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Prevalence and Predictors of Immunization Among Inner-City Infants: A Birth Cohort Study

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ABSTRACT. *Context.* Although the proportion of US children who are appropriately immunized increased dramatically in the past decade, rates remain suboptimal among low-income, inner-city youth. Timely initiation of immunization is an important predictor of immunization status later in childhood; however, prospective studies identifying predictors of initiation are lacking.

Objectives. The objectives of this study were to: 1) describe immunization patterns in a cohort of infants born to predominantly low-income, inner-city mothers; 2) identify determinants, as measured at birth, of immunization status at 3 and 7 months of age; and 3) identify determinants of continuation of immunization among those who initiate immunization by 3 months of age.

Design. Prospective, birth cohort study.

Methods. Maternal/infant dyads were systematically selected from 3 District of Columbia hospitals between August 1995 and September 1996. Three hundred sixty-nine mothers were interviewed shortly after delivery, at 3 to 7 months postpartum, and at 7 to 12 months postpartum. Medical records were reviewed at all reported sites of care for 324 (88%) infants. Vaccinations assessed included diphtheria, tetanus, and pertussis; polio; and *Haemophilus influenzae* type B. Multivariate logistic regression analyses were used to determine factors associated with immunization status of infants at 3 and 7 months of age.

Results. At 3 months of age, 75% of infants were up-to-date (UTD) versus only 41% at 7 months. In adjusted analyses, baseline factors associated with being UTD at 3 months included enrollment in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) during pregnancy, intention to breastfeed, and presence of the infant's grandmother in the household. Infants were less likely to be UTD if their mothers perceived higher barriers to immunization. Baseline factors associated with being UTD at 7 months included lower birth order and maternal employment. Among the subset of infants who were UTD at 3 months, only 53% remained UTD at 7 months. Factors measured at the first follow-up interview that were associated with continuation of immunization at 7 months included maternal employment and lower perceived barriers.

Conclusions. Immunization rates during the first 7 months of life were low in this inner-city population. Factors associated with immunization status that are potentially amenable to change included perceived barriers to immunization and enrollment in WIC during pregnancy. *Pediatrics* 2001;108:661–670; immunizations, cohort studies, infant, vaccination, risk factors.

ABBREVIATIONS. UTD, up-to-date; DTP, diphtheria, tetanus, and pertussis; Hib, *Haemophilus influenzae* type B; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children; OR, odds ratio; CI, confidence interval.

In the United States, although immunization rates in early childhood are currently at record or near-record high levels, rates remain low in many urban areas.^{1–3} A recent report by the Institute of Medicine emphasized the need to address disparities in vaccine coverage between low-income groups and the general population.⁴ Importantly, these low rates of immunization not only leave many young children at high risk for a variety of serious, vaccine-preventable diseases but underimmunization also serves as an indicator of inadequate receipt of other preventive health care.^{5,6}

There seems to be no single cause for these low immunization rates, but rather a group of possible factors including provider practices, parental/child characteristics, and system barriers to receiving care. Studies have emphasized the importance of minimizing “missed opportunities,” ie, visits to a health care provider where an immunization could have been appropriately given but was not.^{6–12} Other research has focused on identifying parental and child characteristics associated with underimmunization to allow appropriate targeting of interventions.^{13–23} Several studies have identified delayed receipt of the initial 2-month vaccinations as a strong risk factor for lack of age-appropriate immunization at 2 years.^{14–18} However, only 1 prospective study has sought to identify behavioral attributes predictive of initiation of immunization.¹³

The primary objective of this study was to identify determinants of immunization status using a prospective study design. Specifically, we sought to 1) describe immunization patterns in a cohort of infants born to predominantly low income, inner-city mothers; 2) identify determinants, as measured at birth, of immunization status at 3 and 7 months of age; and 3) identify determinants of continuation of immunization (up-to-date [UTD] at 7 months) among the sub-

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set of children who initiate vaccination appropriately.

METHODS

The study was approved by the institutional review boards of all participating study sites and collaborating institutions.

Study Sample

Mothers of singleton births were recruited shortly after delivery from 3 hospitals in the District of Columbia. Two of the selected hospitals had a high prevalence of low-income patients, and enrollment at the third site was limited to nonprivate patients (patients cared for by staff physicians) to capture a sample of low-income, inner-city patients. Eligibility criteria included residency in the District of Columbia and the ability to speak and understand either English or Spanish. Infants were excluded if they had birth weights <1800 g, had major congenital malformations, or were not placed in the mother's care on discharge from the hospital (eg, placed in foster care or transferred to a long-term care facility). Infants whose mothers were incarcerated at the time of delivery were also excluded. Mothers were enrolled between August 1995 and September 1996. Recruitment days were chosen systematically to ensure a representative sample of weekend and midweek sample days. Sampling was for a 24-hour period on the selected days. Mothers approached for enrollment in the study were given a layette set. Additionally, those who completed follow-up interviews were given \$25 for each interview. Signed informed consent was obtained from mothers before enrollment in the study.

Interviews

The study included one interview of the mother shortly after delivery (hereafter referred to as the baseline interview), a second interview when the infant was between the ages of 3 and 7 months, and a final interview when the infant was between the ages of 7 and 12 months. Baseline interviews were conducted by trained research assistants and included a face-to-face interview and a short self-administered questionnaire. The face-to-face interview included questions about sociodemographic and psychosocial factors, such as social support and health behaviors, described in detail below. The self-administered questionnaire contained potentially sensitive questions about the wantedness of the pregnancy, maternal depression, persons in the home with drug or alcohol problems, and violence in the home. Information about infant birth weight, gestational age, infant gender, type of delivery, parity, maternal smoking, and maternal drug use during pregnancy was abstracted from delivery/newborn hospital records. Most interviews (92%) were conducted in the hospital during the postpartum stay.

The 2 subsequent interviews gathered information about the home and social environment, the influence of health care providers, and selected psychosocial factors. Additionally, at each follow-up interview mothers were asked to recall all health care visits from birth to the time of the interview, including well child care visits, sick visits, hospitalizations, and visits to emergency departments. Mothers were asked to provide the site of the visit, the name of the provider, and immunizations received. Research assistants recorded whether the mother referred to an immunization record during the interview. Although most interviews were face-to-face, 28 (7%) of the first follow-up interviews and 38 (10%) of the second follow-up interviews were conducted by telephone at the mother's request or because of scheduling difficulties.

Interviewers did not have access to previous interviews at the time they conducted the follow-up interviews. To determine whether participation in the baseline interview influenced immunization rates, 65 infants were systemically assigned to a secondary cohort and did not receive the baseline interview but were contacted for the 2 follow-up interviews. There were no significant differences in immunization rates between the 2 cohorts, thus reported results are for the primary cohort.

Verification of Immunization Data

Immunization outcomes were based on vaccinations recorded in the infants' medical records. Permission to review the infants' medical records was obtained from the infants' mothers. Immu-

nizations documented on either an immunization screening sheet or in the clinicians' documentation of the visit were recorded. Maternal/infant dyads were included in analyses if all reported sites of health care could be located and the infants' medical records could be found at each of the sites. Also included were 15 infants for whom the only missing records were for reported sick visits, visits to subspecialty clinics or emergency departments, or visits that occurred when the infant was ≤ 6 weeks of age. None of these infants were reported as receiving any vaccinations, other than hepatitis B, in these visits. As described below, hepatitis B vaccinations were not included in our outcome.

Immunization Status

In 1996, recommended childhood immunizations included diphtheria-tetanus-pertussis (DTP) vaccinations at 2, 4, and 6 months of age, polio vaccinations at 2 and 4 months with an optional dose at 6 months, and *Haemophilus influenzae* type B (HIB) conjugate vaccinations at 2, 4, and 6 months for all formulations with the exception of the HIB-Meningococcal protein conjugate vaccine for which 2 primary doses were recommended.^{24,25} Although hepatitis B vaccine was also recommended, in our study 97% of infants received the first dose in the hospital and thus immunization with hepatitis reflected hospital practices rather than immunization practices outside of the hospital, the topic of the current analysis. Immunization status was measured 1 month after the recommended age of vaccination. Thus, a child was considered to be UTD at 3 months if 1 DTP, 1 HIB, and 1 polio vaccination had been administered before 92 days; at 5 months if 2 DTP, 2 HIB, and 2 polio vaccinations had been administered before 152 days; and at 7 months if 3 DTP, 3 HIB, and 2 polio vaccinations had been administered before 213 days of age. Data were often not available about the specific type of HIB vaccine. Because of the potential for children to be UTD at 7 months with only 2 HIB vaccinations, data were also analyzed using a 7-month outcome of 3 DTP, 2 HIB, and 2 polio vaccinations by 213 days. This approach resulted in the addition of only 3 children to the UTD group and had no substantive effect on study findings. Thus, only analyses using the outcome of 3 DTP, 3 HIB, and 2 polio vaccinations by 213 days are reported.

Development and Measurement of Psychosocial Constructs

A number of social learning theory variables were hypothesized to impact on immunization outcomes including internal locus of control, perceived benefits of immunization, perceived barriers, previous experiences, self efficacy for obtaining immunizations, perceived social norms, and social support. The internal locus of control scale assessed internal versus external reliance with items such as "it is my responsibility to make sure my baby gets routine check ups."²⁶ To assess perceived benefits of immunizations respondents were asked "Do you think baby shots would keep (baby's name) from getting ... polio, whooping cough, measles, colds, colic, diarrhea, tetanus, hepatitis." Perceived barriers and previous experiences were asked only of mothers with previous experiences with well child care. Examples of questions in the barriers scale include "it was too expensive"; "I had trouble getting off work"; and "it was hard to arrange transportation." Previous experiences included statements such as "the waiting rooms were crowded and uncomfortable"; "doctors and nurses really cared about my baby"; and "I was satisfied with the clinic." The self efficacy scale assessed mothers' confidence in their ability to obtain routine care for their infant, including scheduling, arranging transportation, getting to the appointment on time, and rescheduling an appointment if necessary. Perceived social norms included statements about the expectations of medical providers, friends, and relatives regarding routine medical checkups for the infant. The social support scale included items asking how often someone would be available to help with medical appointments for the infant.

Scale scores were computed by taking the mean of the responses to items in the scale. If more than one third of responses in a given scale were missing or answered "don't know" the observation was eliminated. The scores were divided into tertiles with about a third of respondents in each group, low, medium, and high and then treated as ordinal variables as described below.

Analyses

It was estimated that a sample size of 335 dyads would be sufficient to identify a twofold increased risk of underimmunization in the high risk group. This calculation was based on the following assumptions: 20% prevalence of the risk factor in the population; 20% incidence of the outcome in the total population; comparisons evaluated at $P < .05$ (2-tailed); power ≥ 0.8 . Anticipating overall retention of 80%, we sought to enroll 420 dyads at baseline.

In unadjusted analyses, associations between independent variables and outcome variables were assessed using χ^2 or Fisher's exact tests for categorical variables, the χ^2 test for trend for ordinal variables, and the Student's t test for continuous variables. Factors significantly associated with the outcome at $P < .10$ in bivariate analyses were introduced into multivariate logistic regression models to determine the independent predictive effects of these factors. A backward elimination algorithm, with an exit P value of $< .05$, was used to select variables having an independent contribution to the model. Statistical tests were interpreted in a 2-tailed fashion to estimate P values. Baseline data about maternal drug use were missing for 25% of the observations and maternal drug use was not a significant predictor of immunization status in the initial multivariate models. Thus, final logistic models were rerun omitting maternal drug use.

RESULTS

Study Population

Of the 1802 infants born on sampled days, 583 were eligible for enrollment in the study. The most common reasons for ineligibility were residency outside the District of Columbia ($N = 704$), being a private patient at site C ($N = 373$), and birth weight < 1800 g ($N = 91$). Five hundred eighteen mothers were assigned to the primary cohort, 452 (87%) of whom were enrolled in the study and interviewed at baseline. Based on information abstracted from medical records, eligible maternal-infant dyads enrolled in the study did not differ significantly from those not enrolled with respect to race, age, marital status, type of insurance, maternal employment status, type of delivery, birth weight, gestational age at delivery, or infant gender. Of the 452 mothers interviewed at baseline, 370 (82%) completed both follow-up interviews. Among those with all 3 interviews, 1 dyad was excluded because the infant did not reside with the mother. No significant differences were found in any of the aforementioned characteristics when comparing mothers who completed all 3 interviews versus those who did not complete all interviews.

For the 369 mothers who lived with their infants and completed all follow-up interviews, a total of 3189 medical visits to 68 different providers were reported. According to maternal report, 66% of children had seen 1 primary care provider, 30% had seen 2, and 4% had seen 3 or more (excluding sick visits and visits to emergency departments and subspecialty clinics). Research assistants were able to locate the infants' medical records at all reported sites of care for 324 (88%) of the infants for whom we had all 3 maternal interviews. Data from these 324 infants are reported below.

Mothers were predominantly black (84%), single (71%), and over 20 years of age (78%; Table 1). Sixty-five percent of mothers reported household incomes below the federal poverty level.²⁷ The majority of mothers were not employed during the 12 months

TABLE 1. Characteristics of Mothers and Infants Enrolled in the Study

Characteristic	Number (%) [*] ($N = 324$)
Mother	
Race	
Black	271 (84)
Other	51 (16)
Ethnicity	
Hispanic	62 (19)
Non-Hispanic	262 (81)
Marital status [†]	
Married	94 (29)
Single	229 (71)
Age	
< 20 y	72 (22)
≥ 20 y	252 (78)
Income	
Below poverty [‡]	211 (65)
Above poverty	99 (31)
Employment	
Working	119 (37)
Not working/student	202 (62)
Education	
< 12 years	145 (45)
≥ 12 years	179 (55)
Infant	
Gender	
Male	163 (50)
Female	161 (50)
Birth weight	
1800–2499 g	35 (11)
≥ 2500 g	288 (89)
Gestational age	
< 37 weeks	35 (11)
≥ 37 weeks	269 (83)
Delivery mode	
Caesarian section	75 (23)
Vaginal	244 (75)

^{*} Columns do not total 100% because of missing values.

[†] Respondents living with someone as if they were married are included in the married category.

[‡] Poverty based on family income and size as outlined in the 1996 Health and Human Services Poverty Guidelines.²⁷

preceding delivery, and 45% had less than a high school education.

Baseline Intentions and Knowledge Regarding Childhood Immunizations

When queried at baseline, 98% of mothers reported that immunizing their infant was very important and 100% reported that they intended to take their infant somewhere for check-ups. Ninety-seven percent said they would be very concerned if their child did not get a routine checkup by 3 months of age, and 88% reported that they knew how to make an appointment for well child care. To measure knowledge about immunizations, mothers were asked if they thought immunizations would prevent a variety of vaccine preventable diseases and general conditions. Most mothers answered that vaccines would prevent polio (93%), hepatitis (90%), measles (88%), and tetanus (77%). About a third of mothers thought that vaccines would prevent colds and colic (34% and 27%, respectively). Eighteen percent thought that vaccines would prevent diarrhea.

Immunization Rates

At 92 days of age, 75% of infants had received the combination of 1 DTP, 1 HIB, and 1 polio vaccination

TABLE 2. Immunization Status at 3, 5, and 7 Months of Age (N = 324)

Vaccine	3 Months (92 Days) n (%)	5 Months (152 Days) n (%)	7 Months (213 Days) n (%)
Polio			
0	80 (25)	36 (11)	23 (7)
1	241 (74)	109 (34)	61 (19)
2	3 (<1)	175 (54)	137 (42)
3	0	4 (1)	100 (31)
4	0	0	3 (<1)
HIB			
0	78 (24)	34 (10)	23 (7)
1	243 (75)	111 (34)	58 (18)
2	3 (<1)	175 (54)	108 (33)
3	0	4 (1)	131 (40)
4	0	0	4 (1)
DTP			
0	79 (24)	34 (10)	23 (7)
1	242 (75)	111 (34)	58 (18)
2	3 (<1)	175 (54)	107 (33)
3	0	4 (1)	133 (41)
4	0	0	3 (<1)
Combinations*			
1 DTP, 1 HIB, and 1 Polio	243 (75)	288 (89)	301 (93)
2 DTP, 2 HIB, and 2 Polio	2 (<1)	176 (54)	240 (74)
3 DTP, 3 HIB, and 2 Polio	0 (0)	4 (1)	132 (41)

* Each combination includes the number of children who have a minimum of the listed vaccines.

(Table 2). At 152 days, 54% of infants had received 2 DTP, 2 HIB, and 2 polio vaccinations, and at 213 days 41% of infants had received 3 DTP, 3 HIB, and 2 polio vaccinations. At 213 days of age, 23 infants (7%) had received no immunizations while only 4 infants (1%) were overimmunized.

Baseline Predictors of Immunization Status at 3 Months

In unadjusted analyses, baseline factors significantly associated ($P < .05$) with being UTD at 3 months included lower birth order, maternal intention to breastfeed, and participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) during pregnancy (Table 3). Additionally, among the subset of mothers who had previously cared for another infant, perceived barriers to immunization was inversely related to immunization status.

In adjusted analyses, infants were more likely to be UTD if their mothers had participated in WIC during pregnancy (odds ratio [OR], 1.97; 95% confidence interval [CI]: 1.13–3.42), if the grandmother was present in the household (OR, 2.23; 95% CI: 1.11–4.48), or if the mother intended to breastfeed (OR, 1.81; 95% CI: 1.02–3.22). Among the subset of mothers who had previously cared for another child, infants born to mothers who perceived high or medium barriers to immunization were less than half as likely to be UTD compared with infants of mothers who perceived low barriers (high vs low barriers: OR, 0.34; 95% CI: 0.14–0.78; medium vs low barriers: OR, 0.37; 95% CI: 0.16–0.87). In this subanalysis, participation in WIC and intention to breastfeed were also significantly associated with immunization status (OR, 2.09; 95% CI: 1.04–4.18 and OR, 2.94; 95% CI: 1.41–6.17, respectively).

Baseline Predictors of Immunization Status at 7 Months

Baseline factors significantly associated with being UTD at 7 months included maternal employment,

lower birth order, intention to use a nonprone infant sleep position, and participation in WIC (Table 3). Infants were significantly less likely to be UTD if the infant's birth weight was between 1800 and 2499 g, maternal drug use was documented in the medical record, or the mother reported that someone in the household had a drug problem.

In adjusted analyses, birth order and maternal employment remained significant baseline predictors of immunization status at 7 months. The odds of being UTD declined by an average of 30% with each subsequent birth (OR, 0.70; 95% CI: 0.57–0.87) and infants born to mothers who were employed were almost twice as likely to be UTD (OR, 1.91; 95% CI: 1.15–3.19).

Predictors of Continuation

Among the 243 infants who were UTD at 3 months, only 53% remained UTD at 7 months. Because early health care visits represent additional points of contact for preventive actions we sought to identify factors that predict continuation of immunization. In unadjusted analyses, factors positively associated with continuation of immunization included maternal employment and lower birth order (Table 4). Infants with birth weights between 1800 and 2499 g were less likely to remain UTD, as were infants who resided in a home with a smoker. When measured at the first follow-up interview, perceived self efficacy (ie, confidence in ability to obtain appropriate immunizations for the child) was directly associated with immunization status whereas perceived barriers to immunization was inversely related to immunization status.

In adjusted analyses, lower birth order, maternal employment, and low perceived barriers were significant predictors of continuation of immunization. Infants were more than twice as likely to remain UTD at 7 months if the mother was employed at the time of the first follow-up interview (OR, 2.50; 95%

TABLE 3. Associations Between Baseline (Postpartum) Characteristics and Immunization Status at 3 and 7 Months of Age

Characteristic*	Number (N = 324)	3 Months % UTD	P Value†	7 Months % UTD	P Value‡
Sociodemographic					
Race					
Black	271	74	.32	39	.29
Other	51	80		47	
Maternal age					
<20 y	72	78	.54	38	.53
≥20 y	252	74		42	
Marital status‡					
Single	229	73	.31	39	.33
Married	94	79		45	
Household income					
Below poverty§	211	76	.84	38	.08
Above poverty	99	75		48	
Insurance					
Private	34	76	.86	44	.60
Medicaid	202	73		42	
Uninsured	56	77		41	
Other	16	81		25	
Maternal education					
<12 years	145	74	.85	38	.35
≥12 years	179	75		43	
Maternal employment					
Employed	119	80	.11	50	<.01
Not employed	202	72		35	
Birth order					
First born	113	82	<.01	49	<.01
Second born	74	77		50	
Third born	53	77		26	
Later born	83	61		30	
Birthweight					
1800–2499 grams	35	69	.33	23	.02
≥2500 grams	288	76		43	
Maternal health behaviors/intentions					
Maternal smoking					
Yes	69	68	.10	32	.11
No	229	78		43	
Maternal drug use					
Yes	45	62	.06	22	.03
No	197	76		39	
Initiation of prenatal care					
≥4 months gestation	108	77	.59	36	.23
<4 months gestation	216	74		43	
Intent to breastfeed					
Yes	145	80	.05	45	.15
No	176	70		37	
Intended infant sleep position					
Prone	111	71	.35	32	.02
Nonprone	200	76		46	
Home environment					
Grandmother in home					
Yes	85	82	.07	36	.35
No	239	72		42	
Someone in home with a drug problem					
Yes	20	80	.59	20	.05
No	300	75		42	
Mom or infant ever threatened					
Yes	38	63	.08	32	.24
No	284	76		42	
Wanted pregnancy					
Yes	219	78	.08	43	.11
No	100	69		34	
Influence of healthcare providers					
Discussed first shot with doctor or nurse before baseline interview					
Yes	90	73	.67	41	.93
No	234	76		41	
Discussed first shot with doctor or nurse before discharge from the hospital					
Yes	290	75	.61	40	.60
No	31	71		45	
WIC during pregnancy					
Yes	189	81	<.01	46	.02
No	135	67		33	

TABLE 3. Continued

Characteristic*	Number (N = 324)	3 Months % UTD	P Value†	7 Months % UTD	P Value‡
Provider type					
Private	86	73	.84	42	.26
Hospital	94	74		34	
Clinic	62	79		50	
Mixed	79	77		42	
Psychosocial					
Self efficacy (7, .60)					
Low	98	70	.19	40	.57
Medium	93	75		38	
High	132	78		43	
Perceived social norms (6, .77)					
Low	105	74	.66	44	.86
Medium	109	74		37	
High	108	77		43	
Perceived barriers# (11, .72)					
Low	81	79	.04	36	.48
Medium	64	67		39	
High	64	64		30	
Previous experiences# (11, .87)					
Low	64	73	.17	34	.46
Medium	78	76		41	
High	67	63		28	
Social support (3, .72)					
Low	114	71	.11	38	.16
Medium	84	73		36	
High	125	80		46	
Internal locus of control (4, .85)					
Low	111	74	.55	43	.11
Medium	89	82		47	
High	123	71		33	
Benefit of immunization (8, .73)					
Low	76	70	.31	34	.06
Medium	105	77		42	
High	112	77		48	

* Other baseline variables not associated with immunization status include hospital of birth, length of hospital stay, gestational age, other smokers or persons with alcohol problems in the household, number of moves in the 2 years preceding delivery, presence of supportive relatives, presence of supportive friends, maternal alcohol use, pap smear in the 12 months preceding delivery, type of delivery, infant gender, maternal ethnicity, maternal depression, and situational optimism.

† Simple χ^2 for categorical variables, χ^2 test for trend for ordered variables.

‡ Respondents who were "living with someone as if they were married" are included in the married category.

§ Poverty based on family income and size as outlined in the 1996 Health and Human Services Poverty Guidelines.²⁷

|| Information obtained from follow-up interviews.

¶ Number of items in scale, Cronbach's α .

At baseline, barriers and previous experiences were asked only to mothers who had cared for other children.

CI: 1.26–4.93) and the odds of being UTD declined by an average of 22% with each subsequent birth (OR, 0.78; 95% CI: 0.62–0.99). Infants born to mothers who reported high barriers at the first follow-up interview were less than half as likely to remain UTD at 7 months compared with infants of mothers who reported low barriers (OR, 0.44; 95% CI: 0.23–0.82). Results of adjusted analyses are summarized in Table 5.

DISCUSSION

Immunization rates were low in this urban population with only 75% of infants UTD at 3 months and 41% UTD at 7 months. In contrast, estimates from the National Immunization Survey indicate that in the District of Columbia in 1996, 78% of children ages 19 to 35 months were UTD.²⁸ The lower immunization rates reported in our study may be because of the inclusion of a predominantly low-income population. Additionally we measured immunization rates at 3 and 7 months whereas the National Immunization Survey measures rates later in childhood. Rates

of immunization reported in our study are slightly higher than 3 and 7 month rates reported in earlier studies conducted in similar low-income, urban populations.^{13,16,17} These differences probably reflect increases in immunization rates seen nationwide during the 1990s.

Potential Limitations

Strengths of this study include the prospective design, enrollment and follow-up of a high risk population, collection of a strong battery of psychosocial measures, and confirmation of immunization outcomes through chart reviews. However, a number of limitations should be noted. First, in the absence of an immunization registry we relied on maternal report of where the child went for medical care, followed by inspection of medical records at all reported sites of care. Immunization rates could be artificially low if mothers failed to report all sites of care. This method is similar to that used in many studies of childhood immunizations, including the National Immunization Survey, and reports indicate

TABLE 4. Predictors of Immunization at 7 Months Among Those Who Initiated by 3 Months

Characteristic*	Number (N = 243)	% UTD	P Value†
Sociodemographic			
Race			
Black	200	52	.59
Other	41	56	
Maternal age			
<20 y	56	45	.17
≥20 y	187	55	
Household income‡			
Below poverty	177	50	.40
Above poverty	49	57	
Marital status§			
Single	168	51	.48
Married	73	56	
Maternal employment			
Employed	53	68	.01
Not employed	187	48	
Birth weight			
1800–2499 g	24	33	.05
≥2500 g	219	55	
Birth order			
First born	93	58	.03
Second born	57	63	
Third born	41	34	
Later born	51	45	
Home environment			
Grandmother in home			
Yes	64	48	.43
No	179	54	
Smokers in home			
Yes	108	44	.02
No	128	59	
Someone in home with a drug problem			
Yes	7	57	.79
No	231	52	
Someone in home with a drinking problem			
Yes	10	60	.60
No	229	52	
Mom or infant ever threatened			
Yes	22	64	.26
No	217	51	
Influence of healthcare providers			
Discussed first shot with doctor or nurse before discharge from the hospital			
Yes	218	52	.29
No	22	64	
Provider type			
Private	63	57	.26
Hospital	70	44	
Clinic	49	61	
Mixed	61	51	
Participation in WIC			
Yes	216	54	.36
No	27	44	
Psychosocial			
Self efficacy (7, .60)			
Low	55	40	.02
Medium	83	52	
High	103	59	
Perceived social norms (6, .79)			
Low	130	52	.85
Medium	61	52	
High	49	53	
Perceived barriers (11, .65)			
Low	124	59	.01
Medium	45	58	
High	71	39	
Previous experiences (11, .89)			
Low	92	50	.80
Medium	76	58	
High	72	51	

TABLE 4. Continued

Characteristic*	Number (N = 243)	% UTD	P Value†
Social support (3, 0.80)			
Low	53	47	.21
Medium	74	50	
High	116	57	
Internal locus of control (4, 0.86)			
Low	75	47	.22
Medium	68	53	
High	98	56	
Benefit of immunization (8, 0.76)			
Low	81	52	.66
Medium	78	54	
High	74	55	

* Independent variables shown were measured at the first follow-up interview with the following exceptions: maternal race and age were taken from the baseline interview; infant birth order and birthweight were taken from baseline chart abstractions; provider type was based on providers reported in both follow-up interviews. Other variables not associated with continuation of immunization include situational optimism, depression, and whether the pregnancy was wanted.

† Simple χ^2 for categorical variables, χ^2 test for trend for ordered variables.

‡ Poverty based on family income and size as outlined in the 1996 Health and Human Services Poverty Guidelines.²⁷

§ Respondents who were "living with someone as if they were married" are included in the married category.

|| Number of items in scale, Cronbach's α .

TABLE 5. Factors Associated With Immunization Status at 3 and 7 Months: Adjusted Analyses

Characteristic	Adjusted OR*	95% CI
Baseline predictors of being UTD at 3 months		
WIC during pregnancy	1.97	1.13–3.42
Intention to breastfeed	1.81	1.02–3.22
Grandmother in household	2.23	1.11–4.48
Baseline predictors of being UTD at 3 months in mothers who had previously cared for another child		
WIC during pregnancy	2.09	1.04–4.18
Intention to breastfeed	2.94	1.41–6.17
Perceived barriers		
Medium	0.37	0.16–0.87
High	0.34	0.14–0.78
Baseline predictors of being UTD at 7 months		
Maternal employment	1.91	1.15–3.19
Birth order	0.70	0.57–0.87
Factors measured at the first follow-up interview predictive of being UTD at 7 months		
Maternal employment	2.50	1.26–4.93
Birth order	0.78	0.62–0.99
Perceived barriers		
Medium	0.89	0.43–1.85
High	0.44	0.23–0.82

* For each model, the reported odds ratios are adjusted for all other variables shown.

that this method is more accurate than parental recall or reliance on hand-held immunization records.^{29,30} Second, we were able to complete all interviews and verify reported immunizations for 72% of dyads enrolled in the study. We believe that these data are representative of the enrolled study population as baseline characteristics of mothers lost to follow-up were comparable with those of mothers who completed the study. However, our sampling scheme was not population-based as mothers were selected to represent District of Columbia residents of lower socioeconomic status. Although our findings were consistent with results from studies conducted in other urban settings, they may not be generalizable to all inner-city populations.^{13,16,21}

Relation to Other Studies

Initiation of immunization has been identified as a strong predictor of immunization status at ages 2

and 5 years.^{14–18} In the only other prospective study of immunizations in infancy, Bates et al¹³ also found that mothers were more likely to initiate immunization by 3 months if they perceived fewer barriers to immunization and if the infant's grandmother lived in the home. The grandmothers' presence might provide social and practical support, as well as reduced levels of stress in the family.¹³ Of the 11 items that comprised the barriers scale used in our study, lack of health insurance was a factor frequently perceived to be a problem. Interestingly, neither our study nor the study by Bates et al found a relationship between health insurance or socioeconomic status and initiation of immunizations.¹³ Since 1994, the Vaccines for Children program has provided free immunizations to children without health insurance.³¹ However, in our study some mothers still perceived lack of health insurance to be a barrier for obtaining immuniza-

tions, and these perceptions may be the salient force in motivating behavior.³²

With the exception of perceived barriers, we found no associations between health beliefs or other social cognitive variables measured shortly after delivery and immunization status at 3 months, despite considerable effort to carefully measure these psychosocial variables. Indeed, our sample held uniformly favorable beliefs about the benefits of immunization. It is possible that these constructs truly bear no relationship to infant immunizations. Alternatively, the immediate postpartum period may not be an appropriate time to measure expectations, perceptions, and attributions regarding the future.

Sociodemographic factors consistently linked with delays in immunization include poverty and higher birth order.^{3,13–16,18–23} In our study, higher birth order was associated with delayed completion of the primary series, and falling behind despite having received initial immunizations by 3 months of age. Larger numbers of children place competing demands on mothers while time and resources available to provide for the care of each child become more limited. We examined predictors of immunization within a predominately low-income population and this may explain why poverty was not a significant factor in our study. Additionally, we identified no significant differences in immunization rates by the type of facility for primary care. This finding is consistent with data from the National Immunization Study where, among impoverished children ages 19 to 35 months, the percentage of children UTD was comparable for children seen in private practices (76%), health departments (73%), and hospitals (76%).³³ Thus, among low-income families, the type of facility for primary care does not seem to have a large impact on immunization rates.

Other independent predictors of immunization identified in our study include maternal employment, intention to breastfeed, and enrollment in WIC during pregnancy. The positive relationship between maternal employment and infant immunization is consistent with findings from a cross-sectional study conducted in Los Angeles and may reflect immunization requirements for admission to childcare.¹⁶ The association between intention to breastfeed and immunization supports other reports of positive health behaviors grouping together.¹⁹ We are unaware of previous studies that have examined the relationship between receipt of WIC during pregnancy and later immunization outcomes. However, studies have identified a positive relationship between enrollment in WIC during the postnatal period and immunization status.^{16,21} Currently, a number of state WIC agencies are involved in efforts to improve childhood immunizations including assessment and referral, voucher incentives, sending reminders, and providing incentives to parents.^{34,35} However, we identified no programmatic linkages between WIC and childhood immunizations in the District of Columbia during the time frame of our study. Thus, in our study, enrollment in WIC during pregnancy may

serve as a marker for families who are more adept at accessing services.²¹

CONCLUSION

Immunization rates in the first 7 months of life were low in this urban population. Infants born to mothers who were unemployed and infants of higher birth order were at increased risk of underimmunization, and thus, where resources are limited, would be appropriate for targeted interventions. We found no evidence that maternal psychosocial factors, except perceived barriers, were associated with immunization. Alterations in true barriers, such as scheduling inconveniences, lack of childcare, and lack of transportation, and perceived barriers, such as lack of health insurance coverage for immunizations, are warranted. Moreover, the finding that children were more likely to get immunized if the mother had been enrolled in WIC during pregnancy provides additional evidence that the benefits of enrollment in WIC may extend to timely initiation of childhood immunizations.

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