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Associations of daycare and school entry vaccination requirements with varicella immunization rates

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Abstract

School and daycare entry requirements have been credited with increasing immunization rates among school-age children, but no prior study has assessed the nationwide effects of entry requirements while controlling for individual, family, and household characteristics. The 2002 National Immunization Survey (NIS) is a nationally representative annual survey that includes provider record-verified immunization dates for 20,546 children aged 19–35 months without prior history of varicella. In weighted bivariate and multivariate logistic regression models, we examined the association of state entry mandate implementation with children's up-to-date (UTD) status for varicella vaccine, adjusted for sociodemographic characteristics of children, mothers, and household income and for children's UTD status for other recommended vaccines. In this national sample representative of 5.6 million children, 83.2% (95% CI: 82.3%–84.1%) were UTD for varicella vaccine. Between 1997 and 2002 inclusive, 33 states and the District of Columbia had implemented school and/or daycare entry immunization mandates for varicella. In bivariate analyses, 84.9% (83.9%–85.9%) of children in states with varicella entry mandates were UTD, compared to 76.8% (75.3%–78.4%) of children in states without such mandates. In multivariate analyses controlling for child and family characteristics, children living in states with varicella entry mandates remained significantly more likely to be UTD for varicella than children in states without mandates. These findings indicate that immunization entry requirements are associated with higher immunization rates among preschool-age children, and suggest that the effects of entry requirements are independent of other individual and household factors associated with childhood immunization.

Keywords: Chickenpox vaccine; Entry requirements; National Immunization Survey

1. Introduction

State mandates requiring childhood immunization for school entry in the United States date back nearly 200 years to 1809, when Massachusetts made smallpox vaccination compulsory [1]. Entry mandates have since been recognized as keys to past childhood immunization successes [1–3] and have been lauded as a way "to harness the resources of other programs such as education to the immunization effort" [1].

Published studies of school entry mandates, however, have several limitations. The effects of entry mandates have not previously been compared to the effects of other established determinants of childhood immunization such as child age and race/ethnicity, maternal age and education, maternal marital status, and household income [4–7]. Moreover, school entry mandates have been associated with higher immunization rates among children of kindergarten age, but not among younger children who benefit from timely administration of vaccines within the first 2–3 years of life [1,3]. In a recent single city sample, daycare entry requirements targeting young children were not associated with higher immunization rates [8].

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Live attenuated varicella vaccine was first recommended for universal administration to children aged 12–18 months in 1995 [9,10]. Subsequently, 33 states and the District of Columbia implemented school and/or daycare entry mandates regarding the vaccine from 1997 to 2002 [11]. We viewed the gradual implementation of varicella entry mandates over time as an opportunity to examine possible effects of such requirements on varicella immunization rates on the national level, using the annual National Immunization Survey (NIS) of 19–35-month-old children that has been fielded annually since 1994 [12]. Our study hypothesis was that state school and/or daycare entry requirements are associated with higher varicella immunization rates among preschool-aged children, controlling for child, maternal, and household characteristics and for receipt of other recommended early childhood vaccinations.

2. Methods

2.1. Sample

The NIS is a federally funded, nationally representative survey that yields weighted immunization rate estimates for 19–35-month-old children at the national and state levels [13]. To obtain vaccination information, the NIS uses a two-phase sampling method in which a random-digit-dialing survey that identifies households with eligible children is followed by a provider record check survey. In the latter phase, vaccination histories are obtained from medical records with the cooperation of children's health care providers. Weighting adjustments are made to NIS estimates to account for households without telephones and for non-response from health care providers.

National and state-specific estimates for varicella immunization rates were included in NIS beginning in 1996 [14]. NIS 2002 is the most recent dataset publicly available at this writing. NIS measures vaccination rates among 19–35-month-old children, and therefore children in the NIS 2002 were born in the months February 1999 to May 2001 [15]. Varicella immunization is recommended beginning at 12 months of age, so children represented in NIS 2002 received vaccine beginning in February 2000 and continuing through the time of their survey in 2002.

2.2. Daycare and school entry mandates regarding varicella vaccine

Data regarding years of implementation for entry mandates regarding varicella vaccine were obtained from the Immunization Action Coalition, a widely recognized vaccine information resource in the United States [11]. Years of school entry requirements and daycare entry requirements were tracked separately. In states with both daycare and school entry mandates, the earliest year of implementation for any entry requirement was also noted by taking the earlier of the daycare or school entry mandate years.

2.3. Outcome variables

The principal outcome variable was the weighted proportion of 19–35-month-old children up-to-date (UTD) for varicella vaccination (one dose). Children in NIS whose immunization dates were confirmed with record checks were initially eligible for analysis (unweighted $N = 21{,}410$). Children ineligible to receive the vaccine because they had varicella illness by 12 months of age and children whose varicella vaccine doses were inappropriately administered before 12 months of age were excluded from analyses (combined unweighted $N = 884$), leaving 20,526 children (95.9%) with record-verified vaccination data eligible for this analysis.

2.4. Independent variables

The independent variable of chief interest was the presence of any state entry mandate regarding varicella vaccine. We also conducted separate analyses using the presence of school entry mandates and the presence of daycare entry mandates.

In addition, the NIS collects information regarding several child, maternal, and household characteristics that served as other independent variables in our analysis. Younger child age, younger maternal age, and unmarried maternal marital status have all been associated with underimmunization in prior analyses, while firstborn children have been found to be better immunized than their later born siblings [4–7]. Children living in poverty and those of minority race/ethnicity are at increased risk of underimmunization, as reported by the Centers for Disease Control and Prevention in the 2002 NIS [16,17]. Variables available in the 2002 NIS regarding these child, maternal, and household income characteristics were included in our analyses.

We also included each child's medical record-verified immunization status regarding vaccination with the 4:3:1:3:3 series ($\geq$4 doses of diphtheria and tetanus toxoids and pertussis vaccine, $\geq$3 doses of poliovirus vaccine, $\geq$1 dose of measles-containing vaccine, $\geq$3 doses of *Haemophilus influenzae* type b vaccine, and $\geq$3 doses of hepatitis B vaccine) as an indicator of each child's timely receipt of recommended immunizations aside from varicella vaccine.

In order to determine whether states with higher or lower varicella immunization rates (e.g., more or less effective immunization efforts) were likely to introduce entry requirements, we compared the prior year varicella immunization rates for states that implemented entry requirements versus those that did not, in each calendar year. For example, we compared the mean 1996 varicella immunization rates for states that implemented entry requirements in 1997 to the mean 1996 rates for states that did not. States that

implemented requirements were excluded from later-year comparisons. Data for these comparisons were drawn from the National Immunization Survey published by the CDC [18].

2.5. Statistical analyses

Our cross-sectional analyses were designed to examine the hypothesis that state school and/or daycare entry requirements are associated with higher varicella immunization rates among preschool-aged children, controlling for child, maternal, and household characteristics and for receipt of other recommended immunizations.

We conducted bivariate stratified analyses to examine the up-to-date status of children living in states without varicella entry mandates versus children living in states with entry mandates, for children in strata defined by their own and their maternal and household sociodemographic characteristics. To investigate the possibility of confounding in the observed bivariate associations of personal characteristics with varicella UTD status, we conducted multivariate weighted logistic regressions with all candidate independent variables including entry mandates (operationalized as indicator variables).

We conducted separate regressions regarding daycare entry mandates and school entry mandates and did not find substantively different results. Therefore, only the analyses of any entry mandate are reported.

All analyses were conducted using Stata SE, Version 8.0 (Stata Corp., College Station, TX, USA), suitable for analysis of data collected through complex survey sampling. All results are presented using weighted data, based on observation weights provided for the 2002 NIS.

3. Results

3.1. Sample

In the 2002 NIS, there were 20,526 eligible children aged 19–35 months with medical record-verified information about varicella immunization. These NIS participants were representative in aggregate of approximately 5.6 million children in 2002 who had no history of chickenpox before age 12 months and who did not receive the varicella vaccine prior to their first birthday.

Descriptive information about the sample appears in Table 1. Among these preschool-aged children, 83.2% (95% CI: 82.3%–84.1%) were up-to-date for varicella vaccine in 2002.

3.2. State entry mandates and varicella immunization rates: bivariate analyses

From 1997 to 2002, the majority of states and the District of Columbia implemented varicella entry mandates of some type (Table 2). Most mandates were implemented in the year 2000 and more recently. Daycare entry mandates regarding varicella were more common than school entry mandates, but school mandates had been implemented by more than half of

Table 1
Characteristics of National Immunization Survey Sample, 2002[a]

Characteristics	Weighted proportion (%)
Child age	
19–23 months	30.1
24–29 months	35.5
30–35 months	34.3
Child race/ethnicity	
Non-Hispanic white	53.6
Non-Hispanic black	13.7
Hispanic	24.4
Non-Hispanic other	8.3
Child firstborn in family	
No	62.6
Yes	37.4
Child up-to-date for 4:3:1:3:3[b]	
No	25.2
Yes	74.8
Maternal age	
≤19 years	3.4
20–29 years	44.8
≥30 years	51.8
Maternal marital status	
Never married	21.6
Married	70.7
Separated/divorced/widowed	7.8
Maternal education	
<12 years	17.3
12 years	35.5
>12 years, some college/vocational	15.6
College degree	31.6
Household annual income	
<100% federal poverty level	24.6
101%–200% federal poverty level	24.1
>200% federal poverty level	51.3

[a] Children aged 19–35 months with medical record-verified vaccination data, who did not have varicella illness and did not receive the varicella vaccine prior to 12 months of age. Unweighted $N = 20,526$ except for household annual income ($N = 18,642$).

[b] Up-to-date for other universally recommended childhood vaccines. See text.

Table 2
Year of implementation of varicella daycare and school entry mandates

Year of implementation of varicella entry mandate	Daycare entry mandate (*N*)	School entry mandate (*N*)	Any entry mandate (*N*)
1997	3	2	3
1998	2	1	2
1999	2	2	2
2000	12	7	12
2001	6	7	7
2002	7	8	8
Total states with mandates	32	27	34
None by 2002	19	24	17

Table 3
Year of implementation of state varicella entry mandate and varicella up-to-date status

Year of implementation of state varicella entry mandate[a]	Proportion up-to-date for varicella vaccine [b] (%, [95% CI])
No mandate implemented 1997–2002	76.8 (75.3–78.4)
1997	89.1 (85.8–92.3)
1998	87.0 (83.8–90.2)
1999	85.0 (81.5–88.5)
2000	86.4 (84.7–88.0)
2001	85.2 (83.3–87.2)
2002	78.4 (75.9–81.0)

[a] Year listed reflects year of implementation of school or daycare entry mandate for varicella, whichever came first.
[b] Among children residing in states with a daycare and/or school entry mandate for varicella in the year specified.

the states by 2002. Based on this sample, by the end of 2002 approximately 4.42 million children aged 19–35 months lived in states with varicella entry mandates, versus 1.18 million in states without such mandates.

Among children residing in states with varicella entry mandates, 84.9% (83.9%–85.9%) were UTD for varicella vaccine. In contrast, among children in states without varicella entry mandates 76.8% (75.3%–78.4%) were UTD for varicella vaccine.

When we examined the UTD status of children in states grouped by year of implementation of any entry mandate (Table 3), we found that children living in states with entry mandates implemented from 1997 to 2001 were significantly more likely to be UTD for varicella than children living in states with no mandate by 2002. Children living in states that implemented entry mandates in 2002—the same year in which their UTD status was measured in the 2002 NIS—were not significantly more likely to be up to date than children residing in states without varicella entry mandates.

Results were similar for children in states with only daycare entry mandates (versus all mandate types combined, above). In seven states (Alaska, Delaware, Maine, Missouri, New York, North Carolina, West Virginia) with only daycare entry mandates by 2002, the varicella vaccine coverage rate was 82.2% (79.5%—84.9%), significantly higher than the proportion UTD in states without varicella entry mandates. In the small subsample of two states (South Dakota and Utah) with only school entry mandates by 2002, the varicella vaccine coverage rate was 80.1% (75.4%–84.8%), somewhat higher but not statistically significantly different from children living in states without any varicella entry laws.

Comparison of prior-year varicella UTD status in states with entry mandates versus states without revealed no significant differences in varicella rates, indicating that states with mandates were doing neither worse nor better than other states with regard to varicella immunization at the time mandates were implemented.

3.3. Entry mandates and other determinants of varicella immunization: stratified bivariate analyses

When stratifying our sample by child, maternal, and household variables, we found that varicella entry mandates were strongly associated with higher varicella UTD rates for almost all of the variable strata examined (Table 4). The strongest associations of UTD status and entry mandates, as defined by ≥9% absolute difference in UTD rates for children residing in states with mandates versus children in states without mandates, were observed for children aged 30–35 months, Hispanic children, non-firstborn children, children not otherwise UTD for other recommended vaccines (4:3:1:3:3), children of mothers aged 20–29 years, and children whose mothers had <12 years of education.

3.4. State entry mandates and varicella immunization rates: multivariate analyses

When controlling for child, maternal, and household characteristics, as well as for immunization status regarding other vaccines, we found that the positive association persisted between any varicella entry mandates implemented in 1997 through 2001 and varicella UTD status in 2002 (Table 5). As indicated by the positive regression coefficients, children living in states with varicella vaccine entry mandates implemented in any of the years 1997 through 2001 were significantly more likely to be UTD for varicella vaccine than children living in states without varicella entry mandates. The UTD status of children living in states with entry mandates implemented in 2002 were not significantly different from children in states without mandates.

The only variable in the multivariate model with a stronger effect than entry mandate implementation in the years 1997 through 2001 was UTD status for other recommended childhood immunizations (4:3:1:3:3). Firstborn status and non-Hispanic black race (compared to non-Hispanic white) were also positively associated with varicella UTD status. Multivariate models considering daycare and school entry mandates separately revealed no substantive differences in the findings (data not shown).

4. Discussion

This study of state immunization entry mandates related to varicella lends strong support to the claim that school and daycare entry requirements are a powerful engine for childhood vaccine promotion. More specifically, this is the first study to suggest that school and daycare entry mandates are associated with better vaccination rates among preschool-aged children, even while adjusting for sociodemographic factors such as child age and race/ethnicity, firstborn status, maternal age and education, and household income that are known to influence childhood immunization patterns. This is also the first known analysis since evaluations of measles

Table 4
Comparison of varicella up-to-date rates for children living in states with vs. without entry mandates, stratified by child, maternal, and household characteristics

	Proportion UTD for varicella, *without* entry mandates (%)[a]	Proportion UTD for varicella, *with* entry mandates (%)[a]	*P* value, with mandates vs. without
Child age			
19–23 months	73.9	82.5	<0.0001
24–29 months	79.3	86.1	<0.0001
30–35 months	76.8	85.8	<0.0001
Child race/ethnicity			
Non-Hispanic white	76.1	84.5	<0.0001
Non-Hispanic black	81.3	85.9	NS
Hispanic	76.0	85.3	<0.0001
Non-Hispanic other	79.4	84.6	NS
Child firstborn in family			
No	73.5	82.7	<0.0001
Yes	82.5	88.5	<0.0001
Child up-to-date for 4:3:1:3:3			
No	53.8	64.0	<0.0001
Yes	85.1	91.8	<0.0001
Maternal age			
≤19 years	81.6	87.9	NS
20–29 years	74.1	83.3	<0.0001
≥30 years	78.8	86.1	<0.0001
Maternal marital status			
Never married	76.4	84.9	<0.0005
Married	76.9	85.3	<0.0001
Separated/divorced/widowed	77.5	81.5	NS
Maternal education			
<12 years	74.3	83.4	<0.001
12 years	74.5	82.5	<0.0001
>12 years, some college/vocational	77.2	85.4	<0.0005
College degree	80.2	88.3	<0.0001
Household annual income			
<100% federal poverty level	75.0	82.5	<0.001
101%–200% federal poverty level	73.1	80.1	<0.005
>200% federal poverty level	79.5	88.0	<0.0001

[a] Reflects implementation of either school or daycare entry mandate or both for varicella in any year 1997–2002.

entry mandates over 3 decades ago [19,20] to take a national perspective and examine entry mandates across multiple states.

4.1. Effects of entry requirements

Although varicella immunization rates have increased since the vaccine's licensure in 1995, vaccination efforts against varicella have faced several barriers including the common perception that varicella is a uniformly mild disease and a lack of insurance coverage for the vaccine [21]. As a result, providers' adoption of varicella vaccine into practice has been more hesitant and gradual than for *H. influenzae*, type b (Hib) vaccine and pneumococcal conjugate vaccine, particularly among family physicians [22–26].

Nevertheless, we found an approximately 8% absolute difference in varicella immunization rate for children living in states with varicella entry mandates versus children living in states without such mandates. This difference may be expected to translate into lower varicella incidence rates [27] and lower hospitalization rates [28] for young children and older nonimmune individuals through reduction in the pool of susceptible children through whom varicella spreads. In turn, reduced disease incidence may yield lower societal costs of varicella disease through decreased health care costs and fewer missed days of work for parents.

Measuring these and other beneficial effects are critical to future acceptance of daycare and school entry mandates, because if such mandates are perceived as promoting higher immunization rates but do not necessarily translate into health and economic benefits then mandates are likely to lose support. Furthermore, economic benefits in particular are worth measuring because enforcement of entry requirements imposes administrative costs on the staff of daycares, schools, and the state agencies that bear responsibility for monitoring adherence to the statutory requirements.

4.2. Entry mandates versus other determinants of childhood immunization

Similar to other studies of childhood immunization, we found that firstborn status was positively associated with UTD status, although this is the first study of which we are aware that has documented this phenomenon for varicella vaccination. In contrast to a black–white disparity in vaccination status for the 4:3:1:3:3 series in 2002 [17], non-Hispanic black children were significantly more likely than non-Hispanic white children to be UTD for varicella in our multivariate analysis. We speculate that this latter finding may reflect less frequent exemptions for varicella immunization among non-Hispanic black versus non-Hispanic white children, but this possibility merits further investigation of trends in families' vaccine exemption behavior.

Another salient contribution of this study is the observation that the associations of entry mandates with varicella UTD status appear independent of child and family factors. This suggests that implementation of entry mandates boosts vaccination for children living in a broad variety of circumstances, by holding all children—and the parents and guardians responsible for them—to a standard expectation in their communities. Varicella entry mandates may persuade parents who would otherwise not vaccinate their children against chickenpox to do so, and those are the parents for whose children we would expect to see the greatest incremental effect of entry requirements.

It is theoretically possible that states that implement varicella entry mandates are more predisposed to immunization initiatives in general, and therefore would be expected to have higher varicella immunization rates independent of entry mandates. Three of our findings argue against this possibility. First, in multivariate analyses, children in states that implemented entry mandates in 2002 (i.e., most recently in the study period) were not significantly more likely than children in states without mandates to be UTD for varicella. Second, in comparisons of varicella UTD states for pre-mandate years, those states that implemented mandates were not significantly more likely to be UTD for varicella than other children. Third, effects of varicella entry mandates were independent of UTD status of children for other recommended early childhood vaccines.

Table 5
Multivariate analysis of factors associated with varicella up-to-date status, United States, 2002

Variables	β coefficient	95% confidence interval
Year of varicella entry mandate implementation		
No mandate by 2002	Ref	–
1997	0.99	0.63–1.35
1998	0.51	0.20–0.82
1999	0.48	0.12–0.83
2000	0.66	0.48–0.84
2001	0.56	0.36–0.76
2002	−0.20	−0.43 to 0.03
Child age		
19–23 months	Ref	–
24–29 months	0.08	−0.09 to 0.26
30–35 months	−0.04	−0.22 to 0.13
Child race/ethnicity		
Non-Hispanic white	Ref	–
Non-Hispanic black	0.48	0.23–0.73
Hispanic	0.19	−0.03 to 0.40
Non-Hispanic other	0.22	−0.06 to 0.51
Child firstborn in family		
No	Ref	–
Yes	0.35	0.20–0.50
Child up-to-date for 4:3:1:3:3[a]		
No	Ref	–
Yes	1.79	1.65–1.92
Maternal age		
≤19 years	Ref	–
20–29 years	0.27	−0.21 to 0.74
≥30 years	−0.07	−0.23 to 0.09
Maternal marital status		
Never married	Ref	–
Married	−0.01	−0.27 to 0.27
Separated/divorced/widowed	−0.01	−0.22 to 0.20
Maternal education		
<12 years	Ref	–
12 years	−0.08	−0.32 to 0.17
>12 years, some college/vocational	0.07	−0.21 to 0.35
College degree	0.13	−0.13 to 0.40
Household poverty status		
<100% federal poverty level	Ref	–
101%–200% federal poverty level	−0.12	−0.33 to 0.09
>200% federal poverty level	0.20	−0.01 to 0.42

β coefficient interpretation: β coefficient = 0 and/or 95% CI includes 0 → there is no statistically significant association between the specified variable and varicella UTD status, controlling for other model variables. β coefficient >0 and 95% CI does NOT include 0 → the specified variable is associated with statistically significantly *higher* varicella UTD likelihood than children in the reference group, controlling for other model variables. β coefficient <0 and 95% CI does NOT include 0 → the specified variable is associated with statistically significantly *lower* varicella UTD likelihood than children in the reference group, controlling for other model variables.

[a] Up-to-date for other universally recommended childhood vaccines. See text.

4.3. Study limitations

The most important limitation of this study is that it relies upon the NIS, which is administered through a random-digit-dialing algorithm and therefore depends on having households with telephones. The NIS sampling method does include adjustments for households without telephones [13], but it is still possible that families without telephones—i.e., typically disadvantaged families—are underrepresented in this sample.

We were also limited by the nature of self-reported responses for the NIS participants regarding several of the variables we incorporated in our analyses. Self-reports of education and income, in particular, may be subject to social desirability biases and were not independently confirmed.

In addition, we used the most recent NIS data available from 2002, which limited our ability to investigate the im-

pact of varicella entry mandates implemented since that time. According to the Immunization Action Coalition, there have been 10 additional school or daycare entry mandates implemented in 2003 and 2004, leaving only nine states as of this writing without any varicella entry mandate [11].

A further limitation pertains to the enforcement of entry mandates [1–3,19,20] and the growing number of non-medical immunization exemptions claimed by parents for their children that threaten the public health protections gained through effects of entry mandates [29–31]. The 2002 NIS and Immunization Action Coalition data we used for this analysis do not provide information about entry mandate enforcement or exemptions.

5. Conclusions

This study indicates that state school and daycare immunization entry mandates may be one of the most effective tools for improving childhood vaccination rates. Although entry requirements are susceptible to enforcement inconsistencies and exemptions, they are appealing as an intervention because of the uniformity of their application across different risk groups, communities, and states. Particularly in the case of a vaccine such as varicella, which has been subject to broad skepticism from parents and providers, entry mandates may offer public health officials a persuasive tool in their efforts to boost childhood immunization rates with minimal evidence of disparities.

In today's era of childhood vaccination efforts hampered by supply shortages [32–34] and increasing childhood vaccine costs [35], entry mandate officials will need to be particularly responsive to local needs and obstacles to timely administration of required vaccines. Even so, state vaccine entry requirements may remain the best combination of endorsement and enforcement in vaccine promotion efforts.

References

[1] Orenstein WA, Hinman AR. The immunization system in the United States—the role of school immunization laws. Vaccine 1999;17: 19–24.
[2] Briss PA, Rodewald LE, Hinman AR, Shefer AM, Strikas RA, Bernier RR, et al. Task force on community preventive services. Reviews of evidence regarding interventions to improve vaccination coverage in children, adolescents, and adults. Am J Prev Med 2000;181S:97–140.
[3] Hinman AR, Orenstein WA, Williamson DE, Darrington D. Childhood immunization: laws that work. J Law Med Ethics 2002;S30:122–7.
[4] Griffin MR, Daugherty J, Reed GW, Standaert SM, Hutchins SS, Hutcheson RH, et al. Immunization coverage among infants enrolled in the Tennessee medicaid program. Arch Pediatr Adolesc Med 1995;149:559–64.
[5] Bobo JK, Gale JL, Thapa PB, Wassilak SGF. Risk factors for delayed immunization in a random sample of 1163 children from Oregon and Washington. Pediatrics 1993;91:308–14.
[6] Bates AS, Wolinsky FD. Personal, financial, and structural barriers to immunization in socioeconomically disadvantaged urban children. Pediatrics 1998;101:591–6.
[7] Zimmerman RK, Ahwesh ER, Mieczkowski TA, Block B, Janosky JE, Barker DW, et al. Influence of family functioning and income on vaccination in inner-city health centers. Arch Pediatr Adolesc Med 1996;150:1054–61.
[8] Kolasa MS, Chilkatowsky AP, Stevenson JM, Lutz JP, Watson BM, Levenson R, et al. Do laws bring children in child care centers up to date for immunizations? Ambul Pediatr 2003;3:154–7.
[9] American Academy of Pediatrics Committee on Infectious Diseases. Recommendations for the use of live attenuated varicella vaccine. Pediatrics 1995;95:791–6.
[10] Advisory Committee on Immunization Practices. Prevention of varicella: recommendations of the advisory committee on immunization practices. MMWR Morbidity and Mortality Weekly Rep. 1996;45:1–25.
[11] Immunization Action Coalition. Varicella prevention mandates. Available at: http://www.immunize.org/laws/varicel.htm. Accessed April 13, 2004.
[12] Centers for Disease Control and Prevention. National Immunization Survey. Available at: http://www.cdc.gov/nip/coverage/default.htm-NIS. Accessed April 13, 2004.
[13] Smith PJ, Battaglia MP, Huggins VJ, Hoaglin DC, Roden A, Khare M, et al. Overview of the sampling design and statistical methods used in the National Immunization Survey. Am J Prev Med 2001;204S:17–24.
[14] National Center for Health Statistics. Estimated vaccination coverage with individual vaccines and selected vaccination series among children 19-35 months of age by state—US, National Immunization Survey, Q1/1996-Q4/1996. Available at: http://www.cdc.gov/nip/coverage/NIS/96/toc-96.htm. Accessed April 3, 2004.
[15] National Center for Health Statistics. Estimated vaccination coverage with individual vaccines and selected vaccination series among children 19–35 months of age by state—US, National Immunization Survey, Q1/2002-Q4/2002. Available at: http://www.cdc.gov/nip/coverage/NIS/01/toc-01.htm. Accessed April 3, 2004.
[16] Centers for Disease Control and Prevention. Estimated vaccination coverage with individual vaccines and vaccination series among children 19–35 months of age by poverty level and race/ethnicity—US, National Immunization Survey, Q1/2002-Q4/2002. Available at: http://www2a.cdc.gov/nip/coverage/nis/nis_iap.asp?fmt=r&rpt=tab32_pov_race&qtr=Q1/2002-Q4/2002. Accessed April 3, 2004.
[17] Centers for Disease Control and Prevention. Estimated vaccination coverage with individual vaccines and vaccination series among children 19–35 months of age by race/ethnicity—US, National Immunization Survey, Q1/2002-Q4/2002. Available at: http://www2a.cdc.gov/nip/coverage/nis/nis_iap.asp?fmt=v&rpt=tab30_race_nat&qtr=Q1/2002-Q4/2002. Accessed April 3, 2004.
[18] Centers for Disease Control and Prevention. Immunization coverage in the US. Available at: http://www.cdc.gov/nip/coverage/default.htm. Accessed October 18, 2004.
[19] Centers for Disease Control and Prevention. Measles and school immunization requirements—United States, 1978. MMWR Morbidity and Mortality Weekly Rep. 1978;27:303–4.
[20] Robbins KB, Brandling-Bennett D, Hinman AR. Low measles incidence: association with enforcement of school immunization laws. Am J Public Health 1981;71:270–4.
[21] American Academy of Pediatrics Committee on Infectious Diseases. Varicella vaccine update. Pediatrics 2000;105:136–41.
[22] Schaffer SJ, Bruno S. Varicella immunization practices and the factors that influence them. Archives Pediatr Adolesc Med 1999;153:357–62.
[23] Ehresmann KR, Mills WA, Lowenson PR, Moore KA. Attitudes and practices regarding varicella vaccination among physicians in Minnesota: implications for public health and provider education. Am J Public Health 2000;90:1917–20.

[24] Zimmerman RK, Mieczkowski TA, Mainzer HM, Medsger AR, Nowalk MP. Understanding physician agreement with varicella immunization guidelines. Prevent Med 2002;35:135–42.
[25] Cochi SL, Fleming DW, Hull HF, Preblud SR, Orenstein WA. Haemophilus influenzae b polysaccharide vaccine: physician acceptance and the use of a new vaccine. AJDC 1986;140:1226–30.
[26] Davis MM, Ndiaye SM, Freed GL, Clark SJ. One year uptake of pneumococcal conjugate vaccine: a national survey of family physicians and pediatricians. J Am Board Fam Pract 2003;16:363–71.
[27] Seward JF, Watson BM, Peterson CL, Mascola L, Pelosi JW, Zhang JX, et al. Varicella disease after introduction of varicella vaccine in the United States. JAMA 2002;287:606–11.
[28] Davis MM, Patel MS, Gebremariam A. Varicella hospitalizations and associated expenditures before and after varicella vaccine in the United States. Pediatrics 2004;114:786–92.
[29] Rota JS, Salmon DA, Rodewald LE, Chen RT, Hibbs BF, Gangarosa EJ. Processes for obtaining nonmedical exemptions to state immunization laws. Am J Public Health 2001;91:645–8.
[30] Santoli JM, Hinman AR. Nonmedical exemptions to state immunization laws. Am J Public Health 2002;92:8.
[31] Silverman RD. No more kidding around: restructuring non-medical childhood immunization exemptions to ensure public health protection. Ann Health Law 2003;12:277–94.
[32] Abramson J, Pickering LK. US immunization policy. JAMA 2002;287:505–9.
[33] Freed GL, Davis MM, Clark SJ. Variation in public and private supply of pneumococcal conjugate vaccine during a shortage. JAMA 2003;289:575–8.
[34] Centers for Disease Control and Prevention. Impact of vaccine shortage on diphtheria and tetanus toxoids and acellular pertussis vaccine coverage rates among children aged 24 months—Puerto Rico, 2002. MMWR Morb Mortal Wkly Rep. 2002;51:667–8.
[35] Davis MM, Zimmerman JL, Wheeler JRC, Freed GL. The costs of childhood vaccine purchase in the public sector: past trends, future expectations. Am J Public Health 2002;92:1982–7.