

Are Parental Vaccine Safety Concerns Associated With Receipt of Measles-Mumps-Rubella, Diphtheria and Tetanus Toxoids With Acellular Pertussis, or Hepatitis B Vaccines by Children?

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Objectives: To identify parental perceptions regarding vaccine safety and assess their relationship with the immunization status of children.

Design, Setting, and Participants: Case-control study based on a survey of a sample of households participating in the 2000-2001 National Immunization Survey, a quarterly random-digit-dialing sample of US children aged 19 to 35 months. Three groups of case children not up-to-date for 3 vaccines were compared with control children who were up-to-date for each respective vaccine.

Main Outcome Measure: Measles-containing or measles-mumps-rubella, diphtheria and tetanus toxoids and pertussis or diphtheria and tetanus toxoids with acellular pertussis, and hepatitis B vaccination coverage.

Results: Among those sampled from the 2000-2001 National Immunization Survey, the household response rate was 2315 (52.1%) of 4440. Most respondents (>90%) in all groups believed vaccinations are important. In each case-control group, there was no significant difference

between the percentage of case and control parents expressing general vaccine safety (range, 53.5%-64.1%). However, case parents were more likely to have asked that their child not be vaccinated for reasons other than illness (range, 10.2%-13.7% vs range, 2.9%-5.3%, respectively) and to believe their children received too many vaccinations (range, 3.4%-7.6% vs range, 0.8%-1.0%, respectively). Among the case-control group receiving a measles-containing or measles-mumps-rubella vaccination, only a small percentage of parents knew about the alleged association between autism and measles-mumps-rubella vaccinations (8.2%), and case parents were more likely to believe it than control parents (4.4% vs 1.5%, respectively; $\chi^2 P = .04$).

Conclusions: Despite belief in the importance of immunization by a vast majority of parents, the majority of parents had concerns regarding vaccine safety. Strategies to address important misperceptions about vaccine safety as well as additional research assessing vaccine safety are needed to ensure public confidence.

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MANY VACCINE-PREVENTABLE diseases, such as diphtheria, tetanus, measles, mumps, rubella, and polio, are now rare in developed nations. However, with the near elimination of these infections, disease no longer serves as a reminder of the need for vaccines.¹ Instead, attention has been diverted to concern about adverse events related to vaccines, real or otherwise.² Today, when the topic of vaccines appears in the news, reports often focus on potential adverse events. For example, during the 1980s, whole-cell diphtheria and tetanus toxoids and pertussis vaccine (DTP) was associated with concern about sudden infant death syndrome and encephalopathy.³ More recently, concerns have been raised about

the possible association of the hepatitis B vaccine with multiple sclerosis,⁴ and it has been hypothesized that the measles-mumps-rubella vaccine (MMR) is linked with autism.^{5,6} Although these hypotheses have not been substantiated,⁷ they have affected vaccination coverage in other countries. In fact, in countries with active antivaccine movements, such as Australia, Great Britain, the former West Germany, and Japan, fear of these adverse events from vaccines has been associated with declines in vaccination coverage^{8,9} and has maybe even led to increases in measles¹⁰ and B pertussis cases.¹¹ In the United States, studies presented at a recent meeting conducted by the Institute of Medicine conclude that there is not a causal association between MMR and autism.^{12,13}

This study assesses parental attitudes about vaccine safety and their potential relationship with the receipt of vaccines by children. Because of the publicity about hypothesized adverse events associated with the vaccines, measles-containing vaccine (MCV) or MMR, DTP or the diphtheria and tetanus toxoids with acellular pertussis (DTaP) vaccine, and hepatitis B vaccine were chosen for this analysis.

METHODS

STUDY DESIGN

The National Immunization Survey—Knowledge, Attitudes, and Practices (NIS-KAP) study sampled children from among those participating in the 2000-2001 National Immunization Survey (NIS) and contacted those households for a follow-up interview from January through December 2001. The NIS is a random-digit-dialing survey conducted quarterly that collects vaccination information from households and vaccine providers (which include pediatricians, family physicians, general practitioners, nurses, pediatric nurse practitioners, family nurse practitioners, physician assistants, or other practitioners) for children aged 19 to 35 months.¹⁴ The NIS study population was stratified by physician-verified vaccination status for MCV/MMR, DTP/DTaP, and hepatitis B. The NIS-KAP study included 3 groups of cases selected by a computer-generated random selection technique from these strata to achieve similar numbers (in the United States) of cases (those not up-to-date for 1 or more of the specified vaccines) and 3 groups of controls (those up-to-date for all vaccines; ≥ 4 doses of DTP/DTaP, ≥ 3 doses of polio vaccine, ≥ 1 doses of MMR, ≥ 3 doses of *Haemophilus influenzae* type b vaccine, ≥ 3 doses of hepatitis B vaccine, and ≥ 1 doses of varicella vaccine.) The 3 case-control groups were not mutually exclusive, because some case children were included in more than 1 case group and some control children were included in more than 1 control group. This overlap limited the number of questions asked of each participant. One hundred sixty-one (10%) cases were in 1 group only, and none of the controls were in 1 group only. One interview was conducted for all questionnaires.

SURVEY INSTRUMENT

The survey consisted of a core module for all respondents and 3 vaccine-specific modules. The core module included questions regarding concerns about vaccine safety in general; whether the parent had refused any vaccinations, and if so, reasons for refusing vaccinations, as well as which vaccines were refused; and if any of the respondents' children had a side effect or a reaction to an immunization, what actions were taken. The vaccine-specific modules were used to interview parents of control children and case children who were missing specified vaccinations. For example, if a child never received MCV/MMR, the parent was administered the MCV-specific questionnaire, which included questions such as "Have you heard (ie, aware) that the MCV/MMR shot caused side effects?" and "Are you concerned (ie, worried or alarmed) about the MCV/MMR shot's safety?" Parents who responded that they had heard about side effects associated with the vaccine were asked an open-ended question to specify their concerns. Each question was asked in reference to the index child unless specifically stated otherwise.

STATISTICAL ANALYSIS

Responses were analyzed separately for each case-control group. Data were weighted to adjust for the study design to make re-

sults generalizable to US children aged 19 to 35 months, using SUDAAN, release 7.5.6 (Research Triangle Institute, Research Triangle Park, NC). Statistical methods that adjust for vaccine providers' nonresponse bias were applied.¹⁵ Data were not collected on parental nonrespondents. Some variables (eg, importance of immunizations, parental concern about vaccine safety) were collected on an 11-point Likert scale. These variables were recoded as low, 0 to 3; medium, 4 to 7; and high, 8 to 10. The potential associations between select characteristics and whether the child was vaccinated were examined for each group of cases and controls using a χ^2 test of association as well as logistic regression to determine odds ratios and confidence intervals (CIs). Independent variables included sociodemographic characteristics of the child and parents; if the parent had heard that certain vaccines caused side effects and what they heard; concern about vaccine safety; reasons, if any, for refusing vaccinations as well as which vaccines were refused; if the study child ever had a side effect from a vaccination; if any member of the household suffered from rheumatoid arthritis, autism, autoimmune disease, or multiple sclerosis; and if the respondent had a new baby, would the baby be immunized. Odds ratios were adjusted for race/ethnicity, firstborn status, child's age, and family income. Other variables such as mother's education, mother's age, and respondent's marital status were considered but because of the high multicollinearity among those variables, they were not included.

We considered presenting attributable risk analysis because it would be helpful in understanding what fraction of underimmunization is due to safety concerns. However, the complicated nature of the study design is such that a substantial portion of the children in the 19- to 35-month-old population could neither be cases nor controls. Thus describing the population represented would be very difficult to interpret, rendering this type of analysis unconstructive.

Details about the design of this study have been previously published.¹⁶ Because study participants were chosen from the NIS, which is a random-digit-dialing survey, inherent potential problems with random-digit-dialing are addressed. Failure to adequately account for households without telephones may have yielded estimates of health outcomes that are misleading, particularly in states with at least moderate telephone noncoverage. However,

the dynamic nature of the population of households without telephones offers a way of accounting for such households in telephone surveys. At any given time the population of telephone households includes households that have had a break or interruption in telephone services. Empirical results strongly suggest that these households are very similar to households that have never had telephone service. Thus, sampled households that report having had an interruption in telephone service may be used to represent the portion of the population that has never had telephone service. This strategy can lead to a reduction in non-coverage bias in random-digit dialing surveys.^{17 (p1611)}

The NIS applies this methodology.

RESULTS

RESPONSE RATE

Four thousand four hundred forty households were contacted; of these, 2315 completed the survey (response rate, 52.1%). Of these, 1016 were cases and 1299 were controls. Twelve children were excluded from analysis because their physicians verified additional immunizations after the selection process that included an incorrect original classification.

Table 1. National Immunization Survey—Knowledge, Attitudes, and Practices Weighted Statistics vs 2000-2001 Descriptive Data by Vaccine Case-Control Group*

Variable	MCV/MMR		DTP/DaP		Hepatitis B	
	Cases (n = 643)	Controls (n = 612)	Cases (n = 454)	Controls (n = 595)	Cases (n = 686)	Controls (n = 596)
Race of child						
White	54.6	53.4	43.8	53.8	47.8	59.1
African American	17.7	12.6	20.0	15.2	13.3	18.4
Hispanic	22.1	27.6	31.7	26.6	31.6	15.3
Other	3.1	5.0	2.8	2.4	3.9	5.4
Missing	2.5	1.5	1.7	2.0	3.5	1.8
Firstborn						
Yes	34.4	40.9	37.0	44.6	29.3	42.7
No	64.3	56.2	60.7	54.8	69.1	54.2
Missing	1.4	2.9	2.3	0.6	1.7	3.1
Marital status of parent						
Married	59.2	73.2	57.6	63.4	68.9	71.3
Not married	40.8	26.8	42.4	36.6	31.1	28.7
Maternal education						
<High school	19.7	14.3	20.1	16.4	26.6	11.4
High school graduate/GED	37.6	33.3	36.6	34.6	34.6	37.0
>High school	42.7	52.4	43.3	49.0	38.8	51.6
Mother's age, y						
<20	4.4	1.0	5.3	1.9	3.8	1.8
20-29	53.7	47.3	51.1	46.1	53.2	47.8
≥30	41.5	49.7	41.9	50.6	42.7	49.6
Missing	0.0	2.0	1.8	1.4	0.0	0.9
Annual family income, \$						
<20 000	33.8	16.9	35.0	24.4	33.2	24.2
20 000-50 000	35.7	37.8	30.4	34.8	33.6	28.1
>50 000	16.1	34.5	22.6	27.9	20.4	32.9
Missing	14.4	10.8	12.1	12.9	12.8	14.8
Participation in WIC, ever						
Yes	61.2	52.9	59.7	56.0	57.1	49.8
No	35.9	46.1	39.4	43.5	41.2	50.0
Missing	2.9	1.0	0.9	0.5	1.7	0.2
Participation in WIC, still receiving						
Yes	29.5	29.5	30.4	32.0	31.2	26.5
No	31.7	23.5	29.4	24.1	26.0	23.4
Never received WIC	38.8	47.1	40.3	44.0	42.8	50.1

Abbreviations: DTaP, diphtheria and tetanus toxoids with acellular pertussis vaccine; DTP, diphtheria and tetanus toxoids and pertussis vaccine; GED, general educational development test; MCV, measles-containing vaccine; MMR, measles-mumps-rubella vaccine; WIC, Women, Infants, and Children program.

*Values are expressed as weighted percentages.

STUDY POPULATION

Demographic characteristics were generally similar among the 3 case-control groups (**Table 1**). Overall, case mothers tended to have a lower level of education than control parents in all groups, and the difference was statistically significant for the hepatitis B group. Additionally, case mothers tended to be younger (aged 20-29 years) than control mothers (aged ≥30 years); this difference was statistically significant for the MCV/MMR group. Case families generally had a lower annual income (<\$20,000) than control families (≥\$50,000), with a statistically significant difference among the MCV/MMR and hepatitis B groups. The proportion of minority children varied among the 3 case-control groups. Compared with controls, African American individuals were more likely to be cases (17.7% vs 12.6%), whereas Hispanic individuals were less likely to be cases (22.1% vs 27.6%) in the MCV group. For the hepatitis B group, Hispanic individuals were more likely to be cases. Less than 6% of re-

spondents in any group reported a household member suffering from rheumatoid arthritis, autism, autoimmune disease, or multiple sclerosis.

PARENTAL BELIEFS AND PRACTICES ASSOCIATED WITH VACCINATIONS

Among all 3 case-control groups, the vast majority of respondents (>90%) in all groups believed vaccinations are important, and there was no significant difference between case and control parents. More than half of all case and control parents reported they had expressed concern to their children's physicians about the safety of immunizations, and the differences between case and control parents were not statistically significant (**Table 2**). However, among all groups (MCV/MMR, adjusted odds ratio [AOR], 2.9 [95% CI, 1.3-6.7]; DTP/DaP, AOR, 2.7 [95% CI, 1.3, 5.7]; and hepatitis B, AOR, 9.1 [95% CI, 4.3-19.6]), case children's parents were statistically significantly more likely to have ever refused any vaccine

Table 2. Parental Beliefs and Practices Associated With Vaccinations—United States, 2000-2001, by Vaccine Case-Control Groups*

Variable	MCV/MMR			DTP/DTaP			Hepatitis B		
	Cases	Controls	AOR (95% CI)	Cases	Controls	AOR (95% CI)	Cases	Controls	AOR (95% CI)
Did you express concern to the doctor about the safety of immunizations?									
Yes	305 (53.5)	286 (63.6)	0.6 (0.3-1.0)	209 (61.5)	282 (61.9)	1.0 (0.6-1.7)	321 (62.0)	288 (64.1)	1.0 (0.6-1.7)
No	202 (46.5)	205 (36.4)	1.0 Referent	129 (38.5)	190 (38.1)	1.0 Referent	217 (38.0)	184 (35.9)	1.0 Referent
Have you ever refused any vaccine for your child for a reason other than illness of the child?									
Yes	77 (10.4)	31 (4.7)	2.9 (1.3-6.7)†	43 (10.2)	38 (5.3)	2.7 (1.3-5.7)†	92 (13.7)	25 (2.9)	9.1 (4.3-19.6)†
No	564 (89.6)	580 (95.3)	1.0 Referent	410 (89.8)	556 (94.7)	1.00 Referent	592 (86.3)	571 (97.1)	1.0 Referent
Have you ever refused the vaccine (group-specific [ie, MCV, DTP, hepatitis B]) for your child?									
Yes	22 (21.0)	5 (7.8)	3.1 (0.7-13.3)	5 (14.2)	4 (3.6)	4.4 (0.7-28.7)	32 (35.6)	4 (41.6)	0.8 (0.2-3.4)
No	55 (79.0)	26 (92.2)	1.00 Referent	30 (85.8)	25 (96.4)	1.00 Referent	49 (64.4)	18 (58.4)	1.0 Referent
Have any of your children ever had a side effect or reaction to an immunization?									
Yes	287 (44.9)	287 (41.4)	1.2 (0.7-2.0)	209 (47.4)	258 (33.6)	1.9 (1.2-3.2)†	296 (35.1)	253 (37.9)	1.0 (0.6-1.5)
No	354 (55.1)	324 (58.6)	1.0 Referent	243 (52.6)	333 (66.4)	1.0 Referent	390 (64.9)	338 (62.1)	1.0 Referent
Were there shots you did not want for your child but did so because required by law?									
Yes	69 (10.7)	49 (6.5)	1.9 (1.0-3.7)	41 (10.1)	52 (6.7)	2.1 (1.0-4.2)	74 (10.4)	33 (5.0)	3.1 (1.5-6.5)†
No	569 (89.3)	558 (93.5)	1.0 Referent	408 (89.9)	539 (93.3)	1.0 Referent	606 (89.6)	557 (95.0)	1.0 Referent
If you had a new baby, would you want to get all immunizations?									
Yes	588 (93.6)	593 (98.5)	0.2 (0.1-0.6)†	423 (94.9)	577 (98.4)	0.5 (0.2-1.3)	629 (94.7)	584 (99.4)	0.1 (0.0-0.4)†
No	48 (6.4)	14 (1.5)	1.0 Referent	29 (5.1)	13 (1.6)	1.0 Referent	48 (5.3)	7 (0.6)	1.0 Referent

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; DTaP, diphtheria and tetanus toxoids with acellular pertussis vaccine; DTP, diphtheria and tetanus toxoids and pertussis vaccine; MCV, measles-containing vaccine; MMR, measles-mumps-rubella vaccine.

*Values are expressed as number (weighted percentage) of individuals unless otherwise specified. The AORs are adjusted for race/ethnicity, child's age, firstborn status, and family income.

† $P < .05$.

for their child for a reason other than illness. No significant difference between case and control parents was found in any of the groups among those who had rejected the vaccine specific to their group and those who did not. Case parents in all groups were significantly less likely to report if they had another baby today, they would want the child to get all the recommended immunizations than were control parents ($P < .01$).

To assess association between race/ethnicity and vaccine safety concerns, we stratified by race (controlling for potential confounders) and found no statistically significant association with immunization status in any of the groups.

PARENTAL CONCERNS AND BELIEFS ABOUT POTENTIAL SIDE EFFECTS ASSOCIATED WITH VACCINES

Nearly half of all case and control parents reported hearing that the respective vaccine caused side effects, and the difference between case and control parents was not significant among any of the groups (**Table 3**). Fever

was frequently reported as a side effect by all groups among parents who heard the vaccine caused side effects.

For the MCV/MMR group, differences existed regarding the association between vaccination and autism. More parents of case children (weighted, 5.5%) in the MCV/MMR group reported hearing of an association between autism and vaccination than control parents (weighted, 2.7%). Parents of case children were significantly more likely to believe there was an association between autism and vaccination ($P < .04$).

REASONS PARENTS HAD FOR REFUSING VACCINATION

Among the parents who asked that their child not be vaccinated, beliefs and reasons for refusing vaccination differed between case and control parents (Table 3). For MCV/MMR (weighted, 6.7% of cases vs 2.2% of controls) and hepatitis B (weighted, 8.2% of cases vs 1.5% of controls), case parents were significantly more likely to have asked that their child not be vaccinated because

Table 3. National Immunization Survey—Knowledge, Attitudes, and Practices Parental Concerns and Beliefs About Side Effects Associated With Vaccines and Reasons Parents Had for Asking Their Child Not Be Vaccinated—United States, 2000-2001, by Vaccine Case-Control Group*

Variable	MCV/MMR			DTP/DaP			Hepatitis B		
	Cases (n = 643)	Controls (n = 612)	AOR (95% CI)	Cases (n = 454)	Controls (n = 595)	AOR (95% CI)	Cases (n = 686)	Controls (n = 596)	AOR (95% CI)
Heard that MCV/DTP/hepatitis B caused side effects	47.9	49.7	0.9 (0.5-1.5)	48.5	42.1	1.1 (0.7-1.8)	45.4	46.2	0.8 (0.5-1.3)
Heard vaccine causes autism	5.5	2.7	2.4 (1.1-5.3)†	1.4	2.5	0.6 (0.1-3.1)	1.1	0.6	3.5 (0.8-15.9)
Believed it	4.4	1.5	4.7 (1.4-15.6)†	0.1	0.3	1.0 (0.1-8.1)	0.7	0	NA
Heard vaccine causes fever	4.8	4.3	1.4 (0.6-3.1)	4.2	3.8	0.5 (0.2-1.5)	4.8	4.2	0.5 (0.2-1.6)
Believed it	3.6	3.6	1.2 (0.6-2.7)	2.4	2.7	0.7 (0.3-2.1)	2.0	3.8	0.4 (0.1-1.2)
Heard vaccine causes high fever	1.3	0.2	6.9 (1.8-26.2)†	1.5	1.1	1.4 (0.2-8.3)	0.3	1.4	0.2 (0.0-2.0)
Believed it	0.7	0.1	6.1 (1.2-32.6)†	1.4	0.7	1.6 (0.3-9.5)	0.3	1.3	0.2 (0.0-1.6)
Heard vaccine causes brain damage	4.1	0.9	2.0 (0.5-7.9)	2.7	1.3	2.0 (0.2-19.3)	0.1	1.2	0.1 (0.0-1.9)
Believed it	2.3	0.9	NA	3.0	1.5	NA	0.2	1.5	0.1 (0.0-1.7)
Heard vaccine causes liver problems	0	0	NA	0	0	NA	1.2	0.3	6.1 (0.6-66.4)
Believed it	0	0	NA	0	0	NA	1.1	0	NA
Asked that child not be vaccinated	10.4	4.7	3.0 (1.1-6.6)†	10.2	5.3	2.8 (1.4-5.7)†	13.7	2.9	8.7 (4.0-19.0)†
Why did you ask that your child not be vaccinated?									
Concerned about side effects	6.7	2.2	2.8 (1.1-7.6)†	5.0	2.6	2.5 (1.1-6.0)†	8.2	1.5	10.0 (4.2-23.9)†
Believed child received too many shots	3.4	1.0	4.0 (1.4-10.8)†	3.7	0.9	7.5 (2.1-26.9)†	7.6	0.8	19.1 (2.7-136.7)†
Unlikely child would get the disease	2.7	2.4	2.3 (0.5-11.0)	3.3	2.2	3.8 (1.2-12.3)†	6.3	0.9	8.8 (2.4-32.4)†
Believed the disease was not serious	2.8	1.6	4.5 (1.2-17.2)†	3.9	1.9	8.7 (2.3-33.5)†	2.5	0.4	31.7 (8.4-119.3)†
Wanted to postpone the shot	2.2	0.9	2.5 (0.5-11.9)	0.7	1.6	0.7 (0.2-3.3)	2.2	1.0	5.5 (1.2-24.6)†
Believed shots too expensive	0.5	0	NA	1.0	0	NA	0.4	0	NA

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; DaP, diphtheria and tetanus toxoids with acellular pertussis vaccine; DTP, diphtheria and tetanus toxoids and pertussis vaccine; MCV, measles-containing vaccine; MMR, measles-mumps-rubella vaccine; NA, not applicable.

*Values are expressed as weighted percentage of individuals unless otherwise specified. The AORs are adjusted for race/ethnicity, child's age, firstborn status, and family income. Fewer than 1% of cases and controls reported hearing the vaccine causes seizures, sudden infant death syndrome, diabetes, multiple sclerosis, shingles, or kidney failure.

† $P < .05$.

of concerns about side effects. Among all groups (MCV/MMR, weighted, 3.4% of cases vs 1.0% of controls; DTP/DaP, weighted, 3.7% of cases vs 0.9% of controls; hepatitis B, weighted, 7.6% of cases vs 0.8% of controls), case parents perceived that their child was receiving too many shots more frequently than control parents (MCV, $P = .03$; DTP/DaP, $P = .05$; hepatitis B, $P < .001$).

COMMENT

The vast majority of parents in our study believed immunizations were important to their child's health, but a considerable proportion also had concerns regarding vaccine safety in general. Although general concerns about vaccine safety were not significantly different between case and control parents, a significant difference in vaccination coverage was found between those who had specific concerns regarding side effects (notably the belief that autism was associated with vaccination) and receiving too many shots, as opposed to those who did not. Similar to previous studies,¹⁸⁻²⁰ our results confirm that children of parents with low socioeconomic status (lower level of education, lower annual income, etc) or who belong to a racial/ethnic minority were less likely to be up-to-date with

MCV and hepatitis B vaccination. However, no statistically significant association between immunization status and vaccine safety concerns was found between the different race/ethnicity groups in any of the case-control groups.

A number of reasons may exist for continued acceptance of vaccination despite possible safety concerns. These include the parents' beliefs regarding the benefits of vaccination,¹ compliance with social norms,²¹ and the impact of school entry laws.²² Widespread concerns about vaccine safety, however, can pose a risk to maintaining high coverage, especially as the incidence of vaccine-preventable diseases decrease. Overall, more respondents reported they had expressed concerns to their children's physician about vaccine safety than had reported hearing of side effects. This suggests that some parents are generally concerned without being concerned about any specific side effect. In response to an open-ended question, parents reported hearing of many different side effects but no specific side effect was reported by more than 10% of respondents in any of the 3 groups. This finding is consistent with general concerns about immunization and suggests a need for health care professionals to discuss vaccine safety in general as well as to be able to respond to specific concerns.

What This Study Adds

In the past several years, increased attention to potential adverse events from vaccines has appeared in the news, but this study is the first to examine the effect of parental attitudes about vaccine safety on the receipt of vaccinations by children. In our study, the vast majority of parents believed immunizations were important to their children's health but a considerable proportion also had concerns regarding vaccine safety in general. A significant difference in vaccination coverage was found between those who had specific concerns (eg, belief in an association between autism and MMR, receipt of too many shots) and those who did not. Strategies to address important misperceptions about vaccine safety as well as additional research assessing vaccine safety are needed to ensure public confidence.

Equal proportions of both case and control parents reported hearing of minor side effects associated with vaccines, whereas case parents were more likely to report hearing of serious side effects. For example, equal proportions of both case and control parents reported fever as a side effect of vaccination, and the absence of a significant difference between groups indicates that this did not affect vaccination behaviors. By contrast, parents of children missing MCV/MMR were significantly more likely to report having the belief that vaccination causes autism. This relationship—despite the lack of scientific evidence that MMR and autism are related^{6,12}—likely reflects greater parental concern about this severe and chronic illness. In the United Kingdom, where the controversy has been widely publicized, MMR coverage rates have fallen from 92% to 88%, overall, and are down to 65% in some areas.²³ While MMR vaccination rates in the United States remain high, the perception of a link between MMR and autism, against a background of general concern about vaccine safety, might lead to decreased coverage and jeopardize the elimination of endogenous spread of measles in this country.

Another frequently reported reason in all groups for not having a child vaccinated was the belief that children receive too many vaccinations (range, 3.4%-7.6% of case parents). Currently, children receive approximately 20 vaccinations within the first 2 years of life, an increase of 25% from 5 years ago. For a parent who has not seen a vaccine-preventable childhood disease, the reason for all of these vaccinations may not be clear. A national survey of parental attitudes found that 25% of respondents believed the immune system becomes weak from too many immunizations, and 23% of respondents believed that children get more shots than are good for them.¹ This perception of too many vaccinations may be partially alleviated by the use of combination vaccines. As more vaccines are developed and recommended for routine childhood vaccination, this issue may become even more important for health care professionals to convey to their patients.

Parents' risk-benefit perceptions regarding vaccination are influenced not only by concern about adverse events but also by beliefs regarding the benefits of vac-

cines. Although a small proportion of parents believed hepatitis B is not a serious disease, case parents were significantly more likely to believe it. This finding supports the need for better education about the risk and severity of vaccine-preventable diseases as part of a presentation of vaccine benefits. Health care professionals have been reported to be the primary source of immunization information,⁷ putting them in a unique position to talk with parents about their vaccine safety concerns and specific hypothesized associations between vaccines and side effects. Educational materials to assist health care professionals in effectively communicating the risks and benefits of vaccinations as well as explain the hypothesized associations will help them fulfill the important role of educating parents.

The primary limitation of our study was that respondents with 19 to 35-month-old children were asked to answer questions according to their perceptions at the time their children were immunized but the concerns mentioned might have come about later. In addition, case parents might have felt more comfortable stating they had safety concerns rather than other reasons (eg, inconvenience) for not having their child vaccinated. Another potential limitation is that we could not account for the possible effect health care professionals' services or missed opportunities might have had on immunization status. Hence, our case definition was broad and included both those children not up-to-date for safety reasons and other reasons.

This study has substantial additional contributions to the literature. The ability to link parental attitudes and beliefs with physician-verified vaccination status at a national level helps give direction for the continuation of high vaccination coverage, promotion of public health, and potential research questions. First, more than 90% of parents of both case and control children believe immunizations are important to the health of a child. However, for a small proportion of children, parental vaccine safety concerns and the belief that children receive too many vaccines were associated with the failure to receive MCV/MMR, DTP/DTaP, and hepatitis B vaccines. In addition, even parents whose children were up-to-date for their vaccinations were concerned about vaccine safety issues. Public health communication experts and vaccine providers should consider developing new approaches to ensure immunization facts and messages are reaching and being accepted by parents. In light of our findings, research designed to determine the reasons parents have their children vaccinated despite safety concerns would be beneficial in helping health care professionals in educational efforts. Finally, research to assess the safety of vaccines should continue so that information is available to address potential concerns to the best possible extent.

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