A Population-based Study of Access to Immunization Among Urban Virginia Children Served By Public, Private, and Military Health Care Systems

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ABSTRACT. *Background.* **Pediatric immunization rates have increased in the United States since 1990. Nevertheless, national survey data indicate that up to one third of 2-year-old children in some states and urban areas lack at least one recommended dose of diphtheria–tetanus–pertussis (DTP)-, polio-, or measles-containing vaccines. Immunization has become a key measure of preventive pediatric health care in the United States. To achieve and maintain the national immunization goal that 90% of children receive all recommended immunizations by 2 years of age, the role of the health care system in immunization delivery must be examined. Urban eastern Virginia has a diverse population that obtains immunization services from public, private, and military providers and insurers. At the time of this survey, immunization services in Virginia were available free to all children through public health clinics and to military families when using a military facility.**

Objective. **To examine access to pediatric immunization services and health system factors associated with underimmunization in a representative sample of children at 12 and 24 months of age.**

Methods. **We conducted a household survey in urban eastern Virginia from April through September 1993. A total of 12 770 households in Norfolk and Newport News, VA, were selected for inclusion in the study using probability-proportionate-to-size cluster sampling. Use of probability-proportionate-to-size sampling ensured that children within each city had equal probability of being included in the survey. Selected households were visited by trained interviewers to determine their eligibility, defined as having at least one child 12 to 30 months of age residing in the household. In eligible households, parents were asked to participate in a standardized, 15-minute interview. Survey respondents were asked about household demographics, and for each eligible child, the immunization history, health insurance, the name and location of all immunization providers, the usual immunization provider, and any problems the parent had experienced accessing immunization services with that child. Up-to-date (UTD) immunization status was defined as having all recommended doses of DTP, polio, and measles–mumps–rubella at 12 months (three DTP and two polio immunizations) and 24 months (four DTP, three polio, and one measles–mumps–rubella immunizations). The child's immunization history was assessed from parent and provider records only. Data analysis accounted for the survey's cluster sampling design (ie, within-cluster correlation). Because the immunization rates of the two cities did not differ significantly, unweighted analyses were used for ease of computation. Significance was determined for contingency tables by Wald's χ^2 test.**

Results. **A total of 749 children (91% of eligible households) participated in the survey. Study children were born between October, 1990, and July, 1992. Immunization records were obtained for 705 children (94%). Eighty-seven percent of respondents were mothers, 44% were African-American, 40% of children were military dependents, and 40% were enrolled in the Women, Infants and Children (WIC) program. Sixty-five percent of children were UTD at 12 months and 53% at 24 months. Parents reported that their children's usual immunization providers were private doctors (34%); public health, hospital clinics, or community health centers (32%); and military clinics or a military contract provider (34%). At least one problem accessing immunization services was reported by 35% of respondents, ranging from 29% among those who used a private doctor as their child's usual immunization provider to 46% among those using a military contract provider. Overall, the most commonly reported problem was clinic waiting time (12%), with reports of waiting time as a problem occurring most often among those using the military contract provider (22%) and public health clinics (17%). The second most common problem was difficulty obtaining a timely appointment (10%), with appointment problems ranging from 18% to 24% among those using military facilities compared with 4% to 6% among those using other providers. Some of the other problems reported were taking time away from work, office hours, cost, and transportation, with the frequency varying by type of usual provider.**

Household risk factors for children not being UTD at 12 and 24 months included having a greater number of children, single parenthood, lack of education beyond high school, teenage mother, African-American ethnicity, and not finding the child's immunization record at home. After adjusting for these household factors by multiple logistic regression, the system-related factors significantly associated with not being UTD at 12 months were not being in WIC (odds ratio [OR] = 2.1, 95% confidence interval [CI] 1.4–3.3), having Civilian Health and Medical Program of the Uniformed Services (OR = 5.2; CI: 2.9–9.5) or Medicaid (OR = 2.7; CI: 1.4–5.3) insurance, longer clinic waiting time (for each hour, OR = 1.6; CI: 1.2–2.0), and transportation problems (OR = 2.6; CI: 1.3–5.2); and at 24 months were not being in WIC (OR = 2.0; CI: 1.1–3.7), problems obtaining an appointment (OR = 4.5; CI: 1.8–8.6), and use of a military contract clinic

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(OR = 5.6; CI: 2.6–11.9). Although not all reported problems accessing services were independent risk factors for underimmunization, a dose–response relationship was found between the total number of different reported problems and children not being UTD at 24 months.

Conclusions. **This is the first population-based study of the association between immunization coverage rates and access to public, private, and military health care systems. Overall, one third of parents perceived barriers to pediatric immunization services, and parent-reported problems accessing services had a dose–response association with underimmunization. The most commonly reported problems were long waiting times and difficulty obtaining appointments, but the pattern and magnitude of problems reported differed among public, private, and military services. Despite free immunizations, parents most often reported problems accessing public and military providers. Thus, parents did not necessarily consider cost-free and geographically available pediatric services to be barrier-free. Enrollment in WIC was associated with significantly increased immunization rates, although this study was conducted before linkage of the WIC program with immunization services. This finding suggests the importance of WIC as a point of access to the health care system for vulnerable families. In this population, significant variation in immunization rates was found among health care providers and insurers that was not readily explained by measured population characteristics or parent-reported access barriers, possibly attributable, in part, to differences in provider practices. Population-level measurement of immunization rates and parent perception of services is critical for improving access to, and quality of, immunization services.** ***Pediatrics*** **1998;101(2). URL: http://www.pediatrics.org/cgi/content/full/101/2/e5;** ***immunization, population-based research, access barriers, quality of care.***

ABBREVIATIONS. DTP, diphtheria–tetanus–pertussis; CDC, Centers for Disease Control and Prevention; CHAMPUS, Civilian Health and Medical Program of the Uniformed Services; WIC, Women, Infants and Children Program; AFDC, Aid to Families with Dependent Children; UTD, up to date; MMR, measles–mumps–rubella; OR, odds ratio; CI, confidence interval; HMO, health maintenance organization; Hib, *Haemophilus influenzae* type b; DT, diphtheria–tetanus.

Immunization is the leading preventive health service for children. It is estimated that for every dollar spent on immunization of preschool children with diphtheria–tetanus–pertussis (DTP) vaccine, ~$27 is saved in health care and other costs.[1] The national goal for the year 2000 is to achieve and sustain coverage of at least 90% of 2-year-old children with all recommended immunizations to reduce the cases of most vaccine-preventable diseases to zero.[2] Although national survey data indicate that immunization coverage has increased from the low rates measured during the measles epidemic of 1989 to 1990,[3] a significant proportion of young children remain at risk of serious, vaccine-preventable diseases. According to the 1996 National Immunization Survey of children 19 to 35 months of age, 22% of US children overall, and up to one third of the children in some states and urban areas, lack at least one recommended dose of DTP, polio, or measles-containing vaccines.[4]

Both population and health system factors contribute to the underimmunization of preschool children.[5–23] Population risk factors found to be associated with underimmunization include inner-city residence, African-American ethnicity, multiple-child household, single parenthood, teenage mother, low educational level of the mother, and having Medicaid as the source of health care coverage.[5–18] Although some studies have reported that access barriers to primary care and immunization services, such as lack of transportation, inconvenient clinic locations and hours, long waiting times, restrictive appointment systems, and/or cost of immunization services, contribute to reduced immunization rates,[5,6,9–14,22] others have suggested that access barriers do not explain the low immunization rates found in many populations.[23–25] There is a lack of population-based research that examines the extent to which parents perceive health system access barriers to various types of immunization services and the extent to which health system factors are associated with immunization coverage within a defined geographic area.

In Virginia, a retrospective analysis of 1992 school entry data found that the statewide immunization rate among 2-year-old children was 58%, with children residing in low-income urban areas having a significantly lower immunization rate.[14] In 1993, the Centers for Disease Control and Prevention (CDC) initiated a community-based intervention project in Norfolk and Newport News, two medium-sized, demographically similar port cities in southeastern Virginia. A survey of preschool children residing in randomly selected households was undertaken to establish baseline immunization rates in these cities and to assess the household and health service factors associated with low immunization coverage. This is the first representative, population-based study that examines immunization rates of children in relation to the characteristics of public, private, and military health care systems.

METHODS

Study Design

A survey of households in Norfolk and Newport News, VA, was conducted using cluster sampling methodology that ensured that every household with a child in the target age range had equal probability of selection. Eligibility for inclusion in the survey required having at least one child between 12 and 30 months of age residing in the household. Respondents were adults or adolescents who identified themselves as primary caretakers of eligible children. Interviews were conducted in respondents' homes by trained staff using a standardized, 15-minute questionnaire that asked about the child's immunization history, household factors, and health provider information. An interview was conducted for each eligible child in study households. Immunization histories were determined from parent and provider records. This study was reviewed and approved by the Institutional Review Board of Eastern Virginia Medical School.

Description of the Target Population

Norfolk and Newport News are neighboring port cities located in southeastern Virginia. In 1990, Norfolk had a population of 261 229 and 5561 births, and Newport News had a population of 170 045 and 3549 births. Military personnel and their dependents made up more than one third of the population of each city, with the Navy predominant in Norfolk, and the Army and Air Force in Newport News. Although the census classifies the two cities as

part of the same metropolitan statistical area, they are geographically separated by the Hampton Roads harbor. As a result of this natural barrier, the two cities are served by different local health departments and primary care providers. However, in both cities, children receive care from a combination of private, public, and military health services, with free immunizations available to all children, regardless of family income, through public health clinics. In 1993, there were five public health clinics in Norfolk and two in Newport News. Public sector immunizations also were available through two hospital-based outpatient clinics in Norfolk and one hospital-based clinic and community health center in Newport News. Norfolk had 28 general pediatricians and 16 family physicians, whereas Newport News had 10 pediatricians and 44 family physicians. Health care coverage for military dependents was available through the Civilian Health and Medical Program of the Uniformed Services (CHAMPUS), which was similar to private insurance. Well-child and immunization services were free for military families if obtained from a military clinic, military contract provider, or public health clinic, but were an out-of-pocket expense if obtained elsewhere.

Sampling Design

Selection of study households was performed using probability proportionate to size, multistage cluster sampling to obtain 55 clusters per city, composed of 120 housing units per cluster.[26] A housing unit was defined as any potential residence, including a house, individual apartment, or trailer. In the first stage of sampling, the number of children in the target age range identified in the 1990 census was listed by city and census tract. Probability-proportionate-to size sampling was then applied to determine the number of clusters to be selected per census tract. Using this method, from 0 to 1 clusters were selected from the least populated census tracts, whereas multiple clusters were selected from the most populated census tracts. In the second stage, a block group (census tract subunit) was selected for each cluster by simple random sampling of available block groups. Selected block groups then were mapped using a combination of city maps and field work so that all housing units were counted and located. Next, each block group map was subdivided to create a set of potential study clusters containing 120 housing units each. If the remainder of housing units in the block group numbered 60 or more, they were considered to constitute a distinct cluster, but if fewer than 60, they were combined with another potential cluster. Thus, potential clusters ranged in size from 60 to 179 housing units. In the third stage of sampling, study clusters were selected by simple random sampling from the potential clusters defined within each block group.

Household Interviews

In each selected cluster of households, interviewers proceeded door-to-door to explain the study to all households and identify every household in which a child 12 to 30 months of age resided. If an appropriate respondent was not available at the first attempted contact, a written message was left at the house and multiple attempts were made to contact the household, varying the hours, days, and weeks of attempt until the eligibility status of the household could be validly ascertained.

Once an eligible household was identified, the interviewer asked to speak with someone considered to be the primary caretaker of the child. Although in most cases, interviews were conducted immediately after determining eligibility, appointments were made when respondents preferred that interviewers return at a more convenient time. Interviews collected sociodemographic information about study households and children, including the child's status at the time of interview for enrollment in Women, Infants and Children (WIC) and other government programs, education of the respondent, family income, a listing of all clinics or offices ever used for the child's well-child care and/or immunizations, whether the child currently had health insurance coverage through Medicaid, CHAMPUS, and/or private insurance/managed care plans, any problems or access barriers the respondent had encountered when obtaining immunizations for the child, and transcription of immunization records when available from parents.

Immunization Records

The immunization history of each study child was determined solely from parent and/or provider records. The combination of parent and provider records, when available, was used to provide a complete immunization history for each child. During the first part of the interview, respondents were asked whether the child had ever been given any infant shots or immunizations. If yes, the respondent was asked whether the child's record was available and could be found in the home. Interviewers transcribed available records, including all immunization doses and dates administered, to a standardized recording form. During the interview, parents were asked to sign a form authorizing providers to release a copy of the child's immunization record. All providers listed by the parent were sent requests for the child's immunization records. For valid identification, parent authorization forms sent to providers indicated the child's complete name, any nicknames, his/her date of birth and social security number, and parent names and social security numbers. If provider records were not obtained after the first request, a second request was made.

Definitions

The primary outcomes of this study were defined as up-to-date (UTD) immunization status of study children for the combination of DTP, polio, and measles–mumps–rubella (MMR) vaccines at 12 and 24 months of age. Being UTD at 12 months was defined as having had at least three DTP and two polio vaccines by the first birthday. Being UTD at 24 months was defined as having had at least four doses of DTP, three doses of polio, and one dose of MMR vaccines by the second birthday. Underimmunization was defined as not being UTD at 12 or 24 months. Children were considered nonimmunized if a parent indicated that no immunizations had been received or if no immunization record was available from the parent and health care providers responded that there was no immunization record for the child. The immunization history was considered missing if no record was available from the parent and providers listed by the parent did not respond to requests for records.

The child's usual immunization provider was indicated by the parent. A provider was defined as a clinic, physician's office, or practice site that delivered immunizations. Providers that restricted their patients to military personnel and their dependents were classified into two types: military clinics or military contract provider. Military clinics were those staffed and run by military personnel. The military contract clinic was staffed and operated by nonmilitary personnel under contract with the US Department of Defense.

Illness in the child as a barrier to immunization was defined by survey respondents. Waiting time in a clinic or office as a barrier to immunization was defined by response to two survey items; first, the estimated waiting time in hours and minutes before the child was seen at the last immunization visit, and second, whether the time waited was a problem.

Quality Assurance

Quality-assurance procedures were instituted for each phase of the study. Development of survey instruments involved expert review and extensive pretesting in the community. Interviewers were trained for 3 to 4 days, including practice interviews in nonstudy households. Any questionnaire that was incomplete or contained an error was returned to the interviewer for correction. Data entry was performed on an ongoing basis by trained staff. Each record entered was verified for accuracy and completeness by a second data entry operator. In each city, 150 households with completed interviews were randomly selected for partial reinterview by a second interviewer to verify that interviews were conducted appropriately and that transcription of available immunization records was accurate. Neighboring households also were recontacted to ensure that households listed by interviewers as noneligible were validly designated and that eligible children were not missed.

Statistical Analysis

Analyses were performed using Stata[27] and SUDAAN[28] statistical software. Descriptive analysis included frequencies, odds ratios (OR), and 95% confidence intervals (CI) for UTD status at 12 and 24 months. Significance was determined for contingency ta-

bles by Wald's χ^2 test. Bivariate and stratified analyses were performed to examine the association between independent variables and immunization status and potential confounding and interaction effects. Independent variables that were significantly associated with immunization status in bivariate analyses were included in logistic regression models to determine the relative contribution of health service and access factors controlling for other factors. Independent variables were analyzed as categorical variables, except for the number of children in the household and the respondent's estimated waiting time during the last immunization visit (measured in hours and minutes). Final logistic regression models retained only those variables that were important confounding factors and remained significant at $P \leq .10$, using stepwise elimination of nonsignificant variables. Potential multicollinearity among variables was examined and found not to be a problem. Missing values were < 2% except for household income. For regression models, missing income data were imputed using the median income of respondents living in the same housing cluster. All analyses accounted for the survey cluster sampling design (ie, within-cluster correlation). Because the immunization rates of the two cities did not differ significantly, unweighted analyses were used for ease of computation. Significance was set at $P < .05$.

RESULTS

Response Rate

A total of 12 770 households were identified, of which 6338 were in Norfolk and 6432 in Newport News. All households were contacted to determine eligibility to participate in the study, of which 787 households (6.1%)—417 (6.6%) in Norfolk and 370 (5.8%) in Newport News—included at least one resident child 12 to 30 months of age. Among eligible households, 91% agreed to participate, which yielded a total of 749 children in the target age range (Fig 1).

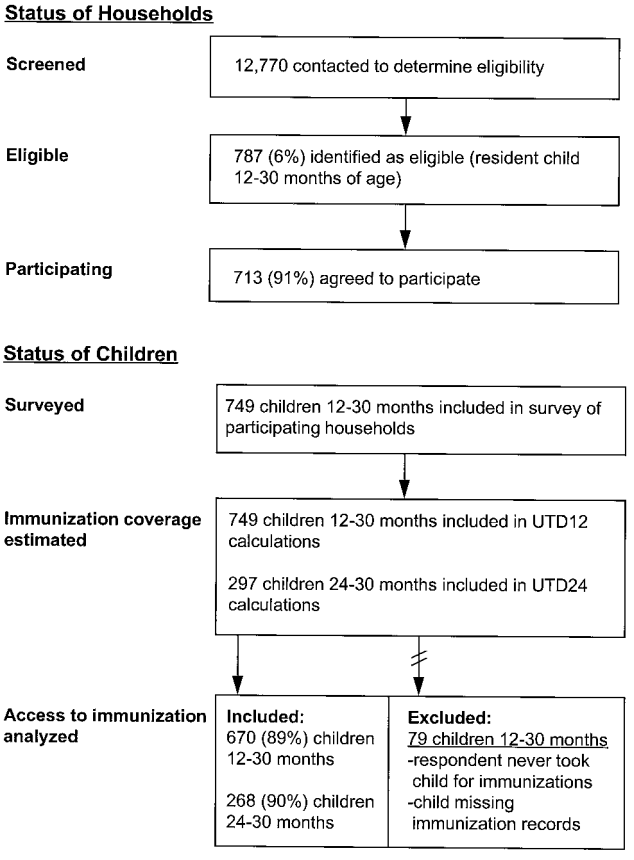

Fig 1. Flow diagram of eligibility and inclusion of study households and children.

Immunization Records

Of the 749 children surveyed, 391 (52%) had an immunization record available at home and 684 parents (91%) signed authorization allowing providers to release a copy of their child's immunization record. Immunization records obtained for study children were as follows: 279 (37%) had both a parent and provider record; 112 (15%) had a parent record only; and 262 (35%) had a provider record only. In addition, 52 children (7%) lacked an immunization record and were classified as nonimmunized: 3 respondents indicated that immunizations were never obtained for the child, whereas 49 lacked parent-held records and the providers listed responded in writing that the children lacked any record of immunization. The remaining 44 (6%) children had missing immunization data because of lack of parent-held records combined with either lack of parent authorization for release of provider immunization records ($n = 34$ [5%]) or lack of provider response to requests for immunization records ($n = 10$ [1%]). There was no significant difference in the sociodemographic or health service characteristics of children with missing immunization records.

Inclusion Criteria

All 749 children surveyed were included in estimates of immunization coverage rates. However, for analysis of health service factors in relation to immunization, we included only the 670 (89%) children for whom both health service and immunization data were available, which excluded 44 children missing immunization records and 35 children for whom survey respondents indicated that they had never taken the child for immunizations (Fig 1).

Description of the Study Population

All children surveyed were born between October 1, 1990, and June 30, 1992. The sociodemographic characteristics of survey participants are shown in Table 1. Study children were nearly evenly divided between residents in Norfolk ($n = 389$) and Newport News ($n = 360$), and there were no significant differences between the cities regarding the sociodemographic characteristics of respondents. Most respondents were mothers. The ethnicity of respondents was nearly evenly distributed between white and African-American, with the remainder a diversity of Asians, Hispanics, and others. There were 298 children (40%) who had at least one parent on active duty in a military service, of whom 209 (70%) were in the Navy, 79 (27%) in the Army, and 10 (3%) in the Air Force.

Health Service Factors

The usual immunization provider reported for 252 children (34%) was a private practice, of which 203 (81%) were pediatric practices, 38 (15%) were family practices, and 11 (4%) were unknown. For the remaining children, the usual immunization provider

TABLE 1. Characteristics of Survey Participants ($N = 749$)

Characteristics		No.	Percent
City of residence	Norfolk	389	52
	Newport News	360	48
Survey respondent	Mother	639	85
	Father	90	12
	Other	20	3
No. children in household*	1	225	30
	2	247	33
	≥3	277	37
Highest educational level of respondent	Not graduated from high school	135	18
	High school graduate	319	43
	More than high school	289	39
Respondent ethnicity	White	367	49
	African-American	329	44
	Other	53	7
Household income	<$10 000	164	22
	$10 000–$39 000	399	53
	≥$40 000	96	13
	Not reported	90	12
Teenage mother		106	14
Single parent		164	22
Enrolled in AFDC program†		160	21
Enrolled in WIC program†		297	40
Military household‡		298	40

* Including study child.
† Status at time of survey.
‡ Military household is defined as a household in which at least one of the parents or head(s) of household are on active military duty.

was as follows: 148 (20%), public health clinic; 63 (8%), hospital-based ambulatory clinic; 26 (3%), community health center; 177 (24%), a military clinic; 77 (10%), military contract clinic; and 6 (<1%), no usual immunization provider. A total of 558 children (75%) had only one immunization provider, whereas 191 (25%) had multiple immunization providers. The percent of children with multiple immunization providers differed ($P < .001$) by type of usual immunization provider; multiple providers were reported by only 13% whose child was usually seen by a private physician compared with 24% whose child usually was seen by a public health, hospital, or community center provider, and 38% who had a military clinic as the usual immunization provider.

A total of 295 children (42%) were insured by CHAMPUS, 224 (32%) were insured by Medicaid, 125 (18%) had private indemnity health insurance, 33 (5%) were enrolled in a health maintenance organization (HMO), and 34 (5%) had no health insurance. Health insurance status was not known for 3 children (<1%). The relationship between children's

TABLE 2. Percent of Children With Health Care Coverage and Parent-reported Barriers to Obtaining Immunizations by Type of Usual Immunization Provider

Health System Factor	Usual Immunization Provider						P‖
	Private Offices $n = 252$	Public Clinics $n = 148$	Hospital Clinics/ Community Center $n = 89$	Military Clinics $n = 177$	Military Contract $n = 77$	Total $N = 749$*	
	%	%	%	%	%	%	
Health care coverage†							
CHAMPUS	16	10	10	97	99	42	<.001
Medicaid	31	60	76	2	1	32	<.001
Private fee-for-service/HMO	49	21	10	3	3	23	<.001
Uninsured	6	10	8	0	1	5	.003
Parent-reported problem obtaining immunizations‡							
At least one problem reported	29	33	34	41	46	35	.049
Waiting time a problem	5	17	11	14	22	12	<.001
Appointment system inadequate	4	4	6	18	24	10	<.001
Taking time away from work a problem	5	5	6	12	7	7	.080
Cost problem	12	5	6	5	0	7	.002
Transportation lacking	3	12	7	2	1	5	<.001
Clinic/office hours too limited	3	3	5	10	6	5	.011
Illness of child	3	<1	5	3	12	4	<.001
Waiting time >1 hour‡	9	23	27	16	30	17	<.001

* The total ($N = 749$) includes six children with no usual source of care who are not included in the tabulation by usual immunization provider.
† Health care coverage percent column does not add to 100% because some children were covered by more than one plan.
‡ For waiting time and parent-reported problems, the sample size used to calculate percentages was restricted to those 670 parents who reported ever having taken the child to obtain immunizations and for whom records were available.
‖ P value calculated by Wald χ^2 test.

usual immunization provider and source of insurance is shown in Table 2.

Barriers to Immunization

Respondents were asked whether they had ever personally taken their child to obtain immunizations; those who responded affirmatively were asked whether they had ever experienced specific problems obtaining immunizations. Thirty-five percent of the 670 respondents reported at least one problem obtaining immunizations for their child (Table 2). The percent of respondents reporting a problem varied significantly ($P = .049$) by the usual immunization provider, ranging from 29% using private practices to 46% using the military contract clinic.

The most commonly reported problem was clinic waiting time (12%). When asked how long they had waited in the office or clinic to obtain the child's last immunization, 31% indicated 30 minutes to 1 hour, and 17% indicated >1 hour. Although a significant ($P < .001$) association was found between waiting >1 hour and report of waiting time as a problem, not all parents who waited >1 hour indicated that it was a problem. Waiting >1 hour was reported significantly ($P < .001$) less often among those using private practices than other immunization services. Having a problem with the waiting time was highest among those using the military contract clinic.

Difficulty obtaining an appointment was the second most commonly reported problem (10%). Appointment problems were reported more often ($P < .001$) by parents using military facilities (18% to 24%) compared with other providers (4% to 6%). Other reported problems also differed by type of provider. The cost of obtaining immunizations (including direct and indirect costs such as transportation or baby sitters) was reported most often among those using private providers (12%). Transportation problems were reported by 7% to 12% of parents using public hospital and community clinics, compared with <3% using other providers ($P <.001$). Limited clinic or office hours were reported by 10% using military clinics, compared with 3% to 6% using other providers ($P = .011$). Illness of the child as a barrier to immunization was reported by 12% of parents using the military contract clinic, compared with <1% of those using public clinics ($P < .001$).

Immunization Rates

At 12 months of age, 69% of study children were UTD; 69% had three DTP and 82% had two doses of polio vaccine. At 24 months, 56% of children were UTD; 59% had four DTP, 67% had three polio, and 77% had one MMR vaccine doses. Immunization against *Haemophilus influenzae* type b (Hib) occurred in 90% of children by 24 months, with 81% receiving two or more doses of Hib. Seven children, all of military families, were given diphtheria–tetanus (DT) after one or more doses of DTP, and two other children had a measles immunization that was not MMR. Of these, only two children would have been classified as UTD if DT and measles-only containing vaccines were counted as equivalent to DTP and MMR.

Sociodemographic Risk Factors

Based on bivariate and stratified analyses, significant ($P < .05$) sociodemographic risk factors for underimmunization at 12 and/or 24 months were African-American ethnicity; teenage mother; increasing number of children in the household; single parenthood; child enrolled in Aid to Families with Dependent Children (AFDC); low-income household; lack of completion of high school or only high school education, compared with education beyond high school; not being enrolled in the WIC program; and lack of having the child's immunization record at home.

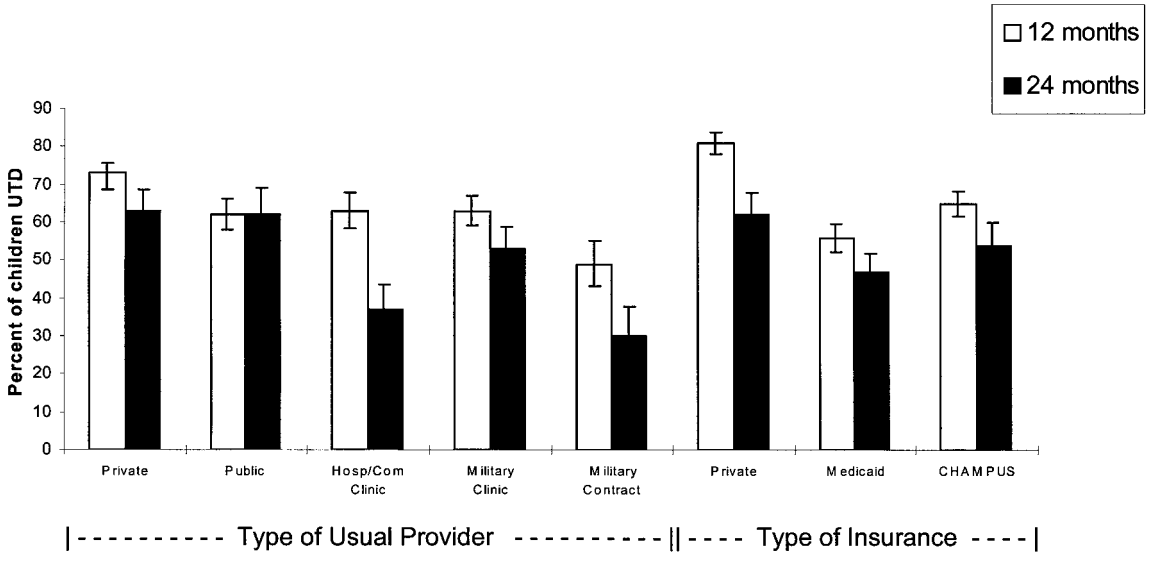

Fig 2. Immunization rates at 12 and 24 months of age by usual provider and type of insurance. The vertical lines at the top of each bar represent SE. The type of usual provider refers to the place cited as the usual place for obtaining the child's immunizations: private physician's office, public health clinic, hospital ambulatory clinic or community health clinic, military clinic, or clinic managed by a private health care organization under contract to the military (military contract).

Immunization Rates by Type of Provider and Insurer

Immunization rates differed significantly at 12 ($P < .001$) and 24 ($P < .01$) months of age by usual immunization provider (Fig 2). At 12 months, the percent of children UTD ranged from 73% seen by private providers to 49% seen by the military contract clinic. At 24 months, immunization rates ranged from 63% among private providers to 30% for the military contract clinic. Among private providers, 12-month immunization rates were similar for pediatric and family practices. At 24 months, children ($n = 73$) seen by pediatric practices had a significantly ($P = .02$) higher immunization rate (68%), compared with children ($n = 14$) seen by family practices (36%).

Type of health insurance was significantly ($P < .001$) associated with immunization rates at 12 months, with the highest rate (81%) among privately insured children and lower rates among Medicaid- (56%) and CHAMPUS-insured (65%) children. At 24 months, trends by type of insurance remained, but differences were not significant. There were too few noninsured children ($n = 36$) to estimate immunization rates reliably, but their rates were comparable with privately insured children.

Respondent-reported Barriers in Relation to Immunization Status

Having any reported problem obtaining immunizations was a significant risk factor for underimmunization at 24 months (OR = 1.9; 95% CI 1.2–3.2), but not at 12 months. Additionally, there was a significant ($P < .001$) dose–response association between the number of different access problems reported by respondents and the likelihood of the child being UTD at 24 months (Fig 3). Estimated waiting time at the last immunization visit was a significant risk factor for underimmunization. At 12 months, 76% of children were UTD if the wait was estimated to be <30 minutes, 66% if 30 to 60 minutes, and 58% if >1 hour ($P = .001$). At 24 months, 67% were UTD if the wait was <30 minutes, 46% if 30 to 60 minutes, and 55% if >1 hour ($P = .006$). Other significant respondent-reported barriers are described below.

Multiple Logistic Regression Analysis

The sociodemographic and health service risk factors identified from multiple logistic regression analysis for not being UTD at 12 and 24 months are shown in Table 3. At 12 months, significant health service risk factors for not being UTD were having Medicaid or CHAMPUS, not being enrolled in WIC, the parent not having the immunization record, having a problem obtaining transportation, and estimated clinic waiting time. For every additional hour of time spent waiting for immunizations in clinics, the child was 1.6 times more likely not to be UTD with immunizations at 12 months. There was a trend toward higher immunization rates at 12 months if the hospital clinic or community health center was the usual immunization provider. At 24 months, significant health service risk factors for not being UTD included lack of enrollment in WIC, having the military contract clinic as the usual immunization provider, and difficulty obtaining an appointment. There was a trend toward association parent-reported problems with clinic hours and/or problem with taking time away from work as a risk factor for underimmunization at 24 months.

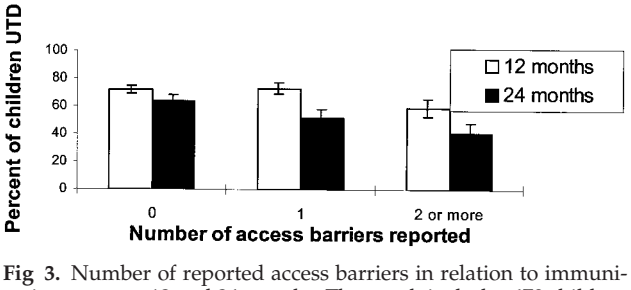

Fig 3. Number of reported access barriers in relation to immunization status at 12 and 24 months. The graph includes 670 children who had immunization records and an adult respondent who took the child for at least one immunization visit.

DISCUSSION

Sixty-five percent of children in Norfolk and Newport News were UTD on immunizations at 12 months and 53% at 24 months of age. These rates are comparable with other urban areas studied before 1994.[3,4] We found immunization rates differed significantly by structural health care system factors, including usual type of immunization provider and insurance type, as well as by subjective measures of access to immunization services determined from parent report. After adjustment for sociodemographic factors, significantly lower 12-month immunization rates were observed among those insured by Medicaid or CHAMPUS, if parents reported waiting times >1 hour in clinics or problems obtaining transportation to services, and if parents did not have their child's immunization record available at home. At 24 months, having the military contract clinic as the usual immunization provider, and report of problem obtaining an appointment were significantly associated with lower immunization rates. Lack of enrollment in WIC was significantly associated with lower immunization rates at 12 and 24 months, despite the fact that at the time of this survey, Virginia had not yet implemented any programs to link WIC with immunization services. This finding suggests the importance of the WIC program as a portal of access to the health care system for young families.

Barriers to immunization were reported by more than one third of parents. The most common problems reported were long waiting times and difficulty obtaining timely appointments, ie, factors that cause delay in use of geographically available services. The frequency and type of barriers reported differed significantly by type of immunization provider, with access problems reported most often by parents using military clinics or the military contract service. Direct cost of immunization services did not appear to be a risk factor for underimmunization in this population, likely because of the availability of free immunizations through public health and military clinics. Although not all problems mentioned by parents were independent risk factors for underimmu-

TABLE 3. Significant Household and Health Services Risk Factors for not Being UTD on Immunizations at 12 and 24 Months by Multiple Logistic Regression

Risk factors	12 Months (n = 655)		24 Months (n = 268)	
	OR (95% CI)	P	OR (95% CI)	P
No. children in household*	1.5 (1.3, 1.8)	<.001	1.4 (1.1, 1.8)	.006
African-American†	2.2 (1.4, 3.4)	<.001	2.4 (1.4, 4.2)	.001
Single parent	2.0 (1.1, 3.3)	.012	1.9 (0.96, 3.8)	.066
Respondent education beyond high school	0.5 (0.3, 0.9)	.018	—	
Teenage mother	—		7.5 (3.3, 17.0)	<.001
No immunization record at home	3.4 (2.3, 5.0)	<.001	—	
Not enrolled in WIC	2.1 (1.4, 3.3)	<.001	2.0 (1.1, 3.7)	.031
Medicaid-insured	2.7 (1.4, 5.3)	.004	—	
CHAMPUS-insured	5.2 (2.9, 9.5)	<.001	—	
Hospital clinic or community center	0.5 (0.3, 1.02)	.058	—	
Military contract clinic	—		5.6 (2.6, 11.9)	<.001
Clinic wait time (hours)	1.6 (1.2, 2.0)	.001	—	
Transportation problem	2.6 (1.3, 5.2)	.007	—	
Problem obtaining an appointment	—		4.5 (1.8, 8.6)	.002
Problem with clinic hours or taking time from work	—		2.2 (0.8, 5.9)	.103

* Number of children includes the study child.
† African-American versus white and others.

nization, a dose–response relationship was found between the number of different problems reported by parents and lower immunization levels at 24 months of age.

A large proportion of children lived in military households and were CHAMPUS-insured. Our findings differ from studies published previously of the immunization status of military dependents. Lopreiato and Ottolini[25] conducted a survey of children 2 months to 18 years of age presenting to seven selected acute care pediatric clinics operated by the Department of Defense; two thirds of eligible families participated. The authors reported that 83% of children 13 to 24 months of age had received all required immunizations at the age they were seen. These results were similar to those of two previous studies that limited inclusion to children with complete records seen in selected military clinics for acute care.[29,30] The only population-based study of the immunization status of US military dependents published previously was that of Weese and Krause,[24] who studied children listed on a US Department of Defense roster as being 2 to 3 years of age with at least one active-duty parent working at Fort Lewis, WA. Children who moved out of the area were excluded. The authors reported that at 24 months of age, 72% of children with complete records were UTD, but that if children with incomplete records (ie, lacking one or more immunizations on their record) were included, only 64% were UTD at 24 months. Although these previous publications have suggested that military dependents have had relatively high immunization rates attributable to a barrier-free system, there is a lack of published, population-based data of immunization outcomes and parent-perceived access to support this view.

National surveys have shown differences among children in access to usual sources of routine care.[8,31] Analysis of the 1988 National Maternal and Infant Health Survey found inequity of receiving well-baby care and infant immunizations associated with low level of maternal education and being enrolled in Medicaid or other government assistance program.[8] Additionally, analysis of the 1988 National Health Interview Survey found that although Medicaid improved access to care for poor children, it did not ensure the same access to care as children covered by private insurance.[31] Concern about inequitable access to immunization services has led to implementation of the Vaccines for Children (VFC) program. Evaluation of the Vaccines for Children program by national survey indicates that physicians who are receiving free vaccine are less likely to refer children to public clinics for vaccination.[32] Although removal of cost as a barrier to immunization is critical, access barriers other than cost also affect use of preventive services, and these other barriers may not be as well addressed.

The factors that impede use of preventive services appear to vary by population and type of health system used. For example, a survey in inner-city Los Angeles, CA, found that Latino children were less immunized if their usual source of care was an HMO rather than a public clinic, whereas African-American children were less immunized if on Medicaid versus private insurance.[9] A study in a California HMO found that not having a regular physician was a risk factor for delayed childhood immunization.[12] Among children of employees of a large US corporation, lower immunization rates at 2 years of age were associated with use of public health clinics, parent-reported difficulty leaving work, and obtaining an appointment with the provider.[11] A study of hospitalized preschool children in Tennessee found that immunization delay was associated with parent-reported lack of transportation.[15] In some circumstances, mothers may perceive many barriers to immunization.[22,33] Although the specific health service barriers vary by population, studies suggest that these perceived barriers predict delay in obtaining immunizations. Bates et al[10] followed a cohort of infants born in a large municipal teaching hospital in the Midwest and found that mothers' anticipation of barriers to immunization was associated with infants' subsequent immunization status.

Although previously studies of immunization typ-

ically have focused on low-income families, clinic attendees, or other selected groups, the current study provides unbiased information about the needs of an entire urban population of children <2 years of age. We found underimmunization was a generalized problem, but that type and degree of need varied significantly. As in previous studies, sociodemographic factors associated with underimmunization in this population were African-American ethnicity, a teenage mother, education at high school level or less, and higher birth order. The Institute of Medicine, the National Vaccine Advisory Committee, and others have advocated a population-based approach to childhood immunization and private and public sector collaboration to improve immunization coverage.[7,34–37] Yet, as state and local public–private partnerships have formed to improve immunization, they are hampered by lack of diagnostic information about their populations, such as coverage rates, pockets of need, health system access, and quality of services. As it has been said that one can't change what one can't measure, it follows that if such partnerships are to be effective in reaching and sustaining high immunization coverage rates, population data are required. Data from this study were included as part of a needs assessment undertaken by a community-based immunization coalition for the purpose of planning and action in the Norfolk urban area.[33,38] Our experience demonstrates that a household survey can be a feasible method of assessing immunization coverage in an urban area.

In this unique, population-based study, we have shown clearly that parents do not necessarily perceive cost-free and geographically available immunization services as barrier-free, which contradicts an assumption that some have made in the past. We found that one third of parents perceived barriers to immunization services, and that the pattern of barriers differed between public, private, and military services. Parent-reported barriers had a dose–response association with lower immunization rates, which indicates the importance of measuring perception of services. In addition, significant variation in immunization rates was found among providers and insurers that was not explained by measured population characteristics or access barriers. This variability in outcome is likely to be explained in part by variation in provider knowledge and practices, including screening the child's immunization status at every clinical encounter and using every opportunity to immunize, following only true contraindications to immunization, simultaneous administration of vaccines, and other aspects of the Standards for Pediatric Immunization Practices.[37] Finding such variation within a defined geographic area underscores the need for routine assessment of immunization rates for continuous quality improvement of services and to benchmark the immunization outcomes of different health care providers.[21,39–41] The focus on immunization continues to be critical for the prevention of serious diseases as well as for improving the delivery of preventive services for children.

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REFERENCES

1. Hatziandreau EJ, Brown RE, Halpern MT. *A Cost Benefit Analysis of the Diphtheria-Tetanus-Pertussis (DTP) Vaccine. Final Report Prepared for the National Immunization Program, Centers for Disease Control and Prevention*. Arlington, VA: Battelle Medical Technology Assessment Program; 1994. Center for Public Health Research and Evaluation
2. Public Health Service. *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. Washington, DC: US Dept of Health and Human Services publication PHS91-50213
3. Zell ER, Dietz V, Stevenson J, Cochi S, Bruce RH. Low vaccination levels of US preschool and school-age children: retrospective assessments of vaccination coverage, 1991–1992. *JAMA*. 1994;271:833–839
4. Centers for Disease Control and Prevention. Status report on the childhood immunization initiative: national, state and urban area vaccination coverage levels among children aged 19–35 months—United States, 1996. *MMWR*. 1997;46:657–664
5. Orenstein WA, Atkinson W, Mason D, Bernier RH. Barriers to vaccinating preschool children. *J Health Care Poor Underserved*. 1990;1:315–330
6. Cutts FT, Orenstein WA, Bernier RH. Causes of low preschool immunization coverage in the United States. *Ann Rev Public Health*. 1992;13:385–398
7. National Vaccine Advisory Committee. The measles epidemic: the problems, barriers and recommendations. *JAMA*. 1991;266:1547–1552
8. Mustin HD, Holt VL, Connell FA. Adequacy of well-child care and immunization in U.S. infants born in 1988. *JAMA*. 1994;272:1111–1115
9. Wood D, Donald-Sherbourne C, Halfon N, et al. Factors related to immunization status among inner-city Latino and African-American preschoolers. *Pediatrics*. 1995;96:295–301
10. Bates AS, Fitzgeral JF, Dittus RS, et al. Risk factors for underimmunization in poor urban infants. *JAMA*. 1994;272:1105–1110
11. Fielding JL, Cumberland WG, Pettitt L. Immunization status of children of employees in a large corporation. *JAMA*. 1994;2761:525–530
12. Lieu TA, Black SB, Ray P, Chellino M, Shinefield HR, Adler NE. Risk factors for delayed immunizations among children in an HMO. *Am J Public Health*. 1994;84:1621–1625
13. Lieu TA, Smith MD, Newacheck PW, Langhorn D, Vankatesh P, Herradora R. Health insurance and preventive care sources of children at public immunization clinics. *Pediatrics*. 1994;93:373–378
14. Williams IT, Milton JD, Farrell JB, Graham NMH. Interaction of socioeconomic status and provider practices as predictors of immunization coverage in Virginia. *Pediatrics*. 1995;96:439–446
15. Kum-Nji P, James D, Herrod HG. Immunization status of hospitalized preschool children: risk factors associated with inadequate immunization. *Pediatrics*. 1995;96:434–438
16. Bobo JK, Gale JL, Thapa PB, Wassilak SG. Risk factors for delayed immunization in random sample of 1163 children from Oregon and Washington. *Pediatrics*. 1993;91:308–314
17. Miller LA, Hoffman RE, Baron AE, Marine WM, Melinkovich P. Risk factors for delayed immunization against measles, mumps, and rubella in Colorado two-year-olds. *Pediatrics*. 1994;94:213–219
18. Guyer B, Hughart N, Holt E, et al. Immunization coverage and its relationship to preventive health care visits among inner-city children in Baltimore. *Pediatrics*. 1994;94:53–58
19. Dietz VJ, Stevenson J, Zell ER, Cochi S, Hadler S, Eddins D. Potential impact of vaccination coverage levels by administering vaccines simultaneously and reducing dropout rates. *Arch Pediatr Adolesc Med*. 1994;148:943–948
20. Szilagyi PG, Rodewald LE, Humiston SG, et al. Immunization practices of pediatricians and family physicians in the United States. *Pediatrics*. 1994;94:517–523
21. Grabowsky M, Orenstein WA, Marcuse EK. The critical role of provider practices in undervaccination. *Pediatrics*. 1996;97:735–737. Commentary
22. Lannon C, Brack V, Stuart J, et al. What mothers say about why poor

children fall behind on immunizations. *Arch Adolesc Med.* 1995;149: 1070–1075
23. Abbotts B, Osborn LM. Immunization status and reasons for immunization delay among children using public health immunization clinics. *Am J Dis Child.* 1993;147:965–968
24. Weese CB, Krauss MR. A "barrier-free" health care system does not ensure adequate vaccination of 2-year-old children. *Arch Pediatr Adolesc Med.* 1995;194:1130–1135
25. Lopreiato JO, Ottolini MC. Assessment of immunization compliance among children in the Department of Defense health care system. *Pediatrics.* 1996;97:308–311
26. Serfling RE, Sherman IL. *Attribute Sampling Methods for Local Health Departments with Special Reference to Immunization Surveys*. Atlanta, GA: US Dept of Health, Education, and Welfare Public Health Service, Communicable Disease Center, Epidemiology Branch; 1965
27. Stata Corporation. *Stata Statistical Software: Release 5.0*. College Station, TX: Stata Corporation; 1997
28. Shah BV, Barnwell BG, Hunt PE, LaVange LM. *SUDAAN Users' Manual: Professional Software for Survey Data Analysis for Multi-stage Sample Designs*. Release 6.0. Research Triangle Park, NC: Research Triangle Institute; 1992
29. Jones WS, Ball BH, Smalley JR, et al. Immunization status of preschool children in a military clinic. *Arch Pediatr Adolesc Med.* 1994;148:986–989
30. Lopreiato JO, Moriarty R. Immunization status of a military dependent population. *Mil Med.* 1993;158:371–373
31. St Peter RF, Newacheck PW, Halfon N. Access to care for poor and non-poor children: separate and unequal? *JAMA.* 1992;267:2760–2764
32. Zimmerman RH, Medsger AR, Ricci EM, Raymund M, Mieczkowski TA, Grufferman S. Impact of free vaccine and insurance status on physician referral of children to public vaccine clinics. *JAMA.* 1997;278: 996–1000
33. Butterfoss FD, Houseman C, Morrow AL, et al. Use of focus group data for strategic planning by a community-based immunization coalition. *Fam Community Health.* 1997;20:49–59
34. Orenstein WA, Bernier RH. Towards immunizing every child on time. *Pediatrics.* 1994;94:545–547
35. Durch J, ed. *Overcoming the Barriers to Immunization*. Washington, DC: National Academy Press; 1994
36. Bernier RH. Towards a more population-based approach to immunization: fostering private- and public-sector collaboration. *Am J Public Health.* 1994;84:1567–1568
37. Ad Hoc Working Group for the Development of Standards for Pediatric Immunization Practices. Standards for pediatric immunization practices. *JAMA.* 1993;269:1817–1822
38. Butterfoss FD, Morrow AL, Rosenthal J, et al. CINCH: an urban coalition for empowerment and action. *Health Educ Behav.* In press
39. Centers for Disease Control and Prevention. Recommendations of the Advisory Committee on Immunization Practices: programmatic strategies to increase vaccination rates—assessment and feedback of provider-based vaccination coverage information. *MMWR.* 1996;45:219–220
40. LeBaron CW, Chaney M, Baughman AL, et al. Impact of measurement and feedback in vaccination coverage in public clinics, 1988–1994. *JAMA.* 1997;277:631–635
41. Fairbrother G, Friedman S, DuMont KA, Lobach KS. Markers for primary care: missed opportunities to immunize and screen for lead and tuberculosis by private physicians serving large numbers of inner-city Medicaid-eligible children. *Pediatrics.* 1996;97:785–790

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