

Compliance with Childhood Immunizations in Kern County, California

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A rapid survey was conducted to describe the immunization status of the 0- to 2-year-old population in selected communities of Kern County, California, and identify reasons for noncompliance with immunization recommendations. Households were selected by two-stage cluster sampling. Among 860 children, 38% had received immunizations on schedule, while 44% had not received the recommended doses for their age. Compliance with the immunization schedule worsened dramatically after the first year of life. Among 2 year olds, the proportion that had the recommended number of vaccine doses was 81% for MMR, 82% for polio, 65% for DTP, and 47% for Hib. Parents' main reasons for noncompliance included child's illness, procrastination, and limited access to information and services. The low levels of compliance reflect lack of active follow-up in preventive health care across socioeconomic levels. The results show the importance of aiming immunization messages at parents and physicians of 12- to 18-month-old children. The rapid survey approach offers public health agencies an efficient means of assessing community health problems and targeting programs according to need.

KEY WORDS: child; Hispanic; immunization; compliance; rapid survey.

INTRODUCTION

The Childhood Immunization Initiative was launched by the U.S. Public Health Service in 1993. Among its principle goals were (1) eliminating indigenous cases of six vaccine-preventable diseases [diphtheria, poliomyelitis, measles, rubella, *H. influenzae* (Hib) disease among children under 5 years of age and tetanus among children under 15 years of age] by 1996 and (2) increasing vaccination coverage levels to at least 90% among 2-year-old children for each of the routinely recommended vaccinations (by 1996, three or four doses of diphtheria-pertussis-tetanus, three or four doses of Hib, three doses of polio, and one dose of measles-mumps-rubella; by 1998, three

doses of hepatitis B) (1). Although 1993 data for the United States indicated that the incidence of most vaccine-preventable diseases was at or near the lowest reported levels, it was recognized that high vaccination levels among children aged 0-2 years were needed to prevent the resurgence of these diseases. The threat posed by inadequate vaccination coverage had been demonstrated by the resurgence of measles during 1989-1991 with 55,000 cases, 11,000 hospitalizations, and 130 deaths, attributed mainly to delays in vaccination of children (1).

In recognition of the importance of a comprehensive national program to overcome unacceptably low vaccination levels in many parts of the United States, the Childhood Immunization Initiative was charged with six broad areas of activity: improve quality and quantity of vaccination-delivery services; increase community participation and education; reduce vaccine costs for parents; improve surveillance for coverage and disease; form and strengthen partnerships among vaccination providers; and improve vaccines with an emphasis on safer, more effective,

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and combined vaccines permitting simplified vaccination schedules (1).

Charged with improving immunization coverage among 0–2 year olds, the Kern County Health Department required baseline data to develop an effective plan of action. In collaboration with the UCLA Department of Epidemiology, the Kern County Health Department conducted a survey to ascertain the immunization status of the 0- to 2-year-old population in selected communities of Kern County, California, and identify reasons for noncompliance with immunization requirements. To ensure that the study did not systematically select for participants of greater residential stability, we made use of rapid survey techniques developed for efficient assessment of community health status. These techniques offer a convenient and cost-efficient means of estimating vaccination coverage among current residents of selected communities (2–4). The rapid survey methodology used for this study was based on the World Health Organization (WHO) Expanded Program on Immunization (EPI) recommended sampling procedure: a two-stage cluster sample in which the clusters comprise conveniently defined population subdivisions (2).

METHODS

Census block groups of the cities of Bakersfield, Lamont, and Delano defined the cluster sampling frame. Clusters were selected at random with a selection probability proportional to the estimated number of 0–2 year olds residing in the block group; population estimates were derived from 1990 U.S. census data. Ninety clusters were selected for the Bakersfield survey and 30 clusters were selected for each of the two smaller populations of Lamont, a community of recent migrants from Mexico, and Delano, a community comprised largely of Mexican-American and Filipino farmworkers. According to 1990 U.S. Census data, the population count for children 2 years of age and younger was 10,413 in Bakersfield, 1470 in Delano, and 828 in Lamont.

Start points for each cluster were selected at random from block group maps. Trained interviewers began each cluster at the predetermined start point address and proceeded to the next nearest household within that cluster until six interviews were completed. Eligible households consisted of all housing units in which any child between 2 and 35 months of age resided. If the last household visited to get the

sixth child for the cluster had more than one eligible child, then all eligible children living at that address were included. Thus the total in a given cluster could have been more than six children. According to standard rapid survey methodology, homes were not revisited if no respondent was available at the first contact. Interviews were conducted at varied times of day and evening, including weekends, to avoid systematic exclusion of households in which all adults are employed.

Immunization history was obtained from the child's immunization card. If no immunization card was available, respondents were asked to recall the child's immunization history for all recommended vaccines. The validity of parent recall of immunizations was evaluated by the Texas Department of Health in a large population-based household survey that randomly sampled Texas children aged 2–24 months (5). Parent recall underestimated immunization coverage in a consistent manner across sociodemographic subgroups. In contrast, exclusion of children whose immunization status could not be verified by provider records overestimated immunization coverage. Use of parent-held immunization records combined with parent recall for children without records resulted in a slight underestimate of vaccine series coverage when provider records were not used to verify recall. The Texas investigators concluded that community surveys based on combined parent-held records and recall provide reasonable estimates for monitoring immunization coverage as well as valid comparisons of coverage across population subgroups (5).

Additional data obtained by questionnaire included reasons for noncompliance, regular place of medical care, ethnicity, household income and parents' age, education, occupation, and presence in the home. Health insurance status was not routinely recorded but lack of insurance was ascertained as a potential reason for noncompliance. Spanish-speaking respondents were interviewed by bilingual interviewers using a Spanish version of the questionnaire. Informed consent was obtained from the responding adults at the time of the interview. Data collection took place in Bakersfield during July through September 1993 and in Delano and Lamont during December 1993 through March 1994.

Data management and basic analysis was done using the EpiInfo 6.0 software package (6), which includes a program that produces the appropriate variance for proportions estimated from cluster sample data. Timely compliance for each vaccine dose

was defined by the childhood immunization schedule currently recommended by the United States Public Health Service (Table I) (7). Overall compliance and compliance for each required vaccine dose were estimated by the proportion immunized, distinguishing whether immunizations were received on time or behind schedule. In addition, the proportion having received zero, one, two, three, or four doses of each type of vaccine was estimated by age groups. Multivariate logistic regression analysis was performed to examine the effects of demographic factors, including the infant's age, ethnicity, household income, mother's age, and parents' education level, on compliance with immunizations. Adjusted odds ratios, comparing the odds of poor compliance across levels of the demographic factors, and the corresponding 95% confidence intervals were estimated using the SUDAAN software package (8), which produces appropriate variance estimates for cluster sample data.

RESULTS

The three surveys yielded completed interviews for 922 children from 807 households. In Bakersfield

5443 households were visited; 510 of these had age-eligible children. Respondents refused or were unable to provide essential information in 58 Bakersfield households, yielding a participation rate of 89%. In Delano, 1307 households were visited; 224 of these had age-eligible children. Respondents refused or were unable to provide essential information in 50 Delano households, yielding a participation rate of 77%. In Lamont, 929 households were visited; 223 of these had age-eligible children. Respondents refused or were unable to provide essential information in 40 Lamont households, yielding a participation rate of 82%. Because infants under 4 months of age must be considered fully compliant on the immunization schedule, whether or not they have been immunized, 62 infants under 4 months of age were excluded from this analysis.

Compliance across subgroups was very similar for the three populations, therefore, the data were combined using the size of the population sampling frame to assign the appropriate weight to each subject. The present analysis includes 860 children from 747 households. Of these households, 651 (87%) contributed one child, 86 (12%) contributed two children, 9 contributed three children, and 1 contributed four children. The informant was the child's mother in 85% of the households, the child's father in 7% of the households, and other relatives in the remaining households. Informants provided documentation of immunization dates from immunization cards for 78% of the 832 children reported to have received one or more vaccine doses. Those with immunization cards were asked if the child had received additional doses that were not recorded; 16% of those with cards recalled unrecorded doses.

Frequency distributions for sociodemographic factors, including age, ethnicity, income, mother's age, and parents' education, are presented in Table II. Over 60% of the children were identified as Hispanic, about one-fourth were non-Hispanic whites, 6% were non-Hispanic blacks, 4% were Filipinos, and 3% were other or mixed ethnicities. Over 40% of the study population fell into the lowest annual household income category of \$10,000 or less, while less than 20% reported annual incomes over \$30,000. The ages of the children's mothers ranged from 15 to 44 years and were approximately evenly distributed across the age groups of 15–24, 25–30, and 31–44 years. Nearly half of the children's mothers had less than 12 years of education, almost 30% were high school graduates, and less than one-fourth had more than 12 years of education. The fathers' education followed a similar

Table I. Recommended Immunization Schedule,^a United States, 1997

Vaccine dose ^b	Acceptable age range (months)
Polio1/DTP1/Hib1	2–3
Polio2/DTP2/Hib2	4–5
DTP3/Hib3 ^c	6–7
Polio3 ^d	12–18 or 6–18
DTP4	15–18
Hib4 ^e	12–15
MMR	12–15

^aEndorsed by the Advisory Committee on Immunization Practices, American Academy of Pediatrics, and American Academy of Family Physicians.

^bDTP, diphtheria, tetanus, pertussis; Hib, *Haemophilus influenzae* B; MMR, measles, mumps, rubella.

^cOf the three available Hib vaccines, the HbOC (HibTITER) and the PRP-T (ActHIB) require dose 3 at 6 months and dose 4 at 12–15 months, while PRP-OMP (PedvaxHIB) requires only three doses, with no dose recommended at 6 months and dose 3 at 12–15 months.

^dIf inactivated vaccine is used for the first two doses, the third dose should be given at 12–18 months of age; if oral poliovirus vaccine is used for the first two doses, the third dose should be given at 6–18 months of age.

Table II. Descriptive Factors Among 4- to 35-Month-Old Children: Kern County, 1993–1994

Factor	<i>n</i>	Percentage
Total	860	100.0
Age		
4–11 mo	242	28.1
12–23 mo	308	35.8
24–35 mo	310	36.0
Ethnicity		
Hispanic	527	61.3
Non-Hispanic white	210	24.4
Non-Hispanic black	54	6.3
Filipino	34	4.0
Other	24	2.8
Missing	11	1.3
Family income		
≤\$10,000	351	40.8
\$11,000–20,000	218	25.3
>\$20,000	248	28.8
Missing	43	5.0
Mother's age		
15–24 yr	307	35.7
25–30 yr	264	30.7
31–44 yr	281	32.7
Missing	8	0.9
Mother's education		
0–11 yr	395	45.9
12	252	29.3
13–23 yr	198	23.0
Missing	15	1.7
Father's education		
0–11 yr	340	39.6
12 yr	245	28.7
13–23 yr	162	19.2
Missing	105	12.4
Child's regular place of medical care		
None	30	3.5
Public clinic	200	23.3
Private doctor/clinic	630	73.3

distribution, except that the proportion with more than 12 years of education was under 20%; however, the father's education level was not reported for 12% of the children. Respondents named a regular place of medical care for 97% of the children; 73% attended a private doctor, clinic, or HMO; 23% attended a public clinic.

Considering all recommended immunizations, 38% of the children had received all doses by the maximum age specified on the United States Public Health Service immunization schedule (see Table I). Thirty-nine percent of the children had been partially immunized, having received one or more required doses but missing others. Five percent of the children had received no immunizations.

Table III displays compliance by vaccine dose. The most consistent on-schedule compliance, ranging from 81 to 83% across progressive doses, was observed for the polio vaccine, for which only three doses are recommended, the third dose having a broad acceptable age range. In contrast, only 57% of the children received the single MMR dose on schedule even though the acceptable age range covers 12–15 months. In general, compliance was best for doses given during the first year of life and worsened progressively for later doses.

Of the four vaccines, the Hib was the least likely to be received on schedule and the most likely to be missed, assuming a four-dose schedule for this vaccine. One of the three available Hib vaccines, the PRP-OMP (PedvaxHIB), requires only three doses, the third of which is recommended at 12–15 months of age, rather than 6 months of age, when the other Hib vaccines require the third dose. Although it was not possible to determine which Hib vaccine was received, only 9 (2.1%) of the 427 19–35 month olds who received a fourth DTP dose received a third Hib dose at the same age. Among the 123 19–35 month olds who had received all four DTP doses on schedule, only 3 (2.4%) received the third Hib dose at 12–15 months of age. Therefore, it was assumed that nearly all of the children required a fourth Hib dose.

Table IV displays the estimated overall compliance by study factors of interest. Stratification by yearly age intervals reveals the most striking trend. The proportion of children who were fully immunized, including doses received on time or behind schedule, declined from 77% among 4–11 month olds to 52% among 12–23-month olds and 43% among 24–35 month olds. During the first year of life, 65% of children received all required vaccine doses on schedule, whereas among 2 year olds, only 20% continued to receive all doses on time. Among 4- to 11-month-old children, just 14% had not received one or more required immunizations, but this proportion rose to 53% among 2 year olds. Compliance among 1 year olds was only slightly better than it was among 2 year olds, revealing a dramatic decline in immunization coverage following early infancy.

The proportion of children who were fully immunized, summing those who were on time and behind schedule, varied little across ethnic groups, ranging from 55 to 58%. The proportion of children immunized on time increased with income, from 28% in families whose yearly income was \$10,000 or less to 44% in families whose yearly income was \$20,000 or more. The proportion of children who were not

Table III. Compliance by Vaccine Dose in 4- to 35-Month-Old Children: Kern County, 1993–1994^a

Vaccine	Received dose						Total, ^b n (missing) ^c
	On schedule		Behind schedule		Missed dose		
	%	95% CI	%	95% CI	%	95% CI	
1st dose							
Polio	82	79–86	9	7–11	5	3–7	860 (31)
DTP	82	78–85	10	7–12	5	3–7	860 (29)
Hib	75	71–79	15	12–17	7	5–9	860 (32)
MMR	57	52–63	17	13–21	21	17–24	528 ^d (12)
2nd dose							
Polio	81	78–84	7	6–10	9	7–12	819 (19)
DTP	73	70–77	15	12–18	10	7–12	820 (17)
Hib	68	64–72	16	13–19	14	11–17	813 (21)
3rd dose							
Polio	83	80–87	3	2–5	12	9–15	548 (11)
DTP	58	54–63	24	19–28	17	13–20	734 (14)
Hib	53	48–57	22	18–26	23	19–27	726 (15)
4th dose							
DTP	53	47–59	9	6–12	36	30–42	444 ^d (4)
Hib	42	37–48	9	6–12	48	42–53	461 (5)

^aCI, confidence interval; DTP, diphtheria, tetanus, pertussis; Hib, *Haemophilus influenzae* B; MMR, measles, mumps, rubella.

^bExcludes children too young to be noncompliant on a given dose.

^cChildren for whom compliance could not be determined due to missing immunization dates.

^d3% (95% CI, 1–5%) received the MMR dose before 11 months of age; 1% (95% CI, 0–3%) received the fourth DTP dose before 11 months of age.

fully immunized decreased with income, from 48% in the lowest income category to 33% in the highest income category. Although very few children did not have a regular source of care, those who did not were more likely than others not to have received any immunizations. Children who attended public clinics were slightly more likely to have missing or late immunizations. Overall compliance with the immunization schedule was better among children whose mothers were older and had 12 or more years of education and among children whose fathers had 13 or more years of education.

Table V displays the total number of doses of each vaccine type among four age groups: 8–11, 19–23, 24–29, and 30–35 months. By 8 months of age, infants should have received two doses of polio vaccine and three doses of DTP and Hib vaccine; by 19 months of age, they should have received three doses of polio vaccine, four doses of DTP and Hib vaccine, and one dose of MMR vaccine. (The 12- to 18-month interval was not examined because each vaccine has a dose due during various ranges of this interval.) Although compliance with the immunization schedule worsened after the first year of age, compliance with the recommended number of doses improved from the second to the third year, particularly for

the DTP and MMR vaccines. Most 2 year olds had received the recommended number of doses for each vaccine type (82% for polio, 81% for MMR, 65% for DTP), except the Hib vaccine, of which slightly less than half had received four doses.

Table VI presents the results of the multivariate logistic regression analysis conducted to identify predictors of poor compliance. Poor compliance was dichotomized in two ways: behind schedule versus on time, comparing children who did not receive all doses by the recommended maximum age to those who did; and incomplete versus complete, comparing children who had not received the recommended number of immunizations for their age to those who had. The multivariate model included age, ethnicity, income, mother’s age, mother’s education level, and father’s education level. Each variable was modeled categorically, and, except for age, for which there were no missing values, each modeled variable included a category for missing values, so that observations with missing values were not deleted from the model. In the multivariate model, age was by far the strongest predictor of poor compliance; 24–35 month olds were nearly nine times more likely to have been immunized behind schedule and nearly five times more likely to have missed immunization doses than

4–11 month olds. Adjusted for income and the other selected factors, ethnicity appeared to be minimally associated with compliance; Hispanics were most likely to be compliant on both outcome measures, while Filipinos were most likely to be behind schedule and non-Hispanic whites were most likely to be incompletely immunized. Children from households with annual incomes of \$10,000 or less were twice as likely to have been immunized behind schedule, while children from households with annual incomes less than \$20,000 were about 1.5 times as likely to have missed immunization doses compared to children from households with higher annual incomes.

There was a moderate increase in poor compliance among children with younger mothers. In the multivariate model, parents' education appeared minimally associated with compliance.

Table VII shows compliance among 19–35 month olds for two immunization series targeted by the CDC National Immunization Survey for this age group (9): the 4:3:1 series (four doses of DTP vaccine, three doses of polio vaccine, and one dose of MMR vaccine) and the 4:3:1:3 series (the 4:3:1 series plus three doses of Hib vaccine). In the Kern County population, 57% were compliant on the 4:3:1 series and 50% were compliant on the 4:3:1:3 series. The

Table IV. Compliance with Immunization in 4- to 35-Month-Old Children: Kern County, 1993–1994^a

	Fully immunized, Doses received. . .				Partially immunized ^b		Not immunized ^b		Total, <i>n</i> (missing) ^c
	On time ^b		Behind schedule ^b		%	95% CI	%	95% CI	
	%	95% CI	%	95% CI					
Total	38	32–41	19	16–22	39	35–42	5	3–6	860 (6)
Age									
4–11 mo	65	59–72	12	7–16	14	9–19	9	5–13	242 (0)
12–23 mo	30	24–37	22	16–27	44	38–50	3	1–6	308 (4)
24–35 mo	20	15–27	23	17–28	53	46–60	3	0–5	310 (2)
Ethnicity									
Hispanic	34	28–39	22	18–26	39	34–44	5	2–7	527 (4)
Non-Hispanic white	41	34–48	14	9–19	39	33–46	4	1–7	210 (2)
Non-Hispanic black	41	28–55	17	8–26	34	23–44	8	0–17	54 (0)
Filipino	33	16–50	24	9–38	42	22–62	2	0–5	34 (0)
Income ^d									
≤\$10,000	28	22–34	24	19–29	43	37–48	5	2–7	351 (2)
\$11,000–20,000	36	27–45	14	9–20	42	33–50	8	3–13	218 (1)
>\$20,000	44	37–52	18	13–23	33	26–40	3	0–6	248 (3)
Child's regular place of care									
None	36	12–59	8	0–16	36	17–55	20	4–37	30 (0)
Public clinic	32	23–42	21	13–28	45	34–56	2	0–4	200 (1)
Private doctor/clinic	37	32–42	19	16–23	38	33–42	5	3–7	630 (5)
Mother's age									
15–24 yr	33	26–39	17	12–21	43	37–49	7	4–11	307 (1)
25–30 yr	37	29–44	23	17–29	36	30–43	3	0–6	264 (3)
31–44 yr	41	33–48	19	14–24	36	29–43	4	1–6	281 (2)
Mother's education									
0–5 yr	27	18–35	29	20–37	43	34–51	5	0–4	175 (0)
6–11 yr	33	25–41	17	12–22	43	36–50	6	2–10	220 (3)
12 yr	40	33–46	20	14–25	36	29–42	5	2–8	252 (0)
≥13 yr	41	32–50	16	10–22	36	28–45	5	0–8	198 (3)
Father's education									
0–5 yr	37	28–46	24	16–32	38	29–46	1	0–2	161 (1)
6–11 yr	33	24–41	20	13–28	38	30–47	9	3–14	180 (0)
12 yr	39	32–46	15	11–20	40	34–47	5	0–8	247 (1)
≥13 yr	44	35–52	20	13–26	33	25–41	3	0–5	165 (2)

^aCI, confidence interval.

^bOn time—all required doses received on schedule; behind schedule—one or more required doses received behind schedule, none missed; partially immunized—one or more required doses received, others missed; not immunized—no required doses received.

^cChildren for whom compliance could not be determined due to missing immunization dates.

^dAnnual household income.

Table V. Number of Doses Received by Age^a and Vaccine in 4- to 35-Month-Old Children: Kern County, 1993–1994^b

	Total doses received									
	0		1		2		3		4	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
8–11 mo (<i>n</i> = 104)										
DTP	6	1–12	10	3–16	10	4–16	73	63–82	1	0–4
Hib	8	2–14	11	4–18	11	4–18	69	58–79	1	0–4
19–23 mo (<i>n</i> = 117)										
Polio	4	0–7	5	0–9	21	13–29	42	34–51	28	20–37
DTP	4	0–9	5	0–10	9	4–14	35	26–43	47	37–56
Hib	7	2–12	8	3–13	11	5–17	26	17–35	48	39–57
MMR	28	19–36	72	64–81	—	—	—	—	—	—
24–29 mo (<i>n</i> = 164)										
Polio	3	0–6	5	0–9	13	7–18	44	35–53	35	26–44
DTP	4	0–8	5	0–10	8	3–13	19	11–27	64	54–73
Hib	5	1–9	10	4–16	14	8–19	20	12–29	51	41–60
MMR	21	14–28	79	72–86	—	—	—	—	—	—
30–35 mo (<i>n</i> = 146)										
Polio	2	0–5	5	1–9	7	3–12	47	37–57	38	29–48
DTP	2	0–5	5	1–8	6	2–10	21	14–29	66	57–75
Hib	3	0–7	13	6–20	7	3–12	32	24–41	44	34–54
MMR	17	10–23	83	77–90	—	—	—	—	—	—

^aRecommended doses by age group: 8–11 months—two doses of polio, three doses of DTP and Hib; 19–35 months—three doses of polio, four doses of DTP and Hib, one dose of MMR.

^bCI, confidence interval.

strongest predictor of compliance with these series in the 19- to 35-month-old age group was age; 24–35 month olds were about twice as likely to be compliant on either series compared to 19–23 month olds. Compliance with both series was somewhat better among Hispanics after adjusting for other factors. Income appeared to be minimally related to compliance with these series.

The most frequent reason given by parents for noncompliance with the immunization schedule was that the child was sick at the time the immunization was to be received (Table VIII). Other common reasons include procrastination or forgetfulness, lack of awareness of recommendations, lack of access to services, and inappropriate advice from health care providers. The relative importance of reasons given for noncompliance was similar for children who had been immunized behind schedule and those who had missed one or more recommended doses, although missing doses were more often attributed to financial constraints or lack of health insurance as well as a variety of conflicting priorities, such as an inflexible work schedule, child care problems, or family illness. Only four parents stated a belief that immunizations were harmful and just one mentioned a negative reaction to earlier doses.

DISCUSSION

We have described an application of the rapid survey method to the assessment of immunization coverage in a California county. In a brief amount of time for a relatively modest cost, we obtained information needed by health department officials to target efforts at improving immunization coverage. We provided community-specific details in the form of technical reports to the Kern County Health Department within weeks of completing the survey in each community. The rapid survey revealed that compliance with the immunization schedule appeared to be the exception rather than the rule for Kern County children. Only 38% of the children had received all required vaccine doses on schedule, while 44% had not received the recommended number of doses for their age. Compliance worsened dramatically with age. The most extreme example of this occurred with the Hib vaccine: 75% of the children received the first dose on time, however, this proportion dropped to 68% for the second dose, 53% for the third dose, and 42% for the fourth dose. Among 2 year olds in Kern County, 18% had not received at least three doses of polio vaccine, 19% had not been immunized against MMR, 35% had not received the received

four doses of DTP vaccine, and 53% had not received four doses of Hib vaccine. Although the precise coverage levels will vary over time and space, these results show the importance of aiming immunization messages at parents and physicians of 12- to 18-month-old children.

The National Immunization Survey (NIS), implemented by the Centers for Disease Control in April, 1994 as part of the Childhood Immunization Initiative, collects quarterly data to estimate national and state vaccination coverage levels among 19–35 month olds (9). The NIS reports emphasize coverage for the combined series (4:3:1) including four doses of DTP vaccine, three doses of polio vaccine, and one dose of MMR vaccine, given that one of the national health objectives for the year 2000 was series-complete coverage of at least 90% of 2 year olds (9). During the first NIS reporting period of April–December 1994, estimated vaccination coverage lev-

els for the 4:3:1 series were 75% (95% CI, $\pm 1\%$) nationally and 74% (95% CI, $\pm 5\%$) for California (9). In contrast, in the Kern County study population, surveyed during July 1993–March 1994, of the 427 participants who were 19–35 months old, only 57% (95% CI, 51–62%) had received the combined 4:3:1 series.

In terms of the Childhood Immunization Initiative goal that 90% of 2 year olds be protected by at least three doses of DTP, Hib, and polio vaccines and one dose of measles vaccine, the 1994 NIS data showed that coverage already exceeded 90% for the DTP vaccine and ranged from 83 to 89% for the polio, Hib, and measles vaccines (10). Vaccine-specific coverage levels for the same number of doses among Kern County 19–35 month olds were 84% for DTP, 79% for polio and measles, and 74% for Hib. Thus vaccine-specific coverage levels among Kern County 19–35 month olds in 1994 ranged from 6 to 16% below

Table VI. Odds Ratios for Predictors of Poor Compliance in 4- to 35-Month-Old Children from Multivariate Logistic Regression Analysis: Kern County, 1993–1994^a

	<i>n</i>	Compliance on immunization schedule			
		Behind schedules vs on time ^b		Incomplete vs complete ^c	
		OR ^d	95% CI	OR ^d	95% CI
Age					
4–11 mo	239	1.0	Referent	1.0	Referent
12–23 mo	306	5.0	3.2–7.8	3.3	2.1–5.2
24–35 mo	307	8.6	5.4–13	4.9	3.2–7.3
Ethnicity					
Hispanic	523	1.0	Referent	1.0	Referent
Non-Hispanic white	208	1.0	0.6–1.7	1.4	0.9–2.2
Non-Hispanic black	53	1.1	0.6–2.2	1.3	0.7–2.2
Filipino	33	1.6	0.6–4.2	1.2	0.5–2.9
Income^e					
≤\$10,000	349	2.1	1.1–4.0	1.5	0.8–2.6
\$11,000–20,000	215	1.6	0.8–3.0	1.7	1.0–3.1
>\$20,000	246	1.0	Referent	1.0	Referent
Mother's age					
15–24 yr	307	1.6	1.0–2.4	1.5	1.0–2.3
25–30 yr	264	1.5	0.9–2.4	1.0	0.7–1.6
31–44 yr	281	1.0	Referent	1.0	Referent
Mother's education					
0–11 yr	392	1.1	0.7–1.7	1.0	0.6–1.6
≥12 yr	447	1.0	Referent	1.0	Referent
Father's education					
0–12 yr	586	0.9	0.4–1.3	1.2	0.7–1.9
≥13 yr	163	1.0	Referent	1.0	Referent

^aOR, odds ratio; CI, confidence interval.

^bChildren who did not receive all doses by the required maximum age versus those who did.

^cChildren who had not received the required number of doses for their age versus those who had.

^dAdjusted for all listed variables in a multivariate model that included 852 children; ethnicity, income, mother's education, and father's education had "other" or "missing" categories not presented.

^eAnnual household income.

Table VII. Compliance with Combined Immunization Series by Selected Study Factors in 19- to 35-Month-Old Children: Kern County, 1993–1994^a

	n	4:3:1 series ^b		Adjusted		4:3:1:3 series ^c		Adjusted	
		%	95% CI	OR ^d	95% CI	%	95% CI	OR ^d	95% CI
Total	427	57	51–62			50	44–56		
Age									
19–23	117	43	34–52	2.4	1.4–4.2	41	32–50	1.8	1.1–3.1
24–29 mo	164	59	50–69	1.2	0.7–2.1	52	42–62	1.1	0.6–2.0
30–35 mo	146	65	56–74	1.0	Referent	57	48–67	1.0	Referent
Ethnicity									
Hispanic	270	58	50–65	1.0	Referent	50	42–57	1.0	Referent
Non-Hispanic white	99	53	43–64	1.5	0.9–2.6	51	41–61	1.3	0.7–2.1
Non-Hispanic black	19	49	27–70	1.5	0.5–4.4	42	22–63	1.2	0.4–3.3
Filipino	19	49	27–70	1.7	0.7–4.5	49	27–70	1.4	0.5–3.9
Income ^e									
≤\$10,000	170	56	48–64	0.9	0.4–2.1	46	37–54	1.3	0.6–2.9
\$11,000–20,000	109	51	38–64	1.2	0.5–2.6	47	34–59	1.2	0.6–2.7
>\$20,000	130	60	49–71	1.0	Referent	56	45–68	1.0	Referent

^aOR, odds ratio; CI, confidence interval.

^bFour or more doses of DTP, three or more doses of polio, one or more dose of MMR.

^cFour or more doses of DTP, three or more doses of polio, one or more dose of MMR, three or more doses of Hib.

^dFrom multivariate model including age, ethnicity, income, mother’s age, mother’s education, and father’s age.

^eAnnual household income.

the target level for 1996, a goal that feasibly could be achieved by aiming efforts at improved immunization coverage among 12- to 18-month-old children. NIS data since 1994 show increasing gains in immunization coverage nationwide across socioeconomic levels (11, 12). However, national coverage levels for the fourth DTP dose, which must be administered during the child’s second year, have not improved since 1996, and coverage for the more recently introduced hepatitis B and varicella vaccines are lagging behind (13).

The rapid survey design makes use of census data as a starting point for the first-stage sampling of clusters based on the distribution of the population targeted for inclusion. Although the actual distribution of the target population may differ from the census, the second-stage household sampling of the rapid survey approach permits inclusion of current residents of selected clusters whether or not they have been counted in the census. This offers an advantage over the simple random sample, which selects study participants from an existing population register. The rapid survey method was originally designed for developing country settings with population data sources that are often less accurate than United States census data. Field studies and computer simulations have shown the two-stage rapid sampling approach to be robust in yielding reason-

able estimates of population parameters (2). A disadvantage of the rapid survey is that it may select for families that spend more time at home; we tried to minimize this limitation by conducting interviews at varied times, including evenings and weekends.

The most frequent justification for late or missing immunizations, cited by over one-third of non-compliant parents, was illness in the child, though it is not clear how frequently the judgment that the child was too ill to be immunized was made by the parent or a doctor. Some parents may have given this reason as a socially acceptable justification for noncompliance. In other cases it may reflect a lack of continuity in preventive health care involving missed opportunities for immunizations and/or failure to immunize children as soon as possible after an illness. Notable proportions of parents were unaware of immunization requirements, misinformed by providers, subject to scheduling errors, or unable to get appointments, and in some cases, children were immunized before the recommended minimum age; this pattern further suggests lack of consistent follow-up of children by preventive health-care providers. Nearly all children in this study had a regular place of health care, however, we did not ascertain residential stability or stability in attending one place of care, thus the extent to which the mobility of children among providers may contribute to this problem is not clear.

Socioeconomic barriers including financial constraints, lack of health insurance, and lack of transportation were mentioned as impediments to compliance by close to 20% of the parents whose children were not completely immunized. In addition, children from households with low incomes were least likely to be immunized on schedule. At the same time, less than half of the children from households in the highest income category were immunized on schedule and more than one-third had not been fully immunized. A considerable proportion of parents acknowledged lack of resolve or forgetfulness as the primary reason for noncompliance. Thus an important determinant of poor compliance was failure of parents to consider the timely immunization of their children among their essential priorities, due to either lack of knowledge or determination. Most parents saw to it that the very first vaccine doses were received on time, but this concern appeared to diminish drastically by the child's second year.

The frequent occurrence of poor compliance observed in Kern County appears to be due largely to lack of continuity in active follow-up of children for preventive health care across socioeconomic levels, including failure to inform parents adequately of immunization requirements and support them in making timely immunization of their children an essential priority. Efforts to improve compliance must be directed at emphasizing to providers and parents the impor-

tance of timely immunization, not only during the first months of life, but into the second year as well.

ACKNOWLEDGMENTS

This project was funded by the State of California using federal Immunization Action Plan funds. The authors thank Gavin Welch of the Kern County Health Department for inviting them to conduct this study using rapid survey methodology. The authors acknowledge the following students of the UCLA Department of Epidemiology for their assistance in conducting this survey: Maxwell Hechter, Wendy McKelvey, Nicole Alexopoulos, Sergio Angulo, Amisha Gupta, Julia Hsu, Wendy Lin, and Michael Marger.

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Table VIII. Most Frequent Reasons^a Mentioned by Parents of 4- to 35-Month-Old Infants for Noncompliance with Immunization Recommendations: Kern County, 1993–1994

	One or more doses			
	Missed (n = 376)		Received late (n = 182)	
	n	% ^b	n	% ^c
Child was sick	136	36	63	35
Procrastination/ forgetfulness	55	15	19	10
Couldn't afford/ no insurance	50	13	6	3
Unaware of re- commendations	43	11	25	14
Followed provider's advice	34	9	20	11
Lacked transportation	17	5	7	4

^aMultiple reasons could be mentioned.

^bPercentage of 376 children who missed one or more doses and whose parent mentioned this reason.

^cPercentage of 182 children who received one more more doses behind schedule but did not miss any doses and whose parent mentioned this reason.