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RESEARCH ARTICLE

The Impact of Gaps in Health Insurance Coverage on Immunization Status for Young Children

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Objective. To examine the impact of full-year versus intermittent public and private health insurance coverage on the immunization status of children aged 19–35 months.
Data Source. 2001 State and Local Area Integrated Telephone Survey's National Survey of Children with Special Health Care Needs (NS-CSHCN) and the 2000–2002 National Immunization Survey (NIS).
Study Design. Linked health insurance data from 2001 NS-CSHCN with verified immunization status from the 2000–2002 NIS for a nationally representative sample of 8,861 nonspecial health care needs children. Estimated adjusted rates of up-to-date (UTD) immunization status using multivariate logistic regressions for seven recommended immunizations and three series.
Principal Findings. Children with public full-year coverage were significantly more likely to be UTD for two series of recommended vaccines, (4:3:1:3) and (4:3:1:3:3), compared with children with private full-year coverage. For three out of 10 immunizations and series tested, children with private part-year coverage were significantly less likely to be UTD than children with private full-year coverage.
Conclusions. Our findings raise concerns about access to needed immunizations for children with gaps in private health insurance coverage and challenge the prevailing belief that private health insurance represents the gold standard with regard to UTD status for young children.
Key Words. Immunization, vaccine, health care access

The Centers for Disease Control and Prevention (CDC) announced in July 2005 that childhood immunization coverage for children aged 19–35 months was at an all time high. Childhood immunizations for the baseline series of vaccines (4:3:1:3:3) were 80.9 percent, exceeding, for the first time, the Healthy People 2010 goal of 80 percent coverage (CDC 2005). Despite this progress, there are still disparities in immunization status by race/ethnicity, income and insurance status, as well as by state of residence and urban or rural location (Department of Health and Human Services 2000; Luman et al. 2005).

Initiatives to further increase immunization coverage for children have focused primarily on missed opportunities in private physician practices and policies to reduce financial barriers. Efforts have been made to promote increases in tracking and record keeping by private physicians, the use of centralized immunization registries, and other strategies such as automated reminder and recall (CDC 2004).

The federal Vaccines for Children Program (VFC) was designed to reduce financial barriers by providing vaccine doses free of charge to eligible children through public and private providers (Santoli et al. 1999). Children who are American Indian/Alaska Native, uninsured, or enrolled in Medicaid are eligible to receive federally purchased vaccines at participating private clinics. Children with private health insurance coverage that does not cover immunizations—or those with coverage with high copayments and deductibles (i.e., the underinsured)—are also eligible to receive VFC vaccines but only in federally qualified health centers or rural health clinics (Santoli et al. 1999). In 2006, the VFC program was expected to provide free vaccine dosage to approximately 37 million eligible children (0–18 years of age) in over 44,000 provider sites, of which 73 percent were private providers (CDC 2007).

The passage of the State Children's Health Insurance Program (SCHIP) in 1997 has also contributed to decreasing financial barriers to immunization by providing subsidized health insurance coverage to low-income children. The program has contributed to a significant increase in the number of children with public health insurance coverage through increased enrollment in both SCHIP and Medicaid, and a reduction of two million uninsured children (Robert Wood Johnson Foundation 2005).

While there has been an increase in public program participation by children through Medicaid and SCHIP, most children (65 percent in 2006) are

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still covered by private health insurance (DeNavas-Walt, Proctor, and Smith 2007). There are three specific concerns with private health insurance coverage related to immunization coverage: gaps in private health insurance coverage over time, increasing copayments and deductibles leading to increased financial barriers for prevention services, and lack of coverage for immunization benefits.

Many children experience gaps in their coverage for significant periods of time. It has been estimated that approximately 9 percent of children under age 18 experience gaps in health insurance coverage. These gaps have been shown to contribute to delays in seeking needed medical care and addressing unmet medical care needs (Olson, Tang, and Newacheck 2005; Cohen and Martinez 2006). It has been demonstrated that even short gaps in health insurance coverage have negative impacts on immunization status for children in the first 2 years of life (Wood 2003).

There has also been a significant change in the nature of private employer-based health insurance. There has been a significant drop in employer-based coverage, with the percentage of firms offering health benefits falling from 69 percent in 2000 to 60 percent in 2005 (Gabel et al. 2005). Recent evidence documents the source of the decline to include a drop in employer-sponsored coverage (48 percent), a drop in the number of employees taking up insurance (27 percent), an increase in ineligible employees (14 percent), and a decrease in dependent coverage (11 percent) (Clemans-Cope and Garrett 2006). While SCHIP and Medicaid have been filling the gap for low-income children, there is little evidence about the children who are falling between the cracks—children whose parents no longer have employer-based coverage but with incomes too high for public program eligibility. These are the children most likely to experience gaps in private health insurance coverage.

Another concern is the reduction in private health insurance benefits, including coverage for immunizations. "A recent article by the American Academy of Pediatrics found that 20 percent of employers were offering catastrophic health insurance plans (high deductible health plans), up from only 5 percent in 2003, and only 30 percent of these plans covered preventive care before the deductible was met" (Lee et al. 2007, p. 642). Another study estimated that approximately one out of five U.S. children with private health insurance had no immunization coverage and another 6 percent had private insurance with significantly high copayments and deductibles (Wood et al. 2004).

In this study, we examine the impact of health insurance coverage on the immunization coverage rates for very young children (age 19–35 months). We specifically look at the impact of full-year and part-year health insurance coverage on immunization status for a nationally representative sample of young children. Understanding the nature of health insurance coverage may help in identifying new strategies to increase immunization coverage.

METHODS

Data Linkage

The dataset was constructed by linking provider-verified immunization status collected as part of the 2000–2002 National Immunization Survey (NIS) with data from the insurance analysis file (IAF) of the 2000–2002 National Survey of Children with Special Health Care Needs (NS-CSHCN), a module of the State and Local Area Integrated Telephone Survey (SLAITS), which uses the sample frame of the NIS (National Center for Health Statistics 2002). The IAF contains insurance data on one randomly selected CSHCN and one randomly selected child without special health care needs (non-CSHCN) from each household, resulting in one child per household if only CSHCN or only non-CSHCN are present in the household or two children per household if both CSHCN and non-CHSCN are present (Blumberg et al. 2003).

The NIS is a random-digit-dialing (RDD) telephone survey conducted by National Center for Health Statistics (NCHS) and the National Immunization Program. In each of the 78 Immunization Action Plan areas in the United States, the NIS draws independent quarterly samples of telephone numbers, using RDD to identify households that have one or more children aged 19–35 months (Zell et al. 2000; Smith et al. 2001). SLAITS modules—such as the NS-CSHCN—are conducted after completion of the NIS interview.

The NS-CSHCN was sponsored by the Maternal and Child Health Bureau of the Health Resources and Services Administration and was conducted from October 2000 to April 2002. There are data on approximately 750 CSHCN in each state and the District of Columbia for a total of 38,866 nationally.[1] Insurance information was collected as part of the questionnaire and a supplemental insurance questionnaire was included for children without special health care needs to permit comparative analysis of children with and without special health care needs (Blumberg et al. 2003). The IAF includes data for 38,866 CSHCN and 176,296 non-CHSCN children. Our linked dataset is the common intersection of these 215,162 children and the set of 69,190 children with provider-verified data on immunization status from the

2000–2002 NIS. Of the 215,162 children in the IAF, 14,182 were in the NIS age range of 19–35 months. Because of the need for an augmentation sample in certain states where the NIS sample frame was not large enough to reach NS-CSHCN sample targets, a small percentage of NS-CSCHN households did not participate in the NIS. As a result, some of the NS-CSHCN records could not be matched to the NIS records. Of the 14,182 IAF children in the NIS age range, 13,065 were successfully linked to their NIS records; of these, 11,002 had adequate provider-verified immunization data.

Final Sample

We analyzed up-to-date (UTD) status for children aged 19–35 months for seven recommended individual vaccines and three combined vaccine series. We excluded from our analysis young CSHCN and those living in households with one or more siblings who have special health care needs. A child with special health care needs would be expected to have high utilization and heavy involvement with the health care system in general, which may yield higher likelihoods of being UTD for immunizations. Such nonhomogeneity across subpopulations argues for modeling them separately. This argument also extends to non-CSHCN children who live in a household with other CSHCN siblings.

Using only the children aged 19–35 months who are not CSHCN nor living in households with one or more siblings who have special health care needs reduces our sample from 11,002 to 9,007. Finally, we were unable to use an additional 146 observations due to missing values on model covariates. Consequently, our analytic sample for our regression models includes 8,861 observations.

Dependent Variables. In each of the 10 logistic regressions, the dependent variable was dichotomous and measured whether the child (age 19–35 months) was UTD or not UTD at the time of the survey. The seven recommended individual vaccines and three combined vaccine series comprise our dependent variables and include the following:

1. DTP/DT/DTaP $\geq$ 3 doses: diphtheria and tetanus toxoids and pertussis/diphtheria and tetanus toxoids/diphtheria and tetanus toxoids and acellular pertussis vaccine.
2. DTP/DT/DTaP $\geq$ 4 doses.
3. Poliovirus $\geq$ 3 doses.

4. Measles/mumps/rubella $\geq$ 1 dose.
5. Hib $\geq$ 3 doses: *Haemophilus influenzae* Type b.
6. Hepatitis B $\geq$ 3 doses.
7. Varicella $\geq$ 1 dose.
8. 4:3:1 series: DTP/DT/DTaP $\geq$ 4 doses, poliovirus $\geq$ 3 doses, measles-containing vaccine $\geq$ 1 dose.
9. 4:3:1:3 series: 4:3:1 series plus Hib $\geq$ 3 doses.
10. 4:3:1:3:3 series: 4:3:1:3 series plus hepatitis B $\geq$ 3 doses

The main covariate included five measures of insurance coverage for the child: private coverage all through the year, private coverage during part of the year, public coverage all through the year, public coverage during part of the year, or uninsured all through the year (in the 12 months before the interview). These insurance categories are mutually exclusive; children reporting both private and public insurance were coded as having private insurance. The distribution of children by our health insurance coverage categories is provided in Table 1.

Table 1: Distribution of Sample by Type Health Insurance Coverage for Full Sample and Excluding Children with Special Health Care Needs (CSHCN) Households

Type of Child (19–35 Months of Age)	*Sample Size*	*Weighted Size*	*Percent Distribution**
All children			
Private full-year	6,819	2,180,022	61.4
Private part-year	446	143,552	4.0
Public full-year	2,679	880,093	24.8
Public part-year	612	235,794	6.6
Uninsured all through the year	306	109,555	3.1
Total	10,862	3,549,015	100.0
Not CSHCN and in non-CSHCN household			
Private full-year	5,739	1,898,834	63.3
Private part-year	392	128,886	4.3
Public full-year	2,003	696,245	23.2
Public part-year	480	183,834	6.1
Uninsured all through the year	272	91,126	3.0
Total	8,886	2,998,925	100.0

*Percent distribution for the weighted size.

Data source: SLAITS NS-CSHCN 2000–2002 and NIS 2000–2002 linked data set.

CSHCN, Children with Special Health Care Needs; SLAITS, State and Local Area Integrated Telephone Survey; NS-CSHCN, National Survey of Children with Special Health Care Needs; NIS, National Immunization Survey.

The logistic regression models included additional covariates to control for characteristics of either the children or their families that could be expected to influence the probability of a child being UTD. Characteristics of the child include race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic, other) and age at interview (19–23 months, 24–29 months, and 30–35 months). Our study's response variables measured whether immunizations were UTD and not timeliness of the receipt of the immunization. Consequently, children at older ages within the 19–35 months span will be more likely to be UTD simply by having more chances to receive the recommended immunizations with a longer passage of time. We trichotomized the 18-month age span to control for any systematic imbalance by insurance type in the distribution of children across age categories at the time of the survey.

Characteristics of the family include: number of children; mother's age (19 years or younger, 20-29 years, 30 years or older); mother's education (less than high school graduate, high school graduate, some college, college graduate/postgraduate degree); marital status (never married, formerly married, married); household income (<100 percent of the Federal Poverty Level [FPL], 100 to <150 percent FPL, 150 to <200 percent FPL, 200 to 300 percent FPL, 300 to <400 percent FPL, 400 percent FPL or higher); an indicator variable specifying whether the state in which the child lives has a mandatory Hepatitis B entry law for daycare in order to control for possible increase in immunizations for Hepatitis B in these states.[2] We also included an indicator variable specifying whether the family moved from a different state.

Tables 2a and 2b provide the descriptive statistics for the vaccination coverage variables and control variables for this analytic sample.

We used *SAS* procedures augmented by *SUDAAN* routines that take account of complex survey features to provide robust standard errors. These *SAS/SUDAAN* procedures use a first-order Taylor Series linear approximation (Research Triangle Institute 2004). Other names sometimes used for this approach are Huber–White or sandwich variance estimation (StataCorp 2005). All data analysis was performed on site at the NCHS.

Using multivariate logistic regression models, we empirically tested whether gaps in insurance coverage were an important determinant of being found UTD for the seven recommended individual immunizations and three combined series. Both raw logistic regression coefficients and odds ratios are nonlinear expressions of the impact of individual covariates on the response variables. As such, they provide an imperfect picture of differences in the

Table 2a: Descriptive Sample Statistics: Mean Proportions Up-to-Date on Vaccination Measures*

Vaccine	*%*	*Standard Error*
DTP/DT/DTaP $\geq$ 3 doses	94.1	0.004
DTP/DT/DTaP $\geq$ 4 doses	81.6	0.009
Poliovirus $\geq$ 3 doses	89.2	0.007
Measles/mumps/rubella $\geq$ 1 dose	90.9	0.006
Hib $\geq$ 3 doses	92.7	0.005
Hepatitis B $\geq$ 3 doses	89.1	0.007
Varicella $\geq$ 1 dose	75.9	0.009
4:3:1 series	78.2	0.009
4:3:1:3 series	76.7	0.009
4:3:1:3:3 series	73.6	0.009

*Analysis sample includes only non-CSHCN in non-CSHCN households.

Data source: SLAITS NS-CSHCN 2000–2002 and NIS 2000–2002 linked dataset.

DTP/DT/DTaP, diphtheria and tetanus toxoids and pertussis/diphtheria and tetanus toxoids/diphtheria and tetanus toxoids and acellular pertussis vaccine; Hib, *Haemophilus influenzae* type b; 4:3:1 series, DTP/DT/DTaP $\geq$ 4 doses, poliovirus $\geq$ 3 doses, measles-containing vaccine $\geq$ 1 dose; 4:3:1:3 series, 4:3:1 series plus Hib $\geq$ 3 doses; 4:3:1:3:3 series, 4:3:1:3 series plus hepatitis B $\geq$ 3 doses; CSHCN, Children with Special Health Care Needs; SLAITS, State and Local Area Integrated Telephone Survey; NS-CSHCN, National Survey of Children with Special Health Care Needs; NIS, National Immunization Survey.

impact of our insurance coverage categories—differences in probabilities of being UTD—which are the focus of this study. We prefer a technique that yields estimates that are more easily interpreted than raw logistic regression coefficients. As such, we have used an alternative transformation of our regression coefficients for our insurance category covariates that utilizes the "method of recycled predictions" (StataCorp 2005), also referred to as "averaging the individual marginal effects" (Greene 2002) and "predictive margins" (Graubard, Edward, and Korn 1999).[3]

We use *SUDAAN* v. 9 to generate the recycled predictions, which are mean predicted marginals calculated by the *PREDMARG* option in the logistic regression procedure (Research Triangle Institute 2004). The significance of differences between predicted marginals for pairs of insurance-type groups is evaluated at the 0.05 level using the *PRED_EFF* option. The predicted marginals allow us to compare children with different insurance types as if the groups had, on average, the same attributes for all other model covariates and only differed on insurance type and consistency of coverage.

Table 2b: Descriptive Sample Statistics: Mean Proportions by Model Covariates*

Variable	*Proportion*	*Standard Error*
Race/ethnicity of child		
Hispanic	0.22	0.010
Non-Hispanic black	0.11	0.006
Non-Hispanic other	0.08	0.006
Non-Hispanic white	0.58	0.010
Age of child		
19–23 months	0.29	0.009
24–29 months	0.37	0.010
30–35 months	0.34	0.009
Number of children in the household		
1	0.32	0.008
2 or 3	0.58	0.010
$\geq$ 4	0.10	0.009
Mother's age		
$\leq$ 19 years	0.04	0.004
20–29 years	0.43	0.010
$\geq$ 30 years	0.53	0.010
Mother's education		
Less than high school degree	0.17	0.009
High school degree	0.32	0.009
Some college	0.21	0.009
College graduate	0.29	0.008
Mother's marital status		
Married	0.74	0.009
Formerly/not currently married	0.07	0.005
Never married	0.19	0.008
Poverty status		
$<$100% FPL	0.16	0.008
100% to $<$150% FPL	0.10	0.007
150% to $<$200% FPL	0.10	0.006
200% to $<$300% FPL	0.15	0.006
300% to $<$400% FPL	0.16	0.008
$\geq$ 400% FPL	0.25	0.008
Hepatitis B entry law for day care	0.46	0.007
Geographic mobility: moved from other state	0.08	0.005
Insurance type		
Private full-year	0.63	0.010
Private part-year	0.04	0.004
Public full-year	0.23	0.008
Public part-year	0.06	0.005
Uninsured all through the year	0.03	0.004

**Data source*: SLAITS NS-CSHCN 2000–2002 and NIS 2000–2002 linked dataset for non-CSHCN households.

FPL, Federal Poverty Level; SLAITS, State and Local Area Integrated Telephone Survey; CSHCN, Children with Special Health Care Needs; NS-CSHCN, National Survey of Children with Special Health Care Needs; NIS, National Immunization Survey.

RESULTS

Table 3 provides a summary of our results. The significance tests and their p-values refer to differences in the adjusted UTD means between each insurance coverage type. The first p-value compares UTD status by type of insurance coverage to private full-year, the second p-value compares UTD status by type of insurance coverage to public full-year.

For all 10 of the immunizations/series, children with private part-year coverage were less likely to be UTD than children with private full-year coverage. This difference was statistically significant for two of the individual immunizations and one of the series ($p<.05$): DPT3, Hib, and the series 4:3:1. For these outcomes, children with private part-year coverage were, on average, 8 percentage points less likely to be UTD than private full-year children. p-values between .05 and .10 were also observed for DPT4, HepB, and the series 4:3:1:3.

Using public full-year as the reference category, we found that for five of the individual immunizations (DPT3, DPT4, MMR, Hib, hepB) ($p<.05$) and all three immunization series (4:3:1, 4:3:1:3, and 4:3:1:3:3) ($p<.01$), children with private part-year were significantly less likely to be UTD compared with children with public full-year coverage. Children with private part-year coverage were on average 10.3 percentage points less likely to be UTD than public full-year. Using a significance test level of .10, the results show that children with private part-year coverage were significantly less likely to be UTD for the remaining two immunizations (polio and varicella), with an average UTD deficit of 7.1 percentage points.

Children with public full-year coverage were significantly more likely to be UTD for two recommended immunizations series (4:3:1:3 and 4:3:1:3:3) compared with children with private full-year coverage ($p<.05$), with an average differential of 5.6 percentage points. The other series (4:3:1) was significant at $p=.08$. Finally, UTD status for children who were uninsured all through the year was not statistically different from either private full-year or public full-year coverage for all the immunization/series tested.

DISCUSSION

Our findings are significant in that they challenge the prevailing belief that young children (age 19–35 months) with *private* health insurance coverage are

Table 3: Mean Recycled Predictions of the Probability of Being Up-to-Date on Immunizations by Insurance Category*

		Type of Health Insurance Coverage				
	All	*Private Full-Year*	*Private Part-Year*	*Public Full-Year*	*Public Part-Year*	*Uninsured Full-Year*
Immunization						
DTP3 (%)	94.1	94.8	85.7	94.0	95.1	92.5
p-value (private full-year)[2]		—	.01	.56	.84	.42
p-value (public full-year)[3]		.56	.03	—	.50	.58
DTP4 (%)	81.6	80.8	73.4	85.0	78.9	84.9
p-value (private full-year)		—	.07	.09	.62	.39
p-value (public full-year)		.09	.01	—	.08	.99
Polio (%)	89.2	89.5	83.9	90.6	86.3	86.2
p-value (private full-year)		—	.11	.60	.32	.49
p-value (public full-year)		.61	.08	—	.15	.35
MMR (%)	90.9	90.9	84.0	92.3	91.9	86.8
p-value (private full-year)		—	.06	.46	.64	.41
p-value (public full-year)		.46	.04	—	.86	.23
Hib (%)	92.7	93.4	86.1	93.4	90.1	90.9
p-value (private full-year)		—	.04	.99	.23	.43
p-value (public full-year)		.99	.05	—	.21	.39
Hepatitis B (%)	89.1	89.1	83.7	90.6	85.4	91.5
p-value (private full-year)		—	.11	.39	.28	.45
p-value (public full-year)		.39	.05	—	.12	.77
Varicella (%)	75.9	75.9	71.3	78.8	71.3	70.3
p-value (private full-year)		—	.26	.30	.25	.35
p-value (public full-year)		.30	.09	—	.05	.15
4:3:1 (%)	78.2	77.3	68.1	81.9	76.5	82.6
p-value (private full-year)		—	.03	.08	.85	.30
p-value (public full-year)		.08	.00	—	.14	.89
4:3:1:3 (%)	76.7	75.3	67.6	80.9	76.4	80.8
p-value (private full-year)		—	.07	.04	.77	.31
p-value (public full-year)		.04	.00	—	.22	.98
4:3:1:3:3 (%)	73.6	71.9	65.5	78.5	72.3	79.2
p-value (private full-year)		—	.13	.02	.92	.19
p-value (public full-year)		.02	.00	—	.11	.89

*Analysis sample includes only non-CSHCN children in non-CSHCN households ($n = 8{,}861$ with no missing data on model covariates).

[2]*p*-value for test of significance difference when compared with private full-year.

[3]*p*-value for test of significance difference when compared with public full-year.

Data source: SLAITS NS-CSHCN 2000–2002 and NIS 2000–2002 linked dataset.

SLAITS, State and Local Area Integrated Telephone Survey; NS-CSHCN, National Survey of Children with Special Health Care Needs; NIS, National Immunization Survey.

more likely to be UTD in their recommended immunization coverage than those with *public* coverage (Santoli et al. 2004; Smith et al. 2005). Our findings show that when controlling for covariates, children with public full-year coverage were significantly more likely to be UTD than children with private full-year coverage in two of the three recommended series of immunizations. Of particular concern are the strong and consistent findings of lower immunization rates for children with private part-year coverage compared with those with either public or private full-year coverage.

Our findings differ from past studies in several ways. First, we analyze each of the seven recommended immunizations separately and all three recommended series. In this way we view the broad spectrum of possible outcomes as opposed to selecting only one series or one recommended immunization. We found that public coverage had significantly higher UTD rates than private full-year in two of the three recommended series. Second, most of the studies that highlight higher UTD rates in the private market rely on their bivariate analysis (Santoli et al. 2004; Smith et al. 2005; Allred, Wooten, and Kong 2007). When other covariates related to immunization status are included in the model (education of parents, marital status, income, race/ethnicity, etc.), the superiority of private insurance is no longer found. Finally, there is more recent evidence that the private health insurance market is changing and our findings may reflect the first indication of these changes and their potential impact on children (Gabel et al. 2005; Clemans-Cope and Garrett 2006). Employers are dropping health insurance coverage, dropping dependent coverage, and increasing copayments and deductibles, potentially creating new barriers to immunization coverage for children.

The children who had gaps in private health insurance coverage fared the worst in our analysis. The increase in SCHIP and Medicaid enrollment suggests that these public programs may be picking up some of the families that are currently lacking coverage, but they may not be covering those children who experience gaps in private coverage. Our findings suggest that these children face the largest risks of not getting their needed immunizations. These children are clearly eligible for the federal VFC. It is possible and even plausible, however, that families with intermittent private coverage may wait until they obtain new health insurance coverage before they return to their provider for preventive services, not knowing of the VFC program. In addition, children with private coverage who have high deductibles or no coverage for immunization (the underinsured) must go to a Federally Qualified Health Center to receive the vaccine unless there is additional state-funded support for vaccinations for private clinics for the underinsured. Even if children with intermittent coverage were classified as "underinsured," they would still need to be informed that their children are eligible for free vaccination at a public health clinic.

The strength of our study is in linking health insurance status from a national household survey with immunization status from the NIS. This allowed us to assess the role of public, private, and intermittent coverage on health insurance status and on immunization coverage rates. One limitation with our study is that we identified approximately 8 percent of the sample that was not linkable and 15 percent that did not have adequate provider verification data. We conducted comparative analysis on the demographics of the analytic file that was used and the observations we could not use, and found very few statistically significant differences between the samples for the demographic characteristics or health insurance coverage variables, our main focus. Moreover, given the nature of how these observations became missing, there are no substantive a priori reasons for suspecting meaningful levels of selection bias in our estimates from their omission. Finally, our linkage approach was replicated in Allred et al. (2007), who linked the National Survey of Children's Health and the NIS with similar findings.

CONCLUSION

Our study reinforces increasing concern about gaps in health insurance coverage in the private health insurance market and its impact on the immunization rates of children. While we do not have a national policy that addresses prevention and immunization coverage for children, other efforts have addressed these concerns. The Medicaid program's emphasis on coverage and prevention for children and the now 10-year-old SCHIP program are focused on increasing health insurance coverage for low-income children. The VFC program was designed to increase immunization coverage by financing free vaccines for the uninsured in private practices and for the underinsured in public health clinics. The question is whether these programs are meeting the emerging needs of children in a changing private health insurance market, with the potential for many more children to experience gaps in private coverage.

The declining private employer-based market, coupled with Medicaid's relatively consistent focus on prevention for children, may have contributed to our finding that public full-year coverage was superior to private full-year coverage. While federal Medicaid policy requires coverage for all immunizations recommended by the Advisory Committee on Immunization Practices, there is no such requirement for private health insurance products or for SCHIP (Rosenbaum, Markus, and Sonosky 2004). Even if states require coverage of prevention and screening services in private plans, these requirements govern only the fully insured health insurance products, which are regulated by state health insurance laws. Employers who self-insure (33 percent of private sector employers and 53 percent of privately enrolled employees in 2005 [AHRQ 2005]) are exempt from state regulations under preemption of the federal Employment Retirement and Income Security Act. There is, however, precedent for mandated benefits for both the fully insured and the self-insured markets, as evidenced in the Health Insurance Portability and Accountability Act of 1996, which mandated mental health "parity" and minimum maternity stays.

A recent study reported in *JAMA* documented increased barriers due to financing issues in both federal and state programs for publicly available vaccinations (Lee et al. 2007). This study conducted surveys with state immunization program directors and concluded that the lack of funding for newer vaccines for children who are not VFC eligible had led many states to adopt more restrictive policies for the provision of publicly purchased vaccines since 2004. For vaccines provided in the private sector, 46 percent of states did not provide publicly purchased varicella vaccine to underinsured children and 51 percent of states did not provide publicly purchased Tdap, tetanus-diphtheria-acellular pertussis, to the underinsured. The growth of such restrictive policies raises concerns about the availability of publicly funded vaccines at a time when the number of underinsured children—including those with intermittent private coverage—is growing.

If immunization rates are lower for children with intermittent coverage because their parents are unaware of the availability of free vaccines, developing ways of informing providers and families of their eligibility could improve immunization status. In this regard, schools may play a key role in increasing information about the availability of the VFC program and low-cost immunization sites. State laws that require proof of vaccination before school entry "have been considered a safety net for the U.S. vaccination program because they are intended to ensure that no child is missed" (CDC 2006, p. 1126). This role of school personnel and health department staff could be expanded to identify potentially VFC-eligible children as well as to provide information on the program to parents whose private health insurance coverage may have lapsed.

A further finding of interest for policy is that immunization coverage rates for children uninsured the entire year were not statistically different from the rates for those with either private full-year or public full-year coverage. Indeed, children uninsured the entire year had higher UTD rates than those with private full-year coverage for three of the immunizations and all three of the recommended series. This finding raises some interesting questions. For the full-year uninsured, the relatively high UTD immunization rates may reflect existing relationships with the VFC program and ties to safety net programs. However, parents with young children moving on and off of private health insurance may not have the ties to—nor even the knowledge of—the safety net that provides free care. As noted, they may simply wait until they regain coverage to seek the needed preventive care, including immunizations. Recent findings by Allred et al. (2007) suggest that having a usual source of care—and more broadly a medical home—may increase immunization coverage for all children. More research is needed on the role of the safety net in providing a usual source of care for the uninsured and its potential role for the underinsured.

Finally, our findings reinforce past research on the importance of continuous coverage, either public or private, in getting children the needed preventive services (Kogan et al. 1995; Newacheck et al. 1998; Starfield and Shi 2004). Immunization of young children is one of the few cost-saving clinical preventive services (Santoli et al. 1999). If changes in health insurance coverage are lowering the immunization rates for some children, new and creative efforts will be required to reach young children who may be falling through the cracks.

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Notes

1. CSHCN are identified as those children who experience at least one of the following five health consequences resulting from a medical condition that has lasted or is expected to last for a period of at least 12 months: use of prescription medications; use of health care services above the average for a child the same age; limitation in activities that most children the same age can do; use of physical, occupational, or speech therapy; or having a behavioral, emotional, or developmental condition requiring treatment or counseling.
2. Thirty-three states mandated HepB vaccination for enrollment in licensed day care during the time period of the study.
3. See Asch et al. (2006) for another application of this model.

References

AHRQ. 2005. *MEPS-IC, National Estimate Table Series, Private Sector Data by Firm Size, Industry Group, Ownership, Age of Firm, and Other Characteristics: Table I.A.2 a (2005) and Table I.B.2.b.(1) (2005).* Rockville, MD: Agency for Healthcare Research and Quality [accessed on January 16, 2008].

Allred, N. J., K. Wooten, and Y. Kong. 2007. "The Association of Health Insurance and Continuous Primary Care in the Medical Home on Vaccination Coverage for 19–35 Month Old Children." *Pediatrics* 119 (2): S4–11.

Asch, S. M., E. A. Kerr, J. Keesey, J. L. Adams, C. M. Setodji, S. Malik, and E. A. McGlynn. 2006. "Who Is at Greatest Risk for Receiving Poor-Quality Health Care?" *New England Journal of Medicine* 354 (11): 1147–56.

Blumberg, S., L. Olson, M. Frankel, L. Osborn, C. Becker, K. Srinath, and P. Giambo. 2003. "Design and Operation of the National Survey of Children with Special Health Care Needs, 2001." *Vital Health Statistics* 1 (41): 1–136.

CDC. 2004. *Vaccines for Children Program: Program in Brief.* Washington, DC: Centers for Disease Control and Prevention.

———. 2005. "National, State, and Urban Area Vaccination Coverage among Children Aged 19–35 Months—United States, 2004." *Morbidity and Mortality Weekly Report* 54 (29): 717–21.

———. 2006. "Vaccination Coverage among Children Entering School—United States, 2005–06 School Year." *Morbidity and Mortality Weekly Report* 55 (41): 1124–6.

———. 2007. *Budget Tables for Fiscal Years 2000–2007 Funding. Direct Communication.* Atlanta, GA: Centers for Disease Control and Prevention, Financial Management Office, June 5.

Clemans-Cope, L., and B. Garrett. 2006. *Changes in Employer-Sponsored Health Insurance Sponsorship, Eligibility, and Participation: 2001 to 2005.* Report no. 7599. Washington, DC: Kaiser Commission on Medicaid and Uninsured.

Cohen, R., and M. Martinez. 2006. *Health Insurance Coverage: Estimates from the National Health Interview Survey.* Hyattsville, MD: Centers for Disease Control and

Prevention [accessed on November 15, 2006]. Available at http://www.cdc.gov/nchs/data/nhis/earlyrelease/insur200606.pdf

DeNavas-Walt, C., B. D. Proctor, and J. Smith. 2007. *Income, Poverty, and Health Insurance Coverage in the United States: 2006 Current Population Reports, P60-233.* Washington, DC: U.S. Census Bureau.

Department of Health and Human Services. 2000. *Healthy People 2010: Leading Health Indicators.* Washington, DC: Department of Health and Human Services Office of Disease Prevention and Health Promotion [accessed on May 4, 2004]. Available at http://www.healthypeople.gov/Document/tableofcontents.htm#volume1

Gabel, J., G. Claxton, I. Gill, J. J. Pickreign, H. Whitmore, B. Finder, S. Hawkins, and D. Rowland. 2005. "Health Benefits in 2005: Premium Increases Slow Down, Coverage Continues to Erode." *Health Affairs* 24 (5): 1273–80.

Graubard, B., L. Edward, and E. Korn. 1999. "Predictive Margins with Survey Data." *Biometrics* 55 (2): 652–9.

Greene, W. 2002. *Econometric Analysis*, 5th Edition, Upper Saddle River, NJ: Prentice Hall.

Kogan, M., G. Alexander, M. Teitelbaum, B. Jack, J. Kotelchuck, and G. Pappas. 1995. "The Effect of Gaps in Health Insurance on Continuity of a Regular Source of Care among Preschool-Aged Children in the United States." *Journal of the American Medical Association* 274 (18): 1429–35.

Lee, G. M., J. M. Santoli, C. Hannan, M. Messonnier, J. E. Sabin, D. Rusinak, C. Gay, S. M. Lett, and T. A. Lieu. 2007. "Gaps in Vaccine Financing for Underinsured Children in the United States." *Journal of the American Medical Association* 298 (6): 638–43.

Luman, E., L. Barker, M. McCauley, and C. Drews-Botsch. 2005. "Timeliness of Childhood Immunizations, a State-Specific Analysis." *American Journal of Public Health* 95 (8): 1367–74.

National Center for Health Statistics. 2002. "SLAITS National Survey of Children with Special Health Care Needs" [accessed on August 31, 2005]. Available at http://www.cdc.gov/nchs/data/slaits/CSHCN%20Factsheet.pdf

Newacheck, P., J. Stoddard, D. Hughes, and M. Pearl. 1998. "Health Insurance and Access to Primary Care for Children." *New England Journal of Medicine* 338 (8): 513–9.

Olson, L., S. Tang, and P. Newacheck. 2005. "Children in the United States with Discontinuous Health Insurance Coverage." *New England Journal of Medicine* 353 (4): 382–91.

Research Triangle Institute. 2004. *SUDAAN Language Manual (Release 9.0).* Research Triangle Park, NC: Research Triangle Institute.

Robert Wood Johnson Foundation. 2005. "Going Without: America's Uninsured Children" [accessed on August 31, 2005]. Available at http://coveringkidsandfamilies.org/press/docs/2005BTSResearchReport.pdf

Rosenbaum, S., A. Markus, and C. Sonosky. 2004. "Public Health Insurance Design for Children: The Evolution from Medicaid to SCHIP." *Journal of Health and Biomedical Law* 1 (1): 1–47.

Santoli, J., N. Huet, P. Smith, L. Barker, L. Rodewald, M. Inkelas, L. Olson, and N. Halfon. 2004. "Insurance Status and Vaccination Coverage among US Preschool Children." *Pediatrics* 113 (6): 1959–64.

Santoli, J., L. Rodewald, E. Maes, M. Battaglia, and V. Coronado. 1999. "Vaccines for Children Program, United States, 1997." *Pediatrics* 104 (2): e15.

Smith, P., M. Battaglia, V. Huggins, D. Hoaglin, A. Roden, M. Khare, T. Ezzati-Rice, and R. Wright. 2001. "Overview of the Sampling Design and the Statistical Methods Used in the National Immunization Survey." *American Journal of Preventive Medicine* 20 (4S): 17–24.

Smith, P. J., J. M. Santoli, S. Y. Chu, D. Q. Ochoa, and L. E. Rodewald. 2005. "The Association between Having a Medical Home and Vaccination Coverage among Children Eligible for the Vaccines for Children Program." *Pediatrics* 116 (1): 130–9.

Starfield, B., and L. Shi. 2004. "The Medical Home, Access to Care, and Insurance: A Review of Evidence." *Pediatrics* 113 (5): 1493–8.

StataCorp. 2005. *Reference Manual (Release 9.0).* College Station, TX: STATA Press.

Wood, D. L. 2003. *Estimating the Need for Publicly Purchased Vaccine for Adults and Children.* Background paper prepared for the Committee on the Evaluation of Vaccine Purchase Financing in the United States. Washington, DC: Institute of Medicine, Division of Health Care Services.

Wood, D. L., J. Gabel, M. Bondi, and M. French. 2004. "Does Private Insurance Adequately Cover Childhood Immunizations for US Children?" Presentation to the 38th National Immunization Conference, Seattle, WA, May 13, 2004.

Zell, E., T. Ezzati-Rice, M. Battaglia, and R. Wright. 2000. "National Immunization Survey: The Methodology of a Vaccination Surveillance System." *Public Health Reports* 115: 65–77.

Supplementary Material

The following supplementary material for this article is available online:

Appendix SA1: Author Matrix.

This material is available as part of the online article from http://www.blackwell-synergy.com/doi/abs/10.1111/j.1475-6773.2008.00864.x (this link will take you to the article abstract).