Underimmunization Among Children: Effects of Vaccine Safety Concerns on Immunization Status

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ABSTRACT. ***Objective.*** **To examine the attitudes, beliefs, and behaviors of parents whose children were underimmunized with respect to ≥2 vaccines that have recently received negative attention, compared with parents whose children were fully immunized with respect to the recommended vaccines.**

Design. **Case-control study.**

Setting. **A sample of households that participated in the National Immunization Survey were recontacted in 2001.**

Main Outcome Measure. **Vaccination status was assessed. Case subjects were underimmunized with respect to ≥2 of 3 vaccines (diphtheria-tetanus-pertussis or diphtheria-tetanus-acellular pertussis, hepatitis B, or measles-containing vaccines), and control subjects were fully immunized.**

Results. **The response rate was 52.1% (2315 of 4440 subjects). Compared with control households, case households were more likely to make $0 to $30 000 (adjusted odds ratio [OR]: 2.7; 95% confidence interval [CI]: 1.5–4.6) than at least $75 000, to have ≥2 providers (OR: 2.0; 95% CI: 1.3–3.1) than 1, and to have ≥4 children (OR: 3.1; 95% CI: 1.5–6.3) than 1 child. With control for demographic and medical care factors, case subjects were more likely than control subjects to not want a new infant to receive all shots (OR: 3.8; 95% CI: 1.5–9.8), to score vaccines as unsafe or somewhat safe (OR: 2.0; 95% CI: 1.2–3.4), and to ask the doctor or nurse not to give the child a vaccine for reasons other than illness (OR: 2.7; 95% CI: 1.2–6.1). Among case subjects, 14.8% of underimmunization was attributable to parental attitudes, beliefs, and behaviors.**

Conclusions. **Attitudes, beliefs, and behaviors indicative of vaccine safety concerns contribute substantially to underimmunization in the United States. Although concerns were significantly more common among parents of underimmunized children, many parents of fully immunized children demonstrated similar attitudes, beliefs, and behaviors, suggesting a risk to the currently high vaccination levels. Efforts to maintain and improve immunization coverage need to target those with attitudes/beliefs/behaviors indicative of vaccine safety concerns, as well as those with socioeconomic and health care access problems.** ***Pediatrics*** **2004;114:e16–e22. URL: http://www.pediatrics.org/cgi/content/full/114/1/e16;** ***underimmunization, attitudes, beliefs, behaviors.***

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ABBREVIATIONS. DTaP, diphtheria-tetanus-acellular pertussis; DTP, diphtheria-tetanus-pertussis; MCV, measles-containing vaccine; MMR, measles-mumps-rubella; NIS, National Immunization Survey; OR, odds ratio; CI, confidence interval.

Immunizations have reduced the incidence of vaccine-preventable disease by >95% for every pediatric vaccine recommended for routine use before 1990.[1] As the number of immunizations has increased, however, reports of postimmunization adverse events, both vaccine-related and coincidental, have increased. This increase, combined with the decrease in the incidence of vaccine-preventable diseases, has resulted in an increased focus on vaccine safety.[2] Some have linked vaccinations with acute and chronic illnesses with no known causes, eg, autism and measles-mumps-rubella (MMR) vaccine,[3] multiple sclerosis and hepatitis B vaccine,[4] and sudden infant death syndrome and diphtheria-tetanus-pertussis (DTP) vaccine.[5] Although current scientific evidence does not support associations between vaccines and these conditions,[6] such hypotheses continue to circulate.[2]

Although immunization coverage in the United States is high, concerns about vaccine safety may adversely affect parents' decisions to immunize their children. This can result in decreased coverage and disease outbreaks.[7,8] In recent years, most media attention on adverse events after routine childhood vaccination has focused on DTP or diphtheria-tetanus-acellular pertussis (DTaP), hepatitis B, and MMR vaccines. In some European countries and in Japan, general concern regarding whole-cell pertussis vaccine safety resulted in substantially lower coverage and outbreaks of disease.[7] In France, 3 people with multiple sclerosis received damage payments from the government because of the purported association with the hepatitis B vaccine.[9] Perhaps the most highly publicized debate involves the hypothesized associations between the MMR vaccine and inflammatory bowel disease and autism.[3] The purpose of the present study was to examine vaccine safety-related attitudes, beliefs, and behaviors of parents whose children are underimmunized with respect to ≥2 of these high-profile vaccines (DTP/DTaP vaccine, hepatitis B vaccine, and measles-containing vaccine [MCV]), compared with parents whose children are fully immunized with all recommended vaccines.

METHODS

Survey

The National Immunization Survey (NIS) is conducted by the Centers for Disease Control and Prevention to obtain accurate national and state-specific estimates of vaccination coverage. The NIS samples children 19 to 35 months of age each quarter, using list-assisted, random-digit dialing. A parent/guardian is interviewed to determine demographic and socioeconomic information. At the end of the interview, consent to contact all vaccination providers for the child is requested. If consent is obtained, then mail surveys are sent to the child's vaccination providers, who obtain the child's vaccination history from their records. The design of the NIS has been described elsewhere.[10]

NIS Survey Module

In the NIS Knowledge, Attitudes, and Practices survey, case and control subjects were randomly sampled from 16 498 NIS-participating children with adequate provider-reported immunization data, from January to December 2001.

Case and Control Subjects

Case subjects were defined as children who were underimmunized with respect to ≥2 of DTP/DTaP vaccine, hepatitis B vaccine, and/or MCV, defined as <3 DTP/DTaP vaccine doses, <3 hepatitis B vaccine doses, and 0 MCV doses. Control subjects were children who were fully immunized for their age with respect to all recommended childhood vaccines. Children may be missing individual doses of vaccines for a variety of reasons attributable to vaccine availability. We restricted the analysis to children missing doses of ≥2 high-profile vaccines to increase the likelihood that we were studying parents who had made a purposeful decision not to receive the vaccines. The households of case and control children were contacted by telephone, generally 3 to 9 months after their initial NIS interviews. At least 10 attempts were made to contact selected households with calls made at various times of the day and week. Multiple strategies were used to obtain contact information for families who had moved since their initial NIS interviews. After informed consent was obtained, parents/guardians were asked questions about their attitudes, beliefs, and behaviors regarding vaccine safety and their sources of information about immunizations. To ensure that questions appropriately addressed key concepts and that respondents interpreted survey questions in a standard manner, the draft questionnaire was reviewed by an expert panel and underwent cognitive testing by volunteers through the National Center for Health Statistics Questionnaire Design Research Laboratory.

Demographic Characteristics and Attitude, Belief, and Behavioral Risk Factors

Demographic characteristics and parental attitude, belief, and behavioral risk factors were used to predict the case/control status of each child. Demographic characteristics of the child, demographic and socioeconomic characteristics of the mother, and information about the household were collected in the NIS interview. We obtained information on potential risk factors, including attitudes, beliefs, and behaviors indicative of vaccine safety concerns, and sources of information about immunizations from the NIS Knowledge, Attitudes, and Practices survey. Five key questions were asked, as follows: "If you had another infant today, would you want him/her to get all the recommended immunizations?" "How safe do you think immunizations are for children?" "Have you ever asked the doctor or nurse not to give your child an immunization for a reason other than illness?" "Were there any immunizations you didn't want to get for your child but did so because they were required by law?" "Do you believe that minor side effects occur with immunizations always, often, sometimes, rarely, or never?" The complete questionnaire is available on request.

Responses to the question, "How safe do you think immunizations are for children?" were dichotomized from an 11-point scale (0 = very unsafe; 10 = very safe) to identify those who believed vaccines were safe (scores of 8-10) versus those who believed vaccines were somewhat safe or unsafe (scores of 0–7). Responses to the question, "Do you believe that minor side effects occur with immunizations always, often, sometimes, rarely, or never?" were dichotomized into always/often and sometimes/rarely/never. For purposes of analysis, race/ethnicity was categorized as non-Hispanic white, African American, Hispanic, or other.

Statistical Analyses

We analyzed case/control status according to sociodemographic characteristics by using the χ^2 test. We included variables found to be significant in bivariate analyses in a logistic regression model and used backward elimination to determine sociodemographic variables that predicted case/control status. Subsequently, we placed each potential attitude, belief, and behavioral risk factor in a logistic regression model individually, controlling for the final predictive sociodemographic variables. We included significant risk factors ($P < .05$) in a logistic regression model, controlling for the predictive sociodemographic characteristics, and used backward elimination to determine the final model, consisting of demographic variables and risk factors. The criterion for keeping a variable in the model was $P < .05$. We also used logistic regression analyses to determine the sociodemographic variables associated with each of the significant attitude/belief/behavioral risk factors. The sociodemographic variables included race/ethnicity, mother's age, education, marital status, and income, provider type, and number of providers.

Survey Weights

Survey weights that accounted for the probability of selecting a household with a child 19 to 35 months of age were developed. The weights were adjusted to account for nonresponses and inability to obtain provider-reported vaccination histories. All analyses other than those presented in Table 1 used weighted data. SUDAAN (version 8)[11] was used for all analyses.

Attributable Risk

We calculated the percentage of children who were underimmunized for each of the 8 combinations of the 3 risk factors in the final logistic regression model. The comparison group was defined as all children whose parents reported wanting a new infant to receive all recommended immunizations, believed immunizations were safe, and had never asked a doctor or nurse not to give the child a vaccine for reasons other than illness. The attributable risk for a specific combination of risk factors was defined as 1 − the ratio of the percent of children underimmunized in the combination of the 3 risk factors ([% underimmunized] − [% fully immunized]/[% underimmunized]). The estimated number of excess cases for the combination was determined by multiplying the number of children underimmunized for the combination by the attributable risk for the combination.[12]

RESULTS

Response Rate

Overall, 2315 interviews were completed, among 4440 eligible children sampled (52.1%). Of the 2315 respondents, 13 were excluded from analyses because of misclassification of the child's vaccination status. The response rate for the control subjects was

TABLE 1. Description of the Underimmunized Children (Case Subjects)

Missing Vaccines	No. (%)
Hepatitis B, MCV	100 (21.6)
DTaP/DTP, hepatitis	76 (16.5)
MCV, DTaP/DTP	61 (13.2)
DTaP/DTP, hepatitis B, MCV	225 (48.7)
Total	462

Case subjects are described in terms of the three vaccines that have received recent negative attention (<3 doses of DTP/DTaP, <3 doses of hepatitis B, or 0 doses of MCV).

54.9%, and that for the case subjects was 47.6%. The primary reason for nonresponse was an inability to locate sampled households that participated in the NIS; refusals or inability to complete a full interview were uncommon.

Case Subjects and Case Description

Of the 2302 eligible respondents, 825 were underimmunized with respect to a single vaccine and were not included in this study. A total of 1015 (weighted estimate for the US birth cohort: 3 185 682) were control subjects (fully immunized), and 462 (weighted estimate: 289 463) were case subjects (underimmunized with respect to ≥2 of the specified vaccines). Table 1 shows the combinations of vaccines missed by case subjects.

Demographic Characteristics

Several demographic characteristics differed between case subjects and control subjects in bivariate analyses (Table 2). The final multivariate logistic regression model showed that 3 demographic variables significantly predicted case/control status, namely, income, number of vaccination providers, and number of children in the household. Compared with control subjects, households of case subjects were significantly more likely to make $0 to $30 000 than at least $75 000 (adjusted odds ratio [OR]: 2.7; 95% confidence interval [CI]: 1.5–4.6) and to have ≥2 vaccine providers than 1 (OR: 2.0; 95% CI: 1.3–3.1). Case subjects also were significantly more likely than control subjects to be members of households with ≥4 children (OR: 3.1; 95% CI: 1.5–6.3) than 1 child.

Attitude, Belief, and Behavioral Risk Factors

We compared case and control parental attitudes, beliefs, and behaviors indicative of vaccine safety concerns, controlling for significant demographic variables. Five survey questions were significantly associated with case status, with control for the significant demographic characteristics. Of these, 3 remained in the final logistic model as significant independent predictors, ie, not wanting a new infant to receive all recommended immunizations (attitude), not thinking immunizations are safe (belief), and asking the doctor or nurse not to give the child an immunization for reasons other than illness (behavior) (Table 3).

Demographic Predictors of 3 Significant Risk Factors

We assessed associations between the 3 significant attitude, belief, and behavioral risk factors and household demographic characteristics for both case subjects and control subjects. More parents whose children were underimmunized (7.3%) versus fully immunized (1.4%) reported that they would not want a new infant to receive all recommended immunizations ($\chi^2 = 13.7$, $P < .005$). Logistic regression analysis demonstrated that parents who did not want a new infant to receive all recommended immunizations were less likely to live in households making $50 001 to $75 000, compared with households making more than $75 000 (OR: 0.3; 95% CI: 0.1–0.9). They were also less likely to have their children cared for by mixed public/private or unknown provider types than by a private provider (OR: 0.2; 95% CI: 0.1–1.0).

Scoring vaccines as somewhat or not safe versus safe also was more prevalent among parents whose children were underimmunized (20.2%) than parents whose children were fully immunized (9.8%) ($\chi^2 = 13.3$, $P < .005$). Logistic regression analysis demonstrated that parents scoring vaccines as somewhat or not safe versus safe were more likely to live in households making $30 001 to $50 000 than more than $75 000 (OR: 2.5; 95% CI: 1.2–5.3). These parents were also less likely to have ≥2 vaccination providers for their children, compared with 1 (OR: 0.4; 95% CI: 0.2–0.7), and mothers were more likely to be non-Hispanic white, compared with Hispanic (OR: 2.7; 95% CI: 1.2–6.3) or "other" race (OR: 5.9; 95% CI: 1.2–25.0).

More parents whose children were underimmunized (11.3%) than fully immunized (4.2%) asked the child's medical provider not to give the child a vaccine for reasons other than illness ($\chi^2 = 8.24$, $P < .005$). The most common reason given by parents for this request was side effects (parents whose children were underimmunized: 57.2%; parents whose children were fully immunized: 45.5%). This was followed by too many shots for parents whose children were underimmunized (33.7%) and disease was not serious for parents whose children were fully immunized (27.1%). Logistic regression analysis demonstrated that households that reported asking their children's medical provider not to give the child a vaccine for reasons other than illness were more likely than those who did not make this request to have mothers with a college degree, compared with mothers with only a high school diploma (OR: 2.8; 95% CI: 1.2–6.5). In addition, the mothers in these households were less likely to be of "other" race, compared with non-Hispanic white (OR: 0.2; 95% CI: 0.1–0.9).

Attributable Risk

Table 4 presents the attributable risk associated with all combinations of the 3 attitude, belief, and behavioral risk variables in the model. Of the 289 463 underimmunized children or case subjects (weighted estimate), the number of excess underimmunized children attributable to the 7 combinations of the risk factors was 42 937 (42 937/289 463 = 14.8%). Each of the risk factors contributed a percentage to the total excess of underimmunized children (not wanting a new infant to receive all recommended immunizations: 38.3%; asking the doctor or nurse not to give the child a vaccine for reasons other than illness: 48.1%; not thinking immunizations are safe: 69.0%). The percentages are >100% because the risk factors are not mutually exclusive. For example, among those who asked the doctor or nurse not to give the child a vaccine for reasons other than illness, a greater percentage of case subjects than control subjects also did not want a new infant to receive all immunizations (36.2% vs 3.8%, $\chi^2 = 12.22$, $P < .005$) and thought immunizations were somewhat or not safe (50.9% vs 22.4%, $\chi^2 = 4.74$, $P = .03$).

TABLE 2. Characteristics of Case Subjects (Undervaccinated Children) and Control Subjects (Fully Vaccinated Children)

Characteristic	Undervaccinated, % (95% CI)	Fully Vaccinated, % (95% CI)	*z* Score *P* Value
Child characteristics			
Gender			
Male	53.2 (45.9–60.4)	50.8 (44.7–56.8)	.62
Female	46.9 (39.6–54.1)	49.2 (43.2–55.3)	.62
Age of child			
19–24 mo	37.8 (30.9–44.8)	33.8 (27.9–39.7)	.38
25–29 mo	30.6 (23.7–37.5)	29.9 (24.6–35.2)	.87
30–35 mo	31.6 (25.0–38.2)	36.3 (30.6–42.1)	.29
Firstborn			
Yes	31.8 (25.1–38.4)	43.4 (37.5–49.3)	.01
No	68.3 (61.6–74.9)	56.6 (50.7–62.5)	.01
Mother's characteristics			
Mother's age			
≤19 y	4.7 (1.5–8.0)	1.8 (0.5–3.1)	.10
20–29 y	50.2 (42.9–57.4)	47.4 (41.5–53.4)	.57
≥30 y	45.1 (37.9–52.3)	50.7 (44.8–56.7)	.24
Education of mother			
<12 y	21.7 (15.5–28.0)	14.4 (9.4–19.4)	.07
12 y	37.2 (30.2–44.2)	35.4 (29.5–41.2)	.70
Some college	11.7 (8.0–15.4)	17.9 (13.0–22.8)	.05
College graduate	29.4 (22.6–36.2)	32.3 (27.3–37.4)	.50
Mother's marital status			
Widowed/separated/divorced	12.4 (7.9–16.9)	8.6 (3.7–13.4)	.26
Never married	28.9 (21.8–36.1)	23.4 (18.3–28.4)	.21
Married	58.7 (51.4–66.0)	68.1 (62.0–74.2)	.05
Race of mother			
White	46.0 (39.0–53.0)	58.7 (52.7–64.6)	.01
Black	22.9 (16.1–29.7)	15.2 (11.1–19.3)	.06
Hispanic	28.2 (21.6–34.8)	21.6 (16.1–27.2)	.14
American Indian	0.6 (0.1–1.2)	0.9 (0.3–1.4)	.54
Asian	2.3 (0.4–4.2)	3.7 (0.5–6.9)	.46
Other	0.0	0.0	
Household characteristics			
Income			
$0 to $30 000	60.9 (53.5–68.3)	42.1 (35.5–48.6)	<.001
$30 001 to $50 000	20.0 (13.4–26.5)	21.5 (16.5–26.4)	.72
$50 001 to $75 000	9.0 (5.7–12.3)	17.9 (13.2–22.5)	<.001
≥$75 001	10.2 (6.3–14.1)	18.6 (14.0–23.2)	.01
No. of people in household			
2	3.3 (0.7–5.9)	4.4 (1.2–7.6)	.59
3	17.4 (12.1–22.6)	25.6 (20.6–30.5)	.03
4	34.0 (27.4–40.5)	40.3 (34.2–46.3)	.17
5	22.5 (15.9–20.1)	14.4 (11.1–17.7)	.03
≥6	22.9 (16.6–29.3)	15.3 (10.9–19.7)	.05
No. of children in household			
1	19.8 (14.3–25.3)	30.0 (24.6–35.4)	.01
2 or 3	61.2 (54.1–68.3)	60.5 (54.8–66.3)	.89
≥4	19.0 (12.9–25.2)	9.5 (6.6–12.4)	.01
Unknown	0.0	0.0	
Shot card availability			
Yes	45.0 (37.9–52.1)	52.1 (46.1–58.1)	.13
No	55.0 (47.9–62.1)	47.9 (41.9–53.9)	.13
No. of providers			
1	55.3 (48.2–62.4)	70.1 (64.6–75.6)	<.001
≥2	44.7 (37.6–51.8)	29.9 (24.4–35.4)	<.001
Type of provider			
All public	20.4 (14.3–26.6)	11.9 (8.8–15.0)	.02
All hospital	5.5 (2.7–8.2)	8.6 (5.6–11.6)	.13
All private	44.6 (37.7–51.6)	55.8 (49.8–61.8)	.02
All military/other	2.8 (0.9–4.7)	0.5 (0–1.1)	.03
Mixed	3.7 (0–7.7)	7.5 (4.5–10.6)	.14
Unknown	23.0 (17.3–28.8)	15.7 (10.4–20.9)	.06
Mobility			
Moved	15.2 (9.5–20.9)	7.3 (4.1–10.5)	.02
Did not move	84.8 (79.1–90.5)	92.7 (89.5–95.9)	.02
Respondent relationship			
Mother	84.7 (79.4–90.0)	87.5 (83.5–91.5)	.41
Father	11.8 (6.9–16.7)	10.1 (6.4–13.8)	.59
Other	3.5 (1.0–6.1)	2.4 (0.9–4.0)	.46

TABLE 3. Initial and Final Multivariate Analyses of Parental Attitude/Belief/Behavioral Risk Factors

Variables	Initial Multivariate Analysis*	Final Multivariate Analysis*
If you had another baby today, would you want him/her to get all recommended immunizations?		
Yes	Referent	Referent
No	8.9 (3.3–24.0)	3.8 (1.5–9.8)
Have you asked the doctor or nurse not to give your child an immunization for a reason other than illness?		
No	Referent	Referent
Yes	3.4 (1.6–7.4)	2.7 (1.2–6.1)
How safe do you think immunizations are for children?		
Safe	Referent	Referent
Unsafe/somewhat safe	2.8 (1.6–4.7)	2.0 (1.2–3.4)
Do you believe minor side effects occur with immunizations?†		
Sometimes/rarely/never	Referent	
Always/often	2.1 (1.2–3.5)	
Were there any immunizations you did not want to get for your child but did so because they were required by law?†		
No	Referent	
Yes	2.2 (1.2–4.2)	

* Initial multivariate analysis refers to each attitude, belief, and behavioral risk factor analyzed separately in a logistic model, controlling for the significant demographic characteristics. The final multivariate analysis includes all significant risk factors in the model together, controlling for the significant demographic characteristics.
† Did not remain in the final model.

TABLE 4. Risk Attributable to Attitudes/Beliefs/Behaviors Indicative of Vaccine Safety Concern

Category (Want Immunizations/ Safe/Declined)	% in Category (95% CI)	% Underimmunized	AR (%)	Total Underimmunized	Excess Cases (Total Underimmunized × AR)
Yes/yes/no*	83.1 (±2.7)	7.1		209 016.5	0
Yes/no/yes	1.2 (±0.6)	18.0	60.7	5509.3	3344.1
Yes/yes/yes	3.7 (±1.5)	12.8	44.7	15 062.6	6732.3
Yes/no/no	8.6 (±1.9)	12.9	45.0	36 534.1	16 438.9
No/no/yes	0.5 (±0.3)	69.8	89.8	10 970.7	9856.2
No/yes/yes	0.1 (±0.1)	68.9	89.7	833.9	748.1
No/no/no	0.8 (±0.5)	19.6	63.7	5006.4	3190.8
No/yes/no	0.6 (±0.4)	18.7	62.2	4225.9	2627.1
Total				28 9463	42 937

* Yes/yes/no: would want new baby to receive all recommended immunizations/think immunizations are safe/never asked the doctor not to give the child a vaccine for reasons other than illness (declined). The calculations are based on the seven combinations of the three risk factors that contributed to the final logistic regression model. The excess cases for each combination were added to determine the total number of excess cases. The yes/yes/no category was used as the comparison to calculate attributable risk (AR) for the remaining categories. Underimmunized children (case subjects) were missing ≥2 of the following vaccines: DTaP/DTP vaccine, hepatitis B vaccine and MCV.

DISCUSSION

Our study documents that attitudes, beliefs, and behaviors indicative of vaccine safety concern contribute substantially to underimmunization in the United States. Moreover, although concerns were significantly more common among parents of underimmunized children, many parents of fully immunized children expressed similar attitudes and beliefs, suggesting potential risks to the currently high vaccine coverage levels.

Our data also document that socioeconomic, family, and health care factors are key contributors for the majority of children who are not up to date for ≥2 of the 3 focus vaccines. Similar to our study, associations between poverty and vaccination status were identified in several studies.[13–15] In addition, we found that having a larger number of children in the household and having ≥2 providers were significantly and independently associated with case status. These factors were also important in other studies. A study of 13-month-old children in a regional health maintenance organization found that independent predictors of delayed immunization included, among other factors, having a larger number of children and not having a regular doctor,[16] and a study of families in Baltimore found lower proportions of age-appropriate immunization among children with ≥2 siblings and children with ≥2 providers during their first 2 years of life.[17] The Vaccines for Children program was implemented in 1994 to make free vaccines available at private provider offices for low-income and uninsured children. Despite the tremendous success of that program, our results suggest that having ≥2 providers for vaccinations remains a problem.

Studies showing a relationship between vaccine-related attitudes and beliefs and underimmunization have been conducted in countries outside the United States[18–20] and in individual states within the United States.[21] Our study provides the first nationally representative survey data of which we are aware that link underimmunization in the United States with vaccine safety concerns. Other studies failed to find this association.[17,22,23] However, those studies were small, each included children from a single metropolitan area, and questions about vaccine safety were very general. In contrast, children included in our study were randomly chosen from a national statistical sample, and interviews included specific questions on vaccine safety attitudes, beliefs, and behaviors that had been cognitively pretested. Our study also was conducted more recently; as vaccine safety concerns have become more prominent in the media and on the Internet, the effects of these concerns might have increased. Additional questions have been added to a module of the NIS to better assess trends in vaccine safety attitudes and beliefs.

We estimated that 42 937 children, or slightly >1% of the US birth cohort, did not receive ≥2 of the focus vaccines because of vaccine safety concerns. Although immunization coverage remains high, many parents of fully vaccinated children demonstrated the same attitudes, behaviors, and beliefs as parents of underimmunized children. Independent of case or control status, significant associations were found for ≥1 of these attitudes/beliefs/behaviors with being non-Hispanic white, having a private medical care provider, being in a higher income category, and having a college degree. These characteristics are markedly different from those associated with underimmunization. The larger number of socioeconomically disadvantaged families in the case group may obscure the different demographic features of those who are underimmunized because of vaccine safety concerns. Alternately, some parents may express concern but be able to discuss their worries with their providers and decide to vaccinate their children; 4.2% of fully vaccinated control children had a parent who reported asking that the child not receive a vaccine. A previous study found that more highly educated parents were more likely to trust medical professionals but also were more concerned about contraindications than were less educated parents.[21] We found that households with highly educated mothers reported asking that the child not receive a vaccine. School entry laws also may have an impact; 11.7% of case parents and 6.3% of control parents reported that they had received a vaccine they did not want because it was required. Interpersonal factors (doctor-patient relationship), community factors (social norms), and public policy factors[24] (immunization laws) all may play important roles in maintaining immunization coverage.

Our study results must be interpreted in the context of several potential limitations. The response rate was 52%, primarily because of an inability to recontact families that had been interviewed for the NIS 3 to 9 months earlier. Weights were adjusted to compensate for differences between responders and nonresponders. Also, parents may have had difficulty recalling their attitudes and beliefs when their children were receiving infant immunizations. It is possible that, in some cases, responses reflected current beliefs, despite interviewers frequently reminding parents to recall when the child was an infant. If vaccine safety concerns had increased since the children of interviewed parents were infants, then the direction of the bias would be toward the null hypothesis (not finding significant associations between beliefs and vaccination status) and the true effects would be greater than reported here. The primary strengths of this study are the large sample size, the ability to weight responses on the basis of the statistical sampling methods, and the ability to analyze both demographic and attitude/belief/behavioral variables as potential predictors of case/control status.

Our study suggests that efforts to maintain and improve immunization coverage need to target those with attitudes/beliefs/behaviors indicative of vaccine safety concerns, as well as those with socioeconomic and health care-related risk factors. Materials that can help vaccination providers communicate effectively with parents about vaccine safety and the balance between the benefits and risks of immunization have been developed (www.cdc.gov/nip/publications). However, it is important to tailor the information provided to each parent's needs. For example, if the parent needs assurance regarding the safety of vaccines, then presenting information in the *Vaccine Safety for Parents* brochure may be useful. If a parent questions the need for vaccines for the child, then reviewing information in the *Helping Parents Who Question Vaccines: A Provider's Guide* brochure may help the provider talk with the parent. The ability to achieve and sustain disease prevention goals depends, in part, on the success of such communication.

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