The Role of State Policies and Programs in Buffering the Effects of Poverty on Children's Immunization Receipt

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ABSTRACT

Objectives. This study assessed the influence of public policies on the immunization status of 2-year-old children in the United States.

Methods. Up-to-dateness for the primary immunization series was assessed in a national sample of 8100 children from the 1988 National Maternal and Infant Health Survey and its 1991 Longitudinal Follow-Up.

Results. Documented immunization rates of this sample were 33% for poor children and 44% for others. More widespread Medicaid coverage was associated with greater likelihood of up-to-dateness among poor children. Up-to-dateness was more likely for poor children with public rather than private sources of routine pediatric care, but all children living in states where most immunizations were delivered in the public sector were less likely to be up to date. Poor children in states with partial vaccine replacement programs were less likely to be up to date than those in free-market purchase states.

Conclusions. While state policies can enhance immunization delivery for poor children, heavy reliance on public sector immunization does not ensure timely receipt of vaccines. Public- and private-sector collaboration is necessary to protect children from vaccine-preventable diseases. (*Am J Public Health.* 1999;89:164–170)

More than 20% of US 2-year-olds do not receive their primary immunization series on schedule,[1] leaving them susceptible to serious but preventable diseases. The problem of underimmunization is multifaceted and involves economic factors, provider and parental barriers, and the availability and impact of state policies and programs.[2] The salient factors related to immunization delivery vary across different populations. Previous reports have yielded conflicting evidence of the relationship between poverty and underimmunization: some published studies have concluded that poor children have lower immunization rates than nonpoor children,[3–6] while others disagree.[7]

Using the 1988 National Maternal and Infant Health Survey (NMIHS), conducted by the National Center for Health Statistics, this analysis explored the relationships among state policies, individual characteristics, and the likelihood that a preschool child is up to date for the primary immunization series. The NMIHS is unique in that it is the only national data set that provides detailed individual-level health data on a large sample of preschool children. Although the NMIHS sample dates back several years, we believe that it provides an important opportunity to explore the structural relationships between individual characteristics, state policies, and immunization delivery. The large sample size, sizable representation of high-risk children, and detailed information included in the database provide a rich context for this issue.

Methods

Data Sources

The investigation used data from the 1988 NMIHS and the NMIHS 1991 Longitudinal Follow-Up Live Birth Survey and Provider Files. The 1988 NMIHS involved a national sample of 9953 children born in the United States during that year. African American and low-birthweight children were oversampled. Excluded from this analysis were children with incomplete data for the 1991 Live Birth Survey (n = 1668), along with children who did not live with their mother during the 30 days prior to the administration of the Live Birth Survey and/or had a proxy respondent on the survey (n = 185). These exclusions resulted in a final sample of 8100 children between 27 and 48 months of age at the time of the follow-up survey.

The 1991 Live Birth Survey prompted the respondent to list any outpatient or inpatient settings in which the sample child had received medical attention since birth. Respondents listed at least 1 provider for 7947 (98%) of the 8100 children in the sample. Listed providers were asked to complete several questionnaire items for each visit or hospitalization for the sample child or to submit a copy of the sample child's chart for data abstraction. At least 1 provider responded for 77% (n = 6168) of the children for whom respondents listed any providers. Since only 48% of children had complete provider reports, sample selection models were used to estimate immunization status, with control for selection bias. Sample selection models are discussed in more detail later (a technical

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appendix is available on request from the authors). Further information regarding the 1988 NMIHS and its associated 1991 data files has been published elsewhere.[8,9]

Data Analysis

Dependent variables. This study investigated whether children received appropriate immunizations (i.e., were "up to date" by provider report) for 3 vaccines: diphtheria–tetanus–pertussis (DTP), oral polio (OPV), and measles–mumps–rubella (MMR). Pediatric diphtheria–tetanus vaccine was accepted in lieu of DTP vaccine, and injectable polio was accepted in lieu of OPV. The dependent variable was whether a sample child was up to date for the series of 4 DTP, 3 OPV, and 1 MMR (i.e., the 4:3:1 series), as recommended by the US Public Health Service. Because the recommended age at administration changed near the time of the survey, *Haemophilus influenzae* type b vaccine was not included in this analysis. Measurement of up-to-dateness was based on provider reports obtained after the Live Birth Survey, regardless of children's ages.

Independent variables. The independent variables used in these analyses reflected the findings of past studies of childhood immunizations and children's use of health care. These reports linked immunization status with certain child and family demographic characteristics, geographic variables, health care delivery system variables, and state policy variables.[3,10–17] Variables included in the present model are listed in Table 1.

Poverty status was constructed via mother's marital status, total number of children, and household income for the 12 months prior to the sample child's birth. Household income was compared with 185% of the 1987 federal poverty level, reflecting the expanded Medicaid eligibility level under federal mandates phased in over the late 1980s and early 1990s. Children living in households whose incomes fell at or below 185% of poverty for their estimated family size were classified as "poor."

Mother's educational attainment was missing for a substantial portion of the sample. As a means of avoiding loss of those observations, the model included a dummy variable to indicate that mother's educational attainment was missing. Dummy variables were also included to indicate missing observations for mother's work status, source of payment for health care, and routine source of pediatric care.

State-level variables. Several state variables were included in the model to reflect the socioeconomic and policy context of the immunization delivery system. State per capita income, constructed from the 1989 Bureau of Health Professions Area Resource File, was included as a proxy for the infrastructure of the health care delivery system in the state. The percentage of poor individuals covered by Medicaid, constructed from the March 1989 Current Population Survey, was included to capture the extent to which Medicaid acts as a safety net for the state's poor and the willingness of the state to ensure the availability of health care for the poor. Unfortunately, state-level data on the percentage of providers participating in Medicaid were not available.

The immunization purchase system in the state reflected whether, in 1989, the child's state of residence operated a universal vaccine purchase system (state-supplied vaccines for

TABLE 1—Independent Variable Labels and Definitions

Variable	Definition
Residential region	Sample child lives in an urban or rural area
Child's health status	
Low birthweight	Sample child weighed <2500 g at birth
Chronic illness	Sample child has at least 1 chronic condition
Ever had an accident	Sample child has ever sought medical care for an accident
Ever hospitalized	Sample child has ever been hospitalized
Family characteristics	
Race	Sample child is White, African American, or other (e.g., Asian American, Native American)
Hispanic origin	Sample child is of Hispanic origin
Family size	
No. of children	No. of children born to respondent (excluding sample child)
Birth order	Sample child was firstborn, second or third born, or fourth or higher birth order
Income	
Household income	Household income during the 12 months prior to delivery
Poverty status	Family lives at or below 185% of the 1987 federal poverty level
Mother's status	
Married	Mother is currently married
Education	Mother completed <12 years, 12 years, or >12 years of schooling
Employment	Mother is either working or in school or at home full time
Payment source and insurance	
Medical care payment	Medical care paid for by insurance, by income (i.e., out of pocket), by Medicaid, or by other public source
Insurance gap	Sample child was ever without health insurance
Source of medical care	
Physician's site	Child's routine source of care is private physician, health maintenance organization, health department, community health clinic, outpatient clinic, other source, or none
State policy	
State per capita income	1989 state per capita income
Medicaid coverage	State percentage of poor covered by Medicaid, 1989
Medicaid coverage squared	State percentage of poor covered by Medicaid, squared term
Public immunization delivery	State percentage of immunizations delivered in the public sector, 1989
Vaccine purchase system	State has a universal purchase system, partial purchase system, or free market system, 1989

all children), a partial purchase system (state replacement of vaccines given to Medicaid-enrolled children at participating public and private sites), or a free-market purchase system (state-supplied vaccines only in public sites). The estimated percentage of immunizations administered in the public sector was obtained directly from state immunization officials, except for 4 states in which Centers for Disease Control and Prevention estimates were required. It is important to note, however, that what constitutes "public-sector immunization" varies from state to state. In most cases, it reflects immunizations administered at public health departments or clinics; in others, it comprises all vaccines purchased by the state, regardless of whether they are administered at a public or private site.

Statistical Models

Single-variable analyses (χ^2 analyses and *t* tests) were performed with SAS 6.11.[18] These analyses provided descriptive statistics on the poor and nonpoor subsamples and identified variables that significantly related to completeness of provider records and the likelihood of being up to date. Among the single-variable analyses performed, only the descriptive statistics on the poor and nonpoor subsamples are presented here. The results of other single-variable analyses are available from the first author.

As previously stated, only 48% of the sample children had complete provider records. Use of standard probit or logit models would have required the omission of observations with incomplete provider records. Statistical tests confirmed that omission of these records would have resulted in selection bias, since several independent variables related to both the likelihood that a child had a complete provider record and the likelihood that the child was up to date. The dichotomous dependent variable of interest precluded the use of standard selection models such as the Heckman model. The analyses reported here were performed by means of the bivariate probit procedure in LIMDEP 6.0.[19] Use of the bivariate probit model allowed the inclusion of all observations, thus avoiding selection bias.[20] The bivariate probit model uses maximum likelihood to estimate 2 equations simultaneously. In this analysis, one equation modeled the likelihood of having a complete provider record, while the other modeled immunization status. The bivariate probit models were run on subsamples of poor and nonpoor children to determine the differential effects of the independent variables on the likelihood of being up to date. A technical appendix explaining the procedures used and their rationale in greater detail is available from the first author.

TABLE 2—Descriptive Statistics, by Poverty Status

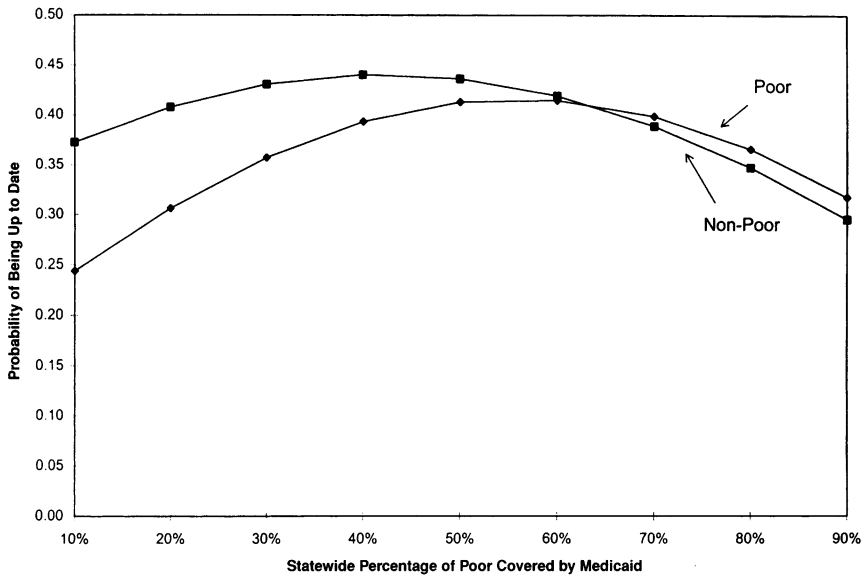
Variable	Poor Children (n = 4020)	Nonpoor Children (n = 4080)
Up to date for 4:3:1 series, %	33	44
Rural residence, %	27	17
Low birthweight, %	28	24
Chronic illness, %	32	31[a]
Ever had an accident, %	19	23
Ever hospitalized, %	22	18
Race, %		
White	31	61
African American	66	35
Other	3	4
Hispanic origin, %	9	8[b]
Birth order, %		
Firstborn	32	49
Second or third born	50	46
Fourth or later child	18	5
Mother married	42	76
Mother's educational attainment, %		
Less than high school	29	8
High school graduate	38	29
At least some college	14	39
Missing	20	24
Mother's employment status, %		
At home full time	54	34
At work or in school	41	63
Missing	5	3
Mean no. children	1.3	0.7
Mean household income, $	8682	36689
Mean maternal age, y	24	27
Payment source, %		
Privately insured	20	63
Out of pocket	19	20
Medicaid	43	9
Other public insurance	12	5
Missing	5	3
Insurance gap, %	30	18
Source of care, %		
Private physician's office	42	68
No routine source	3	1
Health maintenance organization	3	9
Community health center, health department, or outpatient clinic	45	17
Other	2	2
Missing	5	3
Mean state per capita income, $	16841	17626
Medicaid coverage, %	44	49
Public immunization delivery, %	48	42
State immunization purchase system, %		
Free market	70	64
Universal purchase	2	6
Partial purchase	28	31

Note. Differences between the poor and nonpoor groups were statistically significant at $P = .001$ unless otherwise noted.
[a]Not significant at $P < .05$.
[b]Significant at $P < .05$.

The bivariate probit results allowed for a simulation of the probability of immunization for a "base case," a hypothetical child with a specified set of demographic, health status, and residential state characteristics. Base case values were calculated for the poor and nonpoor subsamples. The same base case values for all categorical variables were used in the probability calculations for both subsamples. The mean values for the poor and nonpoor subsamples for all continuous variables were applied to the poor and nonpoor base cases,

respectively. In summary, the base cases for the subsamples differed in the values of the continuous variables only. Through the use of these base case values and the beta coefficients from the bivariate probit results, the expected change in the probability of being up to date associated with an incremental change in any given independent variable was calculated for each explanatory variable. A technical appendix available from the authors offers details of these probability calculations.

It is important to note that the immunization rates presented in this report reflect the experience of this sample only and do not represent national estimates, largely because the 1988 NMIHS survey oversampled low-birthweight and African American children. If national estimates are to be obtained, the statistical analyses must account for the sampling frame design. Sample selection issues and the use of complicated statistical methods precluded the use of methods to account for the complex survey design.



Note. Analysis also controlled for the covariates listed in Table 1.

FIGURE 1—Expected effect of Medicaid coverage on the predicted probability of being up to date for 4:3:1 series, by poverty status.

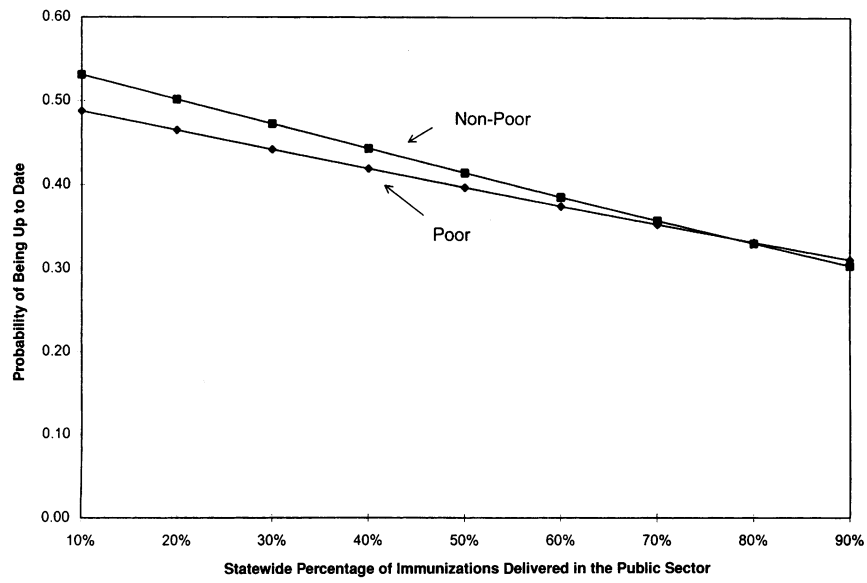
Results

Characteristics of the Poor and Nonpoor Samples

Table 2 presents descriptive characteristics for the poor and nonpoor subsamples. Poor children were significantly less likely to be up to date for the 4:3:1 series than were nonpoor children. Other results mirrored the traditional covariates of poverty. In comparison with nonpoor children, poor children were significantly more likely (1) to be in female-headed households with younger, less educated mothers and more siblings; (2) to be African American and/or Hispanic; and (3) to live in a rural area. Poor children were less likely to have private health insurance and more likely to rely on public clinics. With regard to state-level variables, poor children tended to live in states with lower per capita incomes, less generous Medicaid coverage, and greater reliance on the public sector for immunization delivery.

State-Level Variables

Bivariate probit results were used to calculate the probability of being up to date for the 4:3:1 series for the poor and nonpoor samples. Several state variables had a significant influence on up-to-date status. The statewide percentage of poor individuals covered by Medicaid was related positively and significantly to being up to date among poor children, but this effect was attenuated at higher levels of coverage. As Figure 1 shows, more generous Medicaid coverage yielded a significantly higher probability of being up to date, but only up to 60% of the poor population covered by Medicaid. Beyond that point, additional Medicaid coverage was not associated with an increased likelihood of being up to date.



Note. Analysis also controlled for the covariates listed in Table 1.

FIGURE 2—Expected effect of public sector immunization on the predicted probability of being up to date for 4:3:1 series, by poverty status.

Figure 2 depicts the estimated relationship between public-sector immunization delivery and the probability of being up to date. As the percentage of immunizations delivered in the public sector increased, the probability of being up to date significantly decreased for both poor and nonpoor children. For example, an increase in public-sector immunization from 50% to 70% was associated with an expected 4-point decrease in the probability of being up to date.

With regard to vaccine financing, poor children living in states with a vaccine

TABLE 3—Change in Probability of Completing All Immunization Series: Effect of Changes in Significant Individual-Level Variables

Variable	Poor Sample	Nonpoor Sample
Rural residence	. . .	−.06*
Child's health status		
Birthweight <2500 g	−.07	−.07**
Ever sought medical attention for an accident	. . .	−.05*
Any hospitalizations listed	−.10**	−.14**
Child and family characteristics		
African American	. . .	−.07**
Hispanic origin	. . .	−.12**
Mother's age at birth[a]	.04**	.04**
Second or third born[b]	−.13**	. . .
Fourth or later child[b]	−.25**	. . .
Household income[a]	. . .	.02*
Payment and insurance		
Payment source: Medicaid[c]	−.08**	. . .
Payment source: other goverment source[c]	−.09**	. . .
Ever uninsured	−.08**	−.07*
Source of care		
None[d]	. . .	−.30**
Health maintenance organization[d]	. . .	.08*
Community health center, health department, or outpatient clinic[d]	.07**	. . .

[a]Change in probability of completion calculated for 1 standard deviation increase.
[b]In comparison with firstborn children.
[c]In comparison with those whose payment source is private insurance.
[d]In comparison with those receiving their regular care in a private physician's office.
*$P < .1$; **$P < .05$.

replacement system (i.e., partial purchase) faced a .11 lower probability of being up to date for the 4:3:1 series than children living in free-market states ($P < .05$). Universal purchase systems were not significantly related to the likelihood of being up to date in either the poor or nonpoor sample.

Individual and Familial Characteristics

The predicted probabilities and expected changes associated with variation in the significant individual-level independent variables are shown in Table 3. The predicted probability that a child living in a poor household was up to date, given the base case characteristics, was .40. The probability that the base case nonpoor child was up to date was .44. Among nonpoor children, rural residence was associated with a significantly lower probability of being up to date; this relationship was not seen among poor children. Nonpoor children without routine sources of care had a substantially lower probability of being up to date than nonpoor children routinely seen by private physicians, while those enrolled in health maintenance organizations were significantly more likely to be up to date. Nonpoor children who were African American and/or Hispanic also were significantly less likely to be up to date.

Among poor children, payment source had a particularly strong association with likelihood of being up to date for the 4:3:1 series. Poor children covered by Medicaid or other government programs were significantly less likely to be up to date than poor children with private insurance. Poor children whose usual source of care was a community health center or health department were significantly more likely to be up to date than those receiving routine care from a private physician. Children who had experienced any lapse in their health insurance coverage, regardless of their poverty status, were significantly less likely to be up to date.

Several characteristics related to being up to date among both poor and nonpoor children. Low birthweight and a history of previous hospitalizations lowered the estimated probability of being up to date for both groups. Also, higher maternal age increased the likelihood a child was up to date regardless of poverty status. Maternal education and marital status did not relate significantly to being up to date among either poor or nonpoor children, but higher birth order decreased the probability of being up to date for poor children.

Discussion

Several state policies and programs related significantly to immunization completion, especially among poor children. More extensive Medicaid coverage of the poor was associated with a significantly greater likelihood of being up to date among poor children in our sample. This suggests that denial of Medicaid coverage to poor children negatively affects their access to preventive services. However, the effects of expanded Medicaid coverage are limited. At about 60% of the poor covered by Medicaid, additional Medicaid expansions offered no additional benefit in terms of increased probability of being up to date. More generous Medicaid coverage may increase access to immunizations among poor children but still fail to ensure the same degree of access as that of privately insured children. The attenuation of the relationship between Medicaid coverage of the poor and the likelihood of being up to date may also reflect the effects of sampling error, since this measure may be less accurate in states with small numbers of poor children.

More than 40% of the poor children in this sample listed a community health center, health department, or other public clinic as their usual source of care, demonstrating the integral role these public sites play in providing access to care for poor children. The results of this analysis suggest that these public sources effectively provide preventive services to their pediatric patients. In fact, public clinics appear to be more successful than private physician offices in fully immunizing their poor patients, confirming the findings of at least one previous study.[21] A plausible explanation is that public clinics are a consistently available source of care, whereas access to private physicians varies with changes in families' financial status. A family taking their child to a private office for initial well-child visits may not be able to pay for follow-up visits and immunizations.

These results also indicate that higher levels of public-sector immunization delivery relate negatively to the likelihood of being up to date among both poor and nonpoor children. The reasons for this relationship are not clear, but some hypotheses can be made. Most important, states with low immunization rates may increase public-sector immunization services in an attempt to compensate for poor private-sector involvement in immunization delivery. Another potential explanation is that heavy reliance on the public sector for immunizations may strain the system's capacity and impede access to immunizations. With the increases in vaccine costs during the 1980s, many private physicians limited or discontinued immunization provision and instead referred patients to public sources of care.[14,22–25] This phenomenon increased demand for public-sector

immunization services at a time when federal funding to community health centers and health departments diminished in "real dollar" terms.[22] The increased demand for public provision of immunizations, coupled with decreased financial resources, may underlie the negative relationship observed between public-sector immunization delivery and the likelihood of being up to date.

During the time period studied, several states had partial purchase vaccine financing systems. These programs usually allowed participating providers to obtain vaccines from health departments to replace those administered to Medicaid children. Provider participation in vaccine replacement programs, however, historically has been very low; physicians' reasons for not participating in such programs include excessive paperwork, difficulties with maintaining 2 vaccine inventories simultaneously, and inadequate reimbursement for supplies and staff time.[14] It remains unclear whether low participation in vaccine replacement programs suggests problems in immunization delivery only or whether it reflects a much broader issue of private providers' willingness to accept Medicaid patients for any care. Certainly, this study's finding that poor children living in partial purchase states were less likely to be adequately immunized indicates that a narrow focus on replacing vaccines does not foster improved immunization delivery for Medicaid children.

The situation is less clear regarding universal vaccine purchase programs, in which the state supplies free vaccines to all children regardless of household income or insurance status. This analysis did not detect a significant association between living in a state with a universal purchase system and the likelihood of being up to date. This may be due to the small number of sample children living in universal purchase states. Another possibility is that universal purchase programs, which focus on keeping children in the private sector for immunizations, give less attention to public-sector efforts, which traditionally serve as a safety net for populations with limited access to care. In this way, a universal purchase system may function effectively for some groups of children but not others.

The results of this analysis show that the associations between the individual-level independent variables and the likelihood of being up to date for the 4:3:1 series differed between the poor and nonpoor samples. Several factors that were related to immunization status among nonpoor children (e.g., race, ethnicity, rural residence) had no association with being up to date among poor children. This suggests that for poor children, issues in immunization delivery transcend traditional demographic differences seen in the nonpoor sample. Conversely, among nonpoor children, lower levels of immunization completion for African Americans and Hispanics may reflect the effects of differential access to health care or health insurance, residential segregation, or cultural differences in health care use.

The significant relationship between household income and being up to date suggests that, even among nonpoor children, those at the lower end of the income distribution face financial barriers to health care. Since many insurance plans do not cover preventive services, patients often pay out of pocket for private-sector immunizations, which discourages timely receipt of immunizations. In fact, the primary reason that private providers refer patients to public immunization sites is that the patients cannot afford the cost of immunizations.[15]

The findings of this analysis also highlight systemic and financial barriers to immunization among the poor. Payment variables strongly suggest that children with public forms of insurance were significantly less likely to be up to date than those with private health insurance, yet poor children paying out of pocket were not significantly less likely to be up to date than those with private insurance. These findings suggest that publicly insured children may face other barriers, such as difficulty finding a private provider who accepts Medicaid patients. Both poor and nonpoor children who lacked health insurance coverage at any point in time were significantly less likely to be up to date, underscoring the importance of continuous health insurance coverage to guarantee access to medical care for all children.

Since the state-level variables and immunization rates were measured at only one point in time, this analysis cannot establish temporality or causation. Thus, it cannot be determined whether certain programs initiated in response to low immunization rates are efficacious. Further research on large, national data sets is needed to establish temporal relationships between state immunization policies and programs and children's receipt of immunizations.

The results of this study do suggest that state policies and programs may enhance immunization receipt among children, but with limits. The public health system lacks sufficient resources to deliver immunizations to all children. Promoting private-sector involvement by increasing Medicaid coverage without addressing provider reimbursement and participation does little to increase children's access to preventive services. Our findings support a coordinated public/private approach to improving immunization delivery in all settings and for all children. □

Contributors

All authors participated in the planning and design of the study. Michelle Mayer performed the analyses and had primary responsibility for manuscript preparation. Sarah Clark assisted with data interpretation and manuscript preparation. Thomas Konrad suggested modifications in the statistical analyses and reviewed and edited drafts of the manuscript. Victoria Freeman participated in interpretation of the results and editing of the report. Rebecca Slifkin contributed to the writing and editing of the paper. All authors attest to the scientific integrity of this work.

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