The Effect of Vaccinated Children on Increased Hepatitis B Immunization Among High-Risk Adults

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Routine hepatitis B virus (HBV) vaccination of infants, children, and adolescents as recommended by the Advisory Committee on Immunization Practices has altered the epidemiology of HBV infection in the United States. In the United States, 92.4% of children aged 19 to 35 months received at least 3 doses of HBV vaccination in 2004.[1] The disease incidence has declined significantly among children and adolescents and remains highest among adults.[2,3] Effective strategies are needed for vaccinating older children, adolescents, and adults who are at increased risk for HBV infection.

Previous studies on HBV vaccination among high-risk adults that analyzed National Health Interview Survey (NHIS) data reported an increase in vaccination prevalence between 2000 and 2004.[3,4] Although the adult vaccination rate increased, it was still much lower than the rate among children and adolescents in 2004.[3,5] These studies did not examine the trends in vaccination receipt and the effect of entry into adulthood of a more completely vaccinated cohort on increases in vaccination. NHIS is conducted annually and is the only national survey that collects adult HBV vaccination information. This information allows the assessment of the effect of immunization interventions targeted at various age and risk groups. Examining the national trends in adult immunization and the factors influencing these trends yields information critical for assessing and improving public health function and preventive care.

We examined the trends in HBV vaccination among high-risk adults across NHIS survey years 2000, 2002, and 2004 and the cohort effect on these trends caused by the entry of vaccinated adolescents into adulthood. For the purpose of this study, we defined a cohort effect as the entry of vaccinated children and adolescents into adulthood, resulting in increased HBV vaccination coverage.

Objectives. We sought to examine trends in hepatitis B virus (HBV) vaccination among high-risk adults and assess the potential effect vaccinated adolescents have on these trends as they age.

Methods. We used data from the National Health Interview Survey 2000, 2002, and 2004 to examine trends in HBV vaccination among high-risk adults aged 18 to 49 years and in age subgroups (18–29, 30–39, and 40–49 years). We investigated temporal differences in vaccination rates for the 18- to 29-year-old cohort with model-based linear contrasts constructed from a logistic regression model with age and survey year as predictors.

Results. There was a significant increasing trend in vaccination prevalence across the 3 survey years (32.6%, 35.3%, and 41.4%; trend test, $P = .001$). We found that respondents aged 18 to 29 years were more likely to be vaccinated in 2004 than in 2000, after adjusting for relevant confounders (odds ratio = 1.73; 95% confidence interval = 1.14, 2.6); there was no significant increase in vaccination for the other cohorts.

Conclusions. A cohort effect, in which successfully vaccinated adolescents have reached young adulthood, contributes significantly to recent trends showing improved HBV vaccination among high-risk adults. (*Am J Public Health.* 2008; 98:832–838. doi:10.2105/AJPH.2007.116046)

METHODS

Data and Participants

Data came from the NHIS sample adult component for 2000, 2002, and 2004. NHIS is an annual survey providing estimates of current health indices and health practices of the civilian noninstitutionalized population of the United States, conducted by the National Center for Health Statistics.[6–8] The NHIS data are collected through a personal household interview by census interviewers. Basic sociodemographic characteristics and health information are collected on all household members. Additional information about health care services, behavior, and health status is collected from 1 randomly selected adult per household 18 years or older (sample adult component). The final sample adult response rates (also accounting for household and family nonresponse) for 2000, 2002, and 2004 were 72.1%, 72.5%, and 74.3%, respectively. NHIS respondents are selected through a complex, multistage sampling design that involves stratification, clustering, and oversampling of specific population subgroups. The sample weights are modified for poststratification adjustments for known census gender, age, and race/ethnicity population controls to yield estimates that are representative of the civilian, noninstitutionalized US population.

Our study population was a subset of those surveyed in NHIS. It included adults aged 18 to 49 years who were at high risk for HBV infection. Respondents categorized as high risk for HBV infection were those who answered affirmatively to 1 or both of these survey questions: (1) "In the past 5 years, have you had an STD [sexually transmitted disease] other than HIV or AIDS?" (2) "Tell me if any of these statements are true for you: you have hemophilia and have received clotting factor concentrations; you are a man who has had sex with other men, even just 1 time; you have taken street drugs by needle, even just 1 time; you have traded sex for money or drugs, even just 1 time; you have tested positive for HIV, the virus that causes AIDS; you have had sex (even just 1 time) with someone who would answer 'yes' to any of these statements." Our analysis was restricted to persons aged 18 to 49 years, the group that accounts for the majority of new adult HBV infections, consistent with previous publications.[3,4] Health care workers were excluded from the analysis because their risk factors for HBV and access to vaccination differ from those of the general population.[9]

Variables

The outcome variable was vaccination status. Vaccination status was assessed by self-report. Respondents were asked, "Have you EVER received the hepatitis B vaccine? This is given in 3 separate doses and has been available since 1991. It is recommended for newborn infants, adolescents, and people such as health care workers, who may be exposed to the hepatitis B virus." Those who answered affirmatively were then asked, "Did you receive 3 doses of the hepatitis B vaccine or less than 3 doses?" For our analyses, respondents were considered vaccinated if they received at least 1 dose.

NHIS collects data on age, gender, marital status, race/ethnicity, census region, education, and household income. We categorized age into 3 groups (18–29, 30–39, and 40–49 years) to be consistent with a previous study.[4] Categories provided by NHIS were used for gender (male or female), race/ethnicity (Hispanic, non-Hispanic White, non-Hispanic Black, or non-Hispanic other), and census region (Northeast, Midwest, South, or West). Additional variables were also recoded from the NHIS-collected data: marital status (married, never married, previously married, or living with partner), level of education (less than high school, completed high school or general equivalency diploma, or more than high school) and household annual income (<$20 000 or below poverty level, or ≥$20 000).

NHIS collected data on indicators of health care access and utilization and on health behavior variables, including health insurance coverage (yes or no), receipt of influenza vaccine in the past 12 months (yes or no), receipt of pneumonia vaccine ever (yes or no), receipt of HIV test ever (yes or no), and smoking status (current, former, or never smoker). We also recoded the following variables: respondent had a usual place for care when sick or in need of advice about health (yes or no); respondent had seen a general practitioner, an obstetrician-gynecologist (for women), or a medical specialist in the past 12 months (yes or no); number of primary care office visits in the past 12 months (none or ≥1 visits); and self-reported health status (excellent or very good, good, or fair or poor).

For all the studied measures, the wording of survey questions was highly consistent across all 3 survey years. The categorization of the variables was either consistent or recoded to be consistent across the 3 NHIS years studied.

Analyses

For all analyses, design variables and weights were used to account for the NHIS complex sampling design and allow generalizability to national population estimates. All analyses were conducted with SAS-callable SUDAAN software, version 9.0.1 (Research Triangle Institute, Research Triangle Park, NC). We considered a 2-tailed *P* value of less than 0.05 to be statistically significant for all analyses.

The association between potential predictors of vaccination (demographic factors, socioeconomic status, and health care access and utilization variables) and vaccination status was assessed using bivariable analysis with the χ^2 test. These analyses were conducted with concatenated (derived by annualized weight=weight/3) data from years 2000, 2002, and 2004.

Vaccination prevalence by age and year. We determined vaccination prevalence for all high-risk adults as well as high-risk adults within age subgroups (18–29, 30–39, 40–49 years) across the 3 survey years. We conducted a trend test to assess the linear trend in vaccination prevalence across the 3 years from an analysis combining all years of data (no weight modification).

To investigate the differential effects of age on vaccination status between 2004 and 2000, we constructed a logistic regression model with predictors describing the main effects of age (3-category age variable) and survey year and a corresponding interaction term. To determine the independent association between age group and vaccination receipt by survey year, we modified the interaction model to include the following possible confounders of vaccination receipt: gender, marital status, income, education, and health care access and utilization characteristics. The confounding variables were selected by significance in bivariable analysis, clinical relevance, and previous publications.[3,4] Both unadjusted and adjusted odds ratios (ORs) were computed from the estimated model coefficients for survey year and age group by survey year interaction. These ORs reflected the change in the odds of vaccination coverage in each age group in 2004 compared with 2000.

Temporal differences in vaccination in younger age group. We performed a secondary analysis of vaccination rates among respondents aged 18 to 29 years with a logistic model of the log odds of vaccination as a function of age (continuous), survey year, and age-by-year interaction. The interaction term was retained only if the corresponding parameter was significantly different from zero. We constructed linear contrasts of estimated model parameters to investigate hypotheses concerning differences in vaccination rates across survey years.

Predictive model. To determine the factors associated with receipt of at least 1 dose of HBV vaccination, we fitted a predictive multiple logistic regression model to the 3 survey years of concatenated NHIS data. No interaction terms were considered in this model. Analysis of 3 years of concatenated data provided estimates that were more reliable and more precise than were those from previous studies on single-year NHIS data.[3,4] However, the weights were modified (weight/3) to allow generalization to the US population. Demographic variables and socioeconomic characteristics were placed in the model independent of their significance in bivariable analyses. In this model, the age variable was categorized into 5 groups (18–20, 21–25, 26–30, 31–40, and 41–49 years) to be consistent with a previous study[3] and to obtain the adjusted odds of vaccination across 5 age groups. Health care access and utilization variables demonstrating significance at $P=.25$ in bivariable analysis were included in the multivariable model, following the recommendations of Hosmer and Lemeshow.[10]

RESULTS

Population Characteristics

The total unweighted sample of high-risk adults aged 18 to 49 years analyzed across the 3 survey years was 2 881, which represented

TABLE 1—Comparison of Vaccinated and Unvaccinated Adults at High Risk for Hepatitis B Infection: National Health Interview Survey, 2000, 2002, and 2004

	Total	Vaccinated, % (SE)	Unvaccinated, % (SE)	P[a]
Median age, y	32 (0.2)	28 (0.5)	34 (0.6)	<.001
Gender				
Women	48.1(1.2)	52 (1.9)	46 (1.5)	.01
Marital status				<.001
Married	30.7 (1.1)	24.6 (1.5)	34.2 (1.4)	
Never married	39.6 (1.1)	45.1 (1.6)	36.4 (1.4)	
Previously married	13.4 (0.6)	12.0 (0.8)	14.2 (0.8)	
Living with partner	16.3 (0.8)	18.2(1.4)	15.1 (1.0)	
Race/ethnicity				.18
Hispanic	11.4 (0.7)	11.5 (1.2)	11.4 (0.8)	
Non-Hispanic White	66.7 (1.1)	63.9 (1.9)	68.3 (1.3)	
Non-Hispanic Black	18.4 (1.0)	20.6(1.7)	17.1 (1.1)	
Non-Hispanic other	3.5 (0.5)	3.9 (0.7)	3.2 (0.6)	
Census region				.12
Northeast	17.3 (1.0)	19.6 (1.3)	15.9 (1.3)	
Midwest	24.1 (1.1)	23.5 (1.6)	24.5 (1.4)	
South	33.5 (1.2)	32.4 (1.9)	34.1 (1.4)	
West	25.1 (1.2)	24.5 (1.8)	25.4 (1.3)	
Education				.037
Less than high school	16.9 (0.9)	14.8 (1.3)	18.2(1.1)	
High school or GED	29.2 (1.1)	27.9 (1.7)	30.0 (1.3)	
Some college or more	53.8 (1.2)	57.3 (1.9)	51.8 (1.5)	
Annual income less than $20 000	25.5 (0.9)	27.9 (1.7)	24.2 (1.1)	.007
No health insurance	27.2 (1.1)	23.2 (1.7)	29.6 (1.3)	.002
Has a source of usual care	79.2 (0.9)	82.9 (1.5)	77.1 (1.2)	.003
Office visits in past 12 mo				.001
None	20.0 (0.9)	15.2 (1.4)	22.7 (1.2)	
≥1	80.0 (0.9)	84.8 (1.4)	77.3 (1.2)	
Has been seen by a doctor in past 12 mo	76.1 (1.0)	81.3 (1.5)	73.0 (1.3)	<.001
Received influenza vaccine in past 12 mo	17.7 (0.8)	24.0 (1.5)	14.2 (1.0)	<.001
Has ever received pneumonia vaccine	9.6 (0.7)	13.5 (1.2)	7.3 (0.8)	<.001
Has ever tested for HIV	72.0 (1.1)	79.1 (1.6)	67.9 (1.4)	<.001
Health status				.64
Excellent/very good	58.6 (1.1)	59.8 (2.1)	57.9 (1.4)	
Good	28.1 (1.0)	27.7 (1.7)	28.4 (1.3)	
Fair/poor	13.3 (0.7)	12.5(1.2)	13.7 (0.9)	
Tobacco use				.79
Current smoker	43.5 (1.1)	42.5 (1.9)	44.0 (1.3)	
Former smoker	14.8 (0.8)	15.2 (1.4)	14.6 (0.9)	
Never smoker	41.7 (1.1)	42.2 (1.9)	41.5 (1.3)	
Has received 3 doses of hepatitis B vaccine		80.7 (1.5)		

Note. GED = general equivalency diploma. Data are concatenated and were compiled from household interviews of the civilian noninstitutionalized population. We used annualized weights (unweighted n = 2731). Data were missing for the following characteristics: marital status, 0.3%; education, 0.5%; and insurance, 0.7%. Except for rounding error, column percentages sum to 100%.

[a]We used the χ^2 statistic to compare demographic, socioeconomic status, and health care access and utilization characteristics across the vaccinated and unvaccinated groups.

an estimated (weighted) population of more than 17 million. The sample sizes (unweighted) of high-risk adults analyzed were 1036 in 2000, 941 in 2002, and 904 in 2004.

Bivariable analyses comparing demographics, socioeconomic status, and health care access and utilization variables with vaccination status among high-risk adults on the concatenated data are shown in Table 1. Vaccinated adults were significantly younger than unvaccinated adults (median age=28 and 34 years, respectively; $P<.001$). Gender, marital status, education status, and health care access and utilization variables differed significantly between the 2 groups. Most vaccinated high-risk adults (81%) reported receiving all 3 doses of HBV vaccination.

Trends and Predictors of Vaccination Coverage Among High-Risk Adults

There was a significant increasing trend in the prevalence of vaccination status across the survey years (2000, 32.6%; 2002, 35.3%; 2004, 41.4%; $P=.001$). Specifically, 8.8% more high-risk adults were vaccinated in 2004 than in 2000. Subgroup analyses within age groups by survey year revealed a significant positive trend in vaccination in 18- to 29-year-olds only (2000, 41%; 2002, 45%; 2004, 53%; $P=.02$), shown in Table 2. Although vaccination rates within the other age groups improved, this increase was not statistically significant.

The adjusted and unadjusted ORs reflecting the change in vaccination rates for all high-risk adults and in each age group between 2004 and 2000 are shown in Table 2. There was a 46% increase in the odds of vaccination for all high-risk adults between 2000 and 2004. There was a 68% increase in the odds of vaccination in high-risk adults aged 18 to 29 years in 2004 compared with 2000, before adjusting for relevant confounders. This increase remained significant after adjustment for confounders (OR=1.73; 95% confidence interval [CI]=1.14, 2.6; $P=.01$). No significant increase was observed in the odds of vaccination for the other age groups between 2004 and 2000.

Finally, we compared the percentage of vaccinated high-risk and all other 18- to 29-year-olds in 2004 with those percentages in

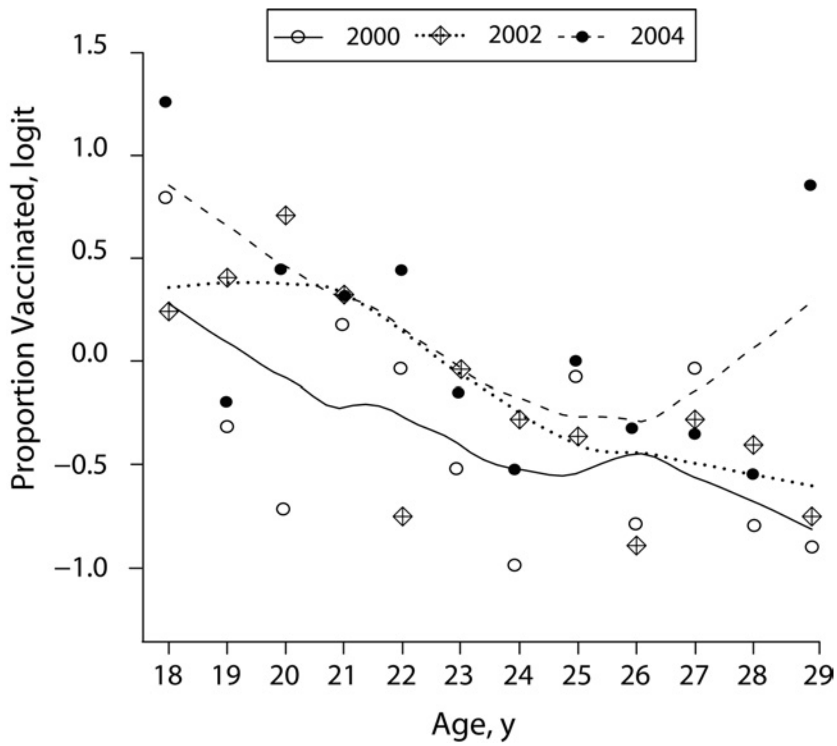

FIGURE 1—Smoothed log odds (log [p/(1−p)]) of the proportion of high-risk young adults (aged 18–29 years) who were vaccinated against hepatitis B, by age: National Health Interview Survey, 2000, 2002, and 2004.

2000. High-risk adults had an 11.3% increase in vaccination (2000, 41.4%; 2004, 52.7%). For all other adults, we observed a similar increase of 11.4% (2000, 33.7%; 2004, 45.1%).

Figure 1 shows smoothed plots of the log odds of vaccination prevalence by age for 2000, 2002, and 2004 among adults aged 18 to 29 years. Results from the logistic regression analysis of this subpopulation showed no significant interaction between age and survey year (*P*=.62), so this term was subsequently removed from the model. We used model-based linear contrasts to test the hypotheses that the difference in the log odds of vaccination between survey years was significantly different from zero. Among adults aged 18 to 29 years, there was a 55% increase in the odds of being vaccinated in 2004 compared with 2000 (OR=1.55; 95% CI=1.04, 2.29; *P*=.031). For this same cohort, we found no significant difference in vaccination prevalence between 2000 and 2002 (*P*=.18) or 2002 and 2004 (*P*=.33).

The results of the predictive model fitted to the concatenated NHIS data from years 2000, 2002, and 2004 are shown in Table 3. Factors independently associated with greater likelihood of receipt of HBV vaccination among high-risk adults aged 18 to 49 years were completing more education, receiving influenza or pneumonia vaccines, ever being tested for HIV, and being younger. The odds of vaccination were highest in the 18- to 20-year age group and showed a gradual decline with increasing age.

TABLE 2—Percentage Vaccinated and Odds Ratios (ORs) for Vaccination Against Hepatitis B, by Age and Year: National Health Interview Survey, 2000, 2002, and 2004

	High-Risk Adults Who Were Vaccinated				Vaccination, 2004 vs 2000			
Age, y	2000, %	2002, %	2004, %	*P* for Trend	OR (95% CI)	*P*	Adjusted OR[a] (95% CI)	*P*
All adults 18–49	32.6	35.3	41.4	.001	1.46 (1.16, 1.84)	.004	1.46 (1.13, 1.89)	.01
18–29	41.4	45.3	52.7	.02	1.68 (1.13, 2.5)	.02	1.73 (1.14, 2.6)	.01
30–39	28.9	30.8	32.8	.38	1.19 (0.43, 3.4)	.38	1.16 (0.39, 3.4)	.53
40–49	24.3	26.2	32.2	.09	1.47 (0.93, 2.3)	.09	1.43 (0.87, 2.3)	.15

Note. CI = confidence interval. Data were compiled from household interviews of the civilian noninstitutionalized population.
[a]The multivariable logistic model was adjusted for demographic characteristics (gender, race/ethnicity, marital status), educational level, annual family income, and health care access and utilization variables (health insurance status, having an established usual source of care, number of office visits in the past year, type of providers seen in the past year, receipt of influenza vaccination in the past year, receipt of pneumococcal vaccination, ever tested for HIV).

DISCUSSION

We found a significant trend toward higher HBV vaccination among high-risk adults across NHIS survey years 2000, 2002, and 2004. Although previous studies suggested an increase in vaccination rates, their results were based on single years of NHIS data, which precluded examining trends.[3,4] Our study pooled NHIS data from 3 separate years, spanning 5 years, and identified a significant increase in vaccination coverage among high-risk adults.

Our analyses of vaccination by age subgroups demonstrated that vaccination prevalence was significantly higher for the youngest age group in 2004 than in 2000. This increase was likely attributable to a cohort effect of successfully vaccinated adolescents reaching young adulthood, shown in Figure 1 as a relatively uniform shift in the log odds of vaccination among the youngest high-risk adults from 2000 to 2004. The data in the figure provided empirical evidence that the difference in the log odds of vaccination decreased somewhat as age increased between

TABLE 3—Factors Associated With Receipt of Hepatitis B Vaccination Among High-Risk Adults Aged 18 to 49 Years: National Health Interview Survey, 2000, 2002, and 2004

Predictors of Vaccination[a]	OR (95% CI)	*P*
Age, y		<.001
18–20	4.64 (2.89, 7.43)	
21–25	3.03 (2.15, 4.27)	
26–30	2.03 (1.43, 2.90)	
31–40	1.40 (1.05, 1.88)	
41–49 (Ref)	1.00	
Gender		.83
Men	1.02 (0.81, 1.29)	
Women (Ref)	1.00	
Marital status		.15
Married	0.81 (0.63, 1.04)	
Previously married	1.04 (0.77, 1.4)	
Living with partner	1.12 (0.82, 1.52)	
Never married (Ref)	1.00	
Race/ethnicity		0.30
Hispanic	1.23 (0.89, 1.69)	
Non-Hispanic White (Ref)	1.00	
Non-Hispanic Black	1.20 (0.91, 1.59)	
Non-Hispanic other	1.34 (0.72, 2.47)	
Education		<.001
Less than high school	0.56 (0.41, 0.76)	
High school or GED	0.78 (0.62, 0.99)	
Some college or more (Ref)	1.00	
Annual income, $		.12
<20 000 (Ref)	1.00	
≥20 000	0.82 (0.64, 1.06)	
Health insurance		.083
No	0.80 (0.62, 1.03)	
Yes (Ref)	1.00	
Source of usual care		.12
Yes	1.28 (0.93, 1.75)	
No (Ref)	1.00	
Office visits in past 12 mo		.64
None (Ref)	1.00	
≥1	1.09 (0.76, 1.54)	
Seen by a doctor in the past 12 mo		0.41
Yes	1.16 (0.81, 1.65)	
No (Ref)	1.00	
Received influenza vaccine in past 12 mo		<.001
Yes	1.79 (1.35, 2.36)	
No (Ref)	1.00	
Ever received pneumonia vaccine		<.001
Yes	1.76 (1.27, 2.44)	
No (Ref)	1.00	
Ever tested for HIV		<.001
Yes	1.83 (1.41, -2.37)	
No (Ref)	1.00	

Note. GED = general equivalency diploma; OR = odds ratio; CI = confidence interval. Data are concatenated and were compiled from household interviews of the civilian noninstitutionalized population. We used annualized weights (unweighted n = 2575).
[a]All the predictor variables were included in the multivariable model.

2000 and 2004, although our regression analysis failed to find this difference statistically significant. When we removed the outlying proportion of vaccinated high-risk 29-year-olds in the 2004 survey and smoothed only the log odds of vaccination for 18- to 28-year-olds, we found stronger visual support for a decrease in the difference of the log odds of vaccination between 2000 and 2004 as age increased (not shown).

Finally, for adults aged 18 to 29 years, the increase in percentage vaccinated between 2000 and 2004 for high-risk as well as other adults was similar (11.3% and 11.4%, respectively). This improvement in younger-adult vaccination, regardless of risk status, coupled with the visual and analytic assessment of the log odds of vaccination among high-risk young adults, supported our conclusion that the observed vaccination improvement was the result of a cohort effect and not of targeted interventions among high-risk adults.

Routine vaccination of young adolescents aged 11 to 12 years with 3 doses of HBV vaccine was recommended by the Advisory Committee on Immunization Practices in 1995, and this recommendation was extended to all previously unvaccinated children younger than 18 years in 1999.[11,12] Acting on these recommendations, several states mandated HBV immunization before elementary and middle school entry.[13] Several studies on adolescent HBV immunization indicated an increase in immunization among adolescents, which reflected successful implementation of immunization guidelines and school law mandates.[14–17]

We observed a significant increase in vaccination from 2000 to 2004 only in the younger age stratum (1975–1986 birth cohort), and this increase was characterized by a shift in the log odds of vaccination within this subpopulation. Therefore, the significant increase in vaccination among high-risk adults likely reflected successful childhood and adolescent vaccination. Because immunization guidelines and laws take time to implement, we likely observed the initial stage of a cohort effect in which vaccination coverage will continue to trend upward.

Aside from a cohort effect, other possible explanations for this finding could include immunization programs and practices that disproportionately target high-risk young adults. Routine vaccination of this group is recommended in several nontraditional settings, such as correctional facilities, sexually transmitted disease clinics, HIV clinics, and drug treatment centers.[18,19] Although vaccination delivery may be suboptimal in these settings,[20,21] several studies have described successful vaccination of high-risk adults and adolescents in them.[22–26] Federally funded programs such as vaccines for children might favor vaccination of adolescents 18 years and younger. Lack of funding for vaccination of all high-risk adults coupled with integration of programs such as vaccines for children could contribute to the inverse association between age and vaccination we found.

Few other studies have examined both the prevalence of HBV vaccination in adults and the effect of age on vaccination. Scott et al. reported prevalence of antibody to HBV surface antigen (proxy for HBV immunity) in military recruits aged 18 to 35 years in 2001.[27] They found that anti-HBV surface antigen seropositivity was highest in 18-year-old military recruits, decreasing with increasing age. They also found that home state immunization laws mandating HBV immunization before entry into elementary and middle schools were significant independent predictors of HBV immunity.

In our multivariable model, younger age, education status, receipt of influenza or pneumococcal vaccines, and being tested for HIV were significant predictors of HBV vaccination. We found lower odds of vaccination in those with an education level less than high school. Previous studies found a similar association.[28,29] Lower likelihood of vaccination and hence increased risk of infection warrant targeted strategies to improve vaccination in this group. Receipt of influenza or pneumococcal vaccination and testing for HIV were also significant predictors of HBV immunization. One explanation for this is our definition of high-risk adults, which included those who were HIV positive, for whom all these vaccines are indicated. However, this finding may also reflect a patient's willingness to receive any vaccination in general.

Considering barriers to vaccine delivery, the Advisory Committee on Immunization Practices made recommendations to improve HBV vaccination in adults.[30] The committee recommended vaccination for all adults in settings where a high proportion have HBV risk factors. It further asserted that acknowledgment of a specific risk factor is not a requirement for HBV immunization and recommended standing orders to identify and implement vaccination in primary care and specialty settings. These recommendations should be translated into practice to improve adult HBV immunization. Policies that finance adult immunization services should account for the fact that resources saved by limiting coverage will be offset by the costs of treating preventable disease.

Limitations

Our results were derived from cross-sectional survey data, so conclusions about causality must remain tentative. Vaccination receipt was self-reported and subject to recall bias. The increasing prevalence of HBV infection with age could explain, in part, the lower odds of vaccination among high-risk adults, but NHIS data did not allow us to exclude those already infected. Nevertheless, this potential effect would be small, because studies on sexually transmitted disease clinic clients found that, despite increasing HBV prevalence with aging, a majority of clients in all age groups were still susceptible to infection.[22,31]

The multicomponent NHIS question on high-risk behaviors did not allow for determining vaccination coverage within distinct subgroups of high-risk adults. NHIS data excluded incarcerated or military personnel and thus did not allow us to study immunization patterns of adults in correctional facilities, who are at high risk for HBV infection.

Conclusions

Our results have significant public health implications. HBV vaccination coverage among adults increased with time, yet this increase was only significant in younger adults. This age-dependent increase in vaccination coverage suggests a cohort effect from successfully vaccinated adolescents reaching adulthood over time and the success of national immunization guidelines and state immunization laws pertaining to children and adolescents. With time, increasing HBV immunity will result from the successive cohorts of immunized children reaching young adulthood. If we rely only on childhood immunization, this change will be slow.

Accelerating the elimination of HBV infection in the United States will require changes at both the policy and practice levels to target unvaccinated high-risk adults of all ages. Public health planners should not be misled by the increases in early adulthood into thinking that strategies aimed at adults have been successful. National immunization programs similar to those that have proven successful with children and adolescents are needed to target immunization of high-risk adults who were too old to benefit from childhood immunization programs and school entry laws. ■

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Contributors

D.L. Koya originated the study, designed and conducted the analysis, and led the writing. E.G. Hill supervised the statistical analysis and contributed to the Methods section. P.M. Darden originated the study and supervised the study design and preparation of the article.

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Human Participant Protection

This study was approved by the institutional review board at the Medical University of South Carolina.

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