, participants were asked if they had a source of usual care. Self-reported health status was categorized as excellent, very good, good, fair, and poor. The following variables were dichotomized: age at first intercourse (less than 18 years old, 18 years and older), insurance status (current coverage, no coverage), history of alcohol abuse (yes, no), and cigarette use (smoker, non-smoker). Participants were classified as having a history of alcohol abuse if they answered yes to the question "Was there ever a time or times in your life when you drank 5 or more drinks of any kind of alcoholic beverage almost every day?".[14-17]

Statistical analysis

All analyses were weighted to consider the complex weighting scheme and adjusted to the 2000 US census population. Vaccination rates were calculated for both low and high risk populations. 95% confidence intervals (95% CI) of each estimate were also calculated. The association between potential predictors of vaccination (demographic variables, socioeconomic status, high risk, and health care access and utilization variables) and vaccination status was assessed using bivariate analysis. We used logistic regression model to obtain odds ratios and their 95% confidence intervals for the association between predictor variables and vaccination status after adjusting for all potential confounding factors. SAS version 9.2 was used to produce the appropriate estimates and standard errors.

RESULTS

Table 3 compares the demographics, socioeconomic status, and health care access and utilization, and risk variables with vaccination status for all adults. Vaccinated adults were more

likely to be female, younger (20-29), Non-Hispanic white, married, born in the United States, have some education beyond high school, have a household income greater than $20000, health insurance coverage, a source of usual medical care, report a health status of good or higher, be non-smokers, and have no history of alcohol abuse. High risk adults comprised about 16% of adults who had received at least one dose of the Hepatitis B vaccine.

Unvaccinated adults were more likely to be male, over the age of 40, Non-Hispanic white, born in the United States, married, have some education beyond high school, have a household income greater than $20,000, live in a household of 6 or fewer people, have health insurance coverage, and a source of usual care. Similar to the vaccinated group, they rated their health status as good or higher, they were non-smokers, and had no history of alcohol abuse. Similar to the vaccinated group, high risk adults were about 15% of unvaccinated adults.

Table 3. Comparison of adults vaccinated and unvaccinated for hepatitis B virus: NHANES 1999-2006

	Vaccinated %	**Unvaccinated %**
Variables		
Sample (n)		
Unweighted	2220	5053
Weighted	30276510	68986610
Gender		
Male	41.90	53.79
Female	58.10	46.21
Age		
20-29	32.10	15.95
30-39	27.80	25.45
40-49	25.13	32.26
50-59	14.97	26.34
Race/ethnicity		
Non-Hispanic White	73.22	75.86
Non-Hispanic Black	10.66	8.66
Hispanic	11.25	12.03
Other	4.87	3.45

Table 3. Comparison of adults vaccinated and unvaccinated for hepatitis B virus: NHANES 1999-2006 (continued)

	Vaccinated %	Unvaccinated %
Variables		
Country of birth		
US	88.96	87.86
Mexico	2.76	4.46
Abroad	8.28	7.68
Marital status		
Never married	23.40	14.55
Married	55.06	62.44
Previously married	12.94	15.07
Living with partner	8.60	7.93
Age at first intercourse		
Less than 18 years old	60.02	57.86
>=18 years old	39.98	42.14
Education		
Less than high school	10.02	15.04
Completed high school	19.49	27.45
Some college or beyond	70.49	57.51
Income		
Less than $20,000	14.03	13.45
$20,000 or more	85.97	86.55
Household size		
1-3 people	59.94	63.43
4-6 people	37.14	33.68
7 or more people	2.92	2.89
Current health insurance coverage		
Yes	82.25	79.72
No	17.75	20.28
Source of usual care		
Yes	86.18	82.54
No	13.82	17.46
Health status		
Excellent	24.44	22.51
Very good	35.13	32.99
Good	28.81	30.66
Fair	9.87	11.09
Poor	1.75	2.75
Cigarette smoker		
Smoker	29.53	29.93
Non-smoker	70.47	70.07

Table 3. Comparison of adults vaccinated and unvaccinated for hepatitis B virus: NHANES 1999-2006 (continued)

	Vaccinated %	Unvaccinated %
Variables		
History of alcohol abuse		
Yes	13.91	17.93
No	86.09	82.07
Received at least 1 dose Hepatitis B vaccine		
High risk	16.02	14.65
Low risk	83.98	85.35

Table 4 shows what factors affect the likelihood of adults receiving at least one dose of the Hepatitis B vaccine along with crude and adjusted ORs and their 95% CIs. The crude analysis indicates that those who were vaccinated were more likely to be female, under the age of 50, of a minority ethnicity/race, never married, born in the United States, have education beyond high school, live in a household of 4-6 people, have current health insurance coverage, and rate their health status as excellent. The adjusted model shows that males are almost 40% less likely to be vaccinated compared to females (OR=0.64, 95% CI [0.57, 0.73]). Adults aged 50-59 were least likely to be vaccinated. Vaccination odds increased with every decrease in decade with 20-29 year olds three times more likely to be vaccinated (OR=3.69 95% CI [2.98, 4.56]). Minorities vaccination odds were only significant for Non-Hispanic blacks (OR=1.22 95% CI [1.03, 1.43]) and other minorities (OR=1.40 95% CI [1.06, 1.83]). Adults who had never been married were vaccinated 25% more often than married adults (OR=1.25 95% CI [1.04, 1.50]). Having less than some college education, decreased the odds of vaccination by half ($OR_{\text{less than HS}}$=0.51 95% CI [0.41, 0.64]). Vaccination status increased by 20% with household size, but only those who lived in a household of 4-6 people was found to be statistically significant (OR=1.24 95% CI [1.08,1.44]) . Factors that had little or no impact on

vaccination status included country of birth, income, self reported health status, being a smoker, or having a history of alcohol abuse.

Table 4. Factors associated with receipt of hepatitis B vaccination among adults: NHANES 1999-2006

	Vaccinated	Unvaccinated	Odds Ratios			
	%	%	Crude (95% CI)		Adjusted (95% CI)	
Variables						
Sample						
Unweighted	2220	5053				
Weighted	30276510	68986610				
Gender						
Male	25.48	74.52	**0.62**	**(0.56, 0.69)**	**0.64**	**(0.57, 0.73)**
Female	35.56	64.44	1.00		1.00	
Age						
20-29	46.90	53.10	**3.54**	**(2.98, 4.21)**	**3.69**	**(2.98, 4.56)**
30-39	32.41	67.59	**1.92**	**(1.61, 2.30)**	**1.85**	**(1.53, 2.24)**
40-49	25.47	74.53	**1.37**	**(1.15, 1.63)**	**1.30**	**(1.10, 1.54)**
50-59	19.96	80.04	1.00		1.00	
Race/ethnicity						
Non-Hispanic White	29.76	70.24	1.00		1.00	
Non-Hispanic Black	35.09	64.91	**1.28**	**(1.10, 1.48)**	**1.22**	**(1.03, 1.43)**
Hispanic	29.09	70.91	0.97	(0.82, 1.14)	1.11	(0.92, 1.35)
Other	38.22	61.78	**1.46**	**(1.15, 1.86)**	**1.40**	**(1.06, 1.83)**
Marital status						
Never married	41.38	58.62	**1.82**	**(1.58, 2.11)**	**1.25**	**(1.04, 1.50)**
Married	27.90	72.10	1.00		1.00	
Previously married	27.36	72.64	0.97	(0.80, 1.18)	1.08	(0.87, 1.36)
Living with partner	32.24	67.76	1.23	(0.99, 1.52)	1.02	(0.79, 1.31)
Country of birth						
US	30.77	69.23	1.00		1.00	
Mexico	21.37	78.63	0.61	(0.48, 0.78)	0.73	(0.53, 1.02)
Abroad	32.12	67.88	1.07	(0.85, 1.34)	1.03	(0.80, 1.32)
Age at first intercourse						
Less than 18 years old	31.28	68.72	1.09	(0.95, 1.26)	1.06	(0.90, 1.24)
>=18 years old	29.40	70.60	1.00		1.00	
Education						
Less than high school	22.63	77.37	0.54	(0.46, 0.65)	**0.51**	**(0.41, 0.64)**
Completed high school	23.75	76.25	0.58	(0.50, 0.67)	**0.56**	**(0.47, 0.66)**
Some college or beyond	34.98	65.02	1.00		1.00	
Household size						
1-3 people	29.31	70.69	1.00		1.00	
4-6 people	32.61	67.39	**1.17**	**(1.02, 1.34)**	**1.24**	**(1.08, 1.44)**
7 or more people	30.77	69.23	1.07	(0.76, 1.51)	1.27	(0.82, 1.95)
Income						
Less than $20,000	31.40	68.60	0.95	(0.79, 1.14)	0.93	(0.76, 1.13)
$20,000 or more	30.36	69.64	1.00		1.00	

Table 4. Factors associated with receipt of hepatitis B vaccination among adults: NHANES 1999-2006 (continued)

	Vaccinated	Unvaccinated	Odds Ratios			
	%	%	Crude (95% CI)		Adjusted (95% CI)	
Variables						
Current health insurance coverage						
Yes	31.17	68.83	**1.18**	**(1.01, 1.37)**	**1.20**	**(0.99, 1.45)**
No	27.75	72.25	1.00			
Source of usual care						
Yes	31.42	68.58	**1.32**	**(1.11, 1.57)**	**1.35**	**(1.11, 1.64)**
No	25.78	74.22	1.00		1.00	
Health status						
Excellent	32.28	67.72	**1.16**	**(1.01, 1.33)**	1.03	(0.88, 1.20)
Very good	31.85	68.15	1.13	(1.00,1.29)	1.05	(0.91, 1.20)
Good	29.19	70.81	1.00		1.00	
Fair	28.09	71.91	0.95	(0.79, 1.13)	1.11	(0.91, 1.34)
Poor	21.87	78.13	0.68	(0.43, 1.08)	0.88	(0.55, 1.42)
Cigarette smoker						
Smoker	30.22	69.78	0.98	(0.85, 1.14)	1.06	(0.90, 1.25)
Non-smoker	30.62	69.38	1.00		1.00	
History of alcohol abuse						
Yes	25.40	74.60	0.74	(0.62, 0.88)	0.96	(0.81, 1.15)
No	31.52	68.48	1.00		1.00	
Received at least 1 dose Hepatitis B vaccine						
High risk	32.43	67.57	1.11	(0.93, 1.32)	1.10	(0.91, 1.34)
Low risk	30.16	69.84	1.00		1.00	

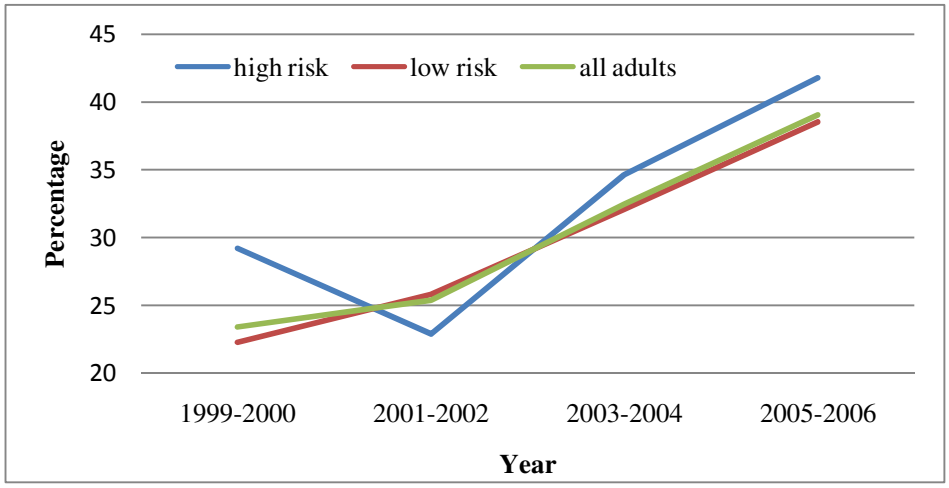
When comparing the self reported vaccination status with serologic status, almost half of the adults who reported receiving all three doses of the vaccine tested negative for immunity. About 4.5% of adults who reported receiving no doses were seropositive (Table 5).

Table 5. Distribution of participants based on their self report vaccination status and serostatus

	Self reported status		
Serostatus	All 3 doses	At least 1 dose	No doses
	%	%	%
Vaccinated	46.87	23.07	4.51
Unvaccinated	48.98	73.41	91.99
History of Hepatitis B infection	4.16	3.51	3.50

Figure 1 shows the trend in prevalence of Hepatitis B vaccination between 1999 and 2006. For all adults the prevalence increased from 23.4% to 39.1%. Compared to adults in 1999-2000, adults were twice as likely to report vaccination in 2005-2006 (OR=2.1 95% CI [1.77, 2.49]).

Figure 1. Trends in self-reported hepatitis B vaccination among adults: NHANES 1999-2006



DISCUSSION

NHANES is the only population based survey that collects data from a nationally representative sample and allows estimates of the prevalence of health status and behaviors. About 44% (7273 of 16419) of the survey participants between age 20 and 59 identified in this study represented approximately one third of the US population.

All Adults

The National Health Interview Survey (NHIS) of 2004 reported that only 34.6% of adults aged 18 to 49 years had received hepatitis B vaccination.[7] In our study, 30.5% of adults aged 20 to 59 from 1999-2006 reported receiving the hepatitis B vaccine. Among 20 to 49 year olds 33.6% reported receiving the hepatitis B vaccination. It is important to note that the vaccination rate increased by almost 15 percentage points between 1999-2000 and 2005-2006. The highest

vaccination rate was reported among 20-29 year olds and is consistent with previous studies that provided national estimates.[7] This high rate of self-report among 20-29 year olds is most commonly attributed to successful childhood and adolescent vaccination from ACIP recommendations of 1995.[7,24] Even before those recommendations were implemented, some states already had laws mandating childhood immunization of hepatitis B before enrolling in elementary or middle school.[24] As time goes on, it is likely that this cohort effect will continue to trend vaccination rates upward for adults.

In this study, we found that Non-Hispanic blacks and other minorities were more likely to be vaccinated than Non-Hispanic whites and Hispanics. NHIS of 2004 also found higher reported vaccination rates among non-Hispanics and other minorities.[7] While studies have shown higher odds of hepatitis B vaccination among minorities, they were not statistically significant.[7,24,26] Generally, health disparities exist among adults in immunization especially for pneumococcal and influenza vaccines.[27,28] Even studies with targeted populations of high risk young adults minorities found no significant difference in hepatitis B immunization rates when compared to other ethnic groups.[24,29]

Other social demographics that affected vaccination status were marital status, household size, education, insurance coverage, and having a source of usual care. Studies have shown statistically insignificant odds of married and previously married individuals less likely to be vaccinated when compared to those who had never been married.[7,24,26]

For adults, person-to-person transmission of HBV can occur in settings involving nonsexual interpersonal contact over an extended period of time. Risk usually increases with household size. In our study, adults who lived with 4 or more people were more likely to be vaccinated. Although this was not significant for household sizes of 7 or more people, being

vaccinated for hepatitis B will decrease this group's likelihood of HBV infection in the future. Lower odds of vaccination were found with education of high school or less and lack of health insurance coverage and a source of usual care. These findings were consistent with other studies.[24-26] Since these individuals are at higher risk of infection, efforts should be initiated to improve vaccination rates.

High-risk adults

In this study we estimated that almost 15 million adults were at risk of HBV. Of the high risk population only 32% were reported vaccinated. This percentage is comparable to other recent national studies on hepatitis B vaccination among high risk adults.[24] In our study the report rate increased from 29.2% in 1999-2000 to 41.8% in 2005-2006. However, being high risk was not associated with higher odds of vaccination. Although acute HBV infection has decreased substantially among adults, approximately 95% of the cases of acute HBV cases in 2005 were among adults.[2] Our findings imply that high risk adults remain under-immunized.

Several city and state interventions have shown success with increases in immunization, particularly with the first dose.[7,9,30-31] However, funding for maintaining such programs is limited and these adults remain at risk for infection. Unlike national vaccination programs for children, there is no similar infrastructure for vaccine administrant to adults. Numerous barriers to vaccination have been identified including cost, time constraints of providers, lack of awareness, reluctance to discuss risk behaviors, and non-completion of the three doses. Adults at increased risk also have missed opportunities to receive hepatitis B vaccination with up to a 60% rate of lost opportunities.[7, 30-31]

Methods used that have shown increased in adult vaccination coverage include reminders to health care providers, comprehensive health centers for high risk adults, and patient reminder

systems.[7] Insufficient evidence is available regarding the effectiveness of in-clinic patient education, providing family or patient incentives, or the implementation of state and federal laws.[31] In 2005, the ACIP recommended strategies to improve vaccination for adults at risk for hepatitis B, by increasing access at facilities that have a high proportion of persons more likely to be at risk.[9] These sites include STD/HIV testing and treatment facilities, correctional facilities, and drug-abuse treatment facilities.

Vaccination serostatus

The 3-dose hepatitis B vaccine series produces a protective antibody response in approximately 30%-55% of healthy adults less than 40 years old after the first dose, 75% after the second dose, and greater than 90% after the third dose.[9] For adults over the age of 40 protective antibody response declines below 90% and is only 75% for adults over 60 years old.[9] Our study found that less than 50% of adults who reported receiving all three doses were seropositive for vaccination. Of those who reported receiving at least one dose, 27% already showed full protection from HBV. Among adults who received no doses of the vaccine, 4.5% had a seropositive vaccination status. About 3.5% of adults showed immunity due to history of HBV infection.

Many factors contribute to decreased vaccination response or negative serostatus including smoking, obesity, genetics, stress, immune suppression, and loss of antibodies.[9,35-39] Other behavioral and psychological factors also influence immune functions. Studies have shown that non-response accounts for about 10-25% of cases.[9] Up to 50% of those vaccinated lose their antibodies within a few years. However, undetectable anti-HBs levels do not necessarily indicate loss of immunity. If exposed to HBV, the immune memory initiates an anamestic response that prevents acute and chronic infection.[37] While most studies regarding long term immune response

have examined children and adolescents, a few studies have followed the immunologic memory in adults who had lost protective antibodies after vaccination. One study found that participants who lost their anti-HBs still had immunologic memory that was able to trigger anti-HBs production when revaccinated.[37] Other studies suggest that immunologic memory in healthy individuals last 5-12 years.[35-39] This is also shown in studies that followed high-risk vaccinees.[36]

Another factor that affects seropositivity rate is knowledge of vaccination status. In the United States, research on the validity of self-reported vaccination status is primarily limited to elderly adults or the pneumococcal and influenza vaccines. A study conducted among high risk adults in Australia found that 52.2% of those who believed they were protected were not immune.[32] Previous studies on self-reports of HBV exposure and vaccination among high risk adults have found that results were specific, but not sensitive.[33] One study in Switzerland found that knowledge of HBV vaccination status was associated with gender, language and dietary attitudes.[34] Researchers and health care providers should be cautious in using such self-reports. However, it is also important to properly document when patients receive an immunization and to test serostatus after the series completion so they do not receive unnecessary boosters.[35-37,39] The analysis of self-report and serostatus for this data are unpublished at this time.

Limitations

Although we had a large sample size, our population was limited to adults aged 20-59 who provided responses to sensitive questions regarding sexual practices, illegal drug use, also provided laboratory examination data for HBV, HCV, and HIV. Secondly, our study did not include estimates on other high risk participants such as people receiving hemodialysis and health care workers. NHANES data are representative of the civilian non-institutionalized US population. As a result, populations with higher risk of infection are excluded including

incarcerated persons, homeless, military service members, and residents in long-term care facilities.

Underreporting and recall bias are concern for this study as well. NHANES uses audio computer assisted personal self interview (ACASI) and computer assisted personal interview (CAPI) questionnaire. However, it has been noted that response rates are lower in areas such as sexual behaviors and illegal drug use. There is a possibility that high-risk populations were underestimated due to the lower response rates to sensitive questions. The potential of underestimating high risk adults supports the conclusion that a substantial proportion of the US population is at risk of HBV.

Although the question regarding hepatitis B vaccination status provided a description of the vaccine and its recommendations, it is possible that respondents confused their vaccination status with others collected in the survey including Hepatitis A, pneumococcal, and influenza. However, since these vaccinations are administered to different risk groups, it is unlikely to occur.

CONCLUSIONS

Despite these limitations, few studies have examined national estimates of hepatitis B vaccination among the general US population. Although, hepatitis B vaccination rates are rising, only 32% of high risk adults are vaccinated. The rise in vaccination rates in young adults is mostly related to childhood immunization strategies and not strategies aimed at adults. Older males, those with less than high school education, without health insurance coverage and a source of usual care were least likely to be vaccinated. More targeted interventions are needed to educate and vaccinate the adult population and to create a means for identifying those at risk and those already vaccinated. Interventions should also be implemented to improve adult awareness

about vaccinations that may have already received. Further research will also provide insight into social and demographic factors that may affect non-response and loss of antibodies. Similar to programs for children and adolescents, national immunization programs should be implemented to target immunization of adults at higher risk of HBV.

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