Vaccination coverage among children aged 13 to 59 months in Buenos Aires, Argentina, 2002

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ABSTRACT

Objectives. *To estimate antigen-specific and series-complete vaccination coverage among children aged 13 to 59 months in Buenos Aires; to compare the results of a community-based household survey with coverage rates obtained from administrative records; and to identify risk factors for incomplete vaccination.*

Methods. *Census tracts in Buenos Aires were surveyed systematically in March and April, 2002. Three children aged 13 to 24 months and 25 to 59 months were surveyed per block in each census tract. Written documentation of vaccination was required. Risk factors associated with incomplete vaccination were identified with univariate analysis and multivariate logistic regression.*

Results. *A total of 1391 children were surveyed. Antigen-specific coverage ranged from 69.4% (95% CI 66.7%–72%) for* Haemophilus influenzae *type b vaccination to 99% (95% CI 98.4%–99.6%) for BCG vaccination. Except for measles, coverage estimates found in the survey did not differ substantially from those obtained from city health authority records. Multivariate logistic regression analysis showed child's age* ($P < 0.001$) *and vaccination provider (public or private)* ($P = 0.001$) *to be risk factors associated with incomplete vaccination. Not being the first child* ($P < 0.001$) *was associated with incomplete coverage under the long-standing program. Living in the Northern zone of the city* ($P = 0.001$)*, being uninsured* ($P = 0.02$)*, and lower educational level of the primary caregiver* ($P = 0.04$) *were risk factors associated with incomplete coverage under the current vaccination program.*

Conclusions. *Although coverage rates for some vaccines were high, complete vaccination coverage remains low among children aged 13 to 59 months in Buenos Aires. Increasing coverage will require better access to vaccination, particularly in sections of the community with risk factors.*

Key words Vaccination, coverage, survey, Argentina.

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Childhood vaccination is one of the major public health successes of the past century (1). Vaccination can protect individuals and whole communities by interrupting disease transmission (2, 3). Ideally, vaccination programs should achieve the coverage required to block the spread of diseases. The success of a vaccination program is measured by monitoring the incidence of diseases and vaccination coverage on a regular basis.

Buenos Aires is the capital of Argentina, with a population of approximately 2.8 million (4). Vaccination in this city is provided by both the public and private sectors. In the public sector, vaccination is implemented mainly through 20 public hospitals and 33 healthcare centers. In addition, the city government purchases some vaccines to be administered in 24 vaccination centers belonging to union groups. Vaccinations may also be obtained in private hospitals, pharmacies or vaccination centers.

In Buenos Aires, vaccines are administered according to the National Immunization Schedule (NIS) (Table 1) (5). Vaccinations added to the schedule more recently are *Haemophilus influenzae* type b (Hib) (in 1997), combined measles-mumps-rubella (MMR) (in 1998), and hepatitis B vaccine (in November 2000). A second opportunity for measles immunization is provided through follow-up campaigns targeted to all children 1–4 years old, in accordance with the Pan American Health Organization recommendations (6). In Argentina, the most recent follow-up campaign was in 2002. Other vaccinations not included in the NIS may also be received particularly through the private sector, e.g., hepatitis A, pneumococcus, varicella or meningococcus.

Vaccination coverage in Buenos Aires is calculated by dividing the number of doses administered by the target population for each dose. Although vaccination coverage estimated by the Secretariat of Health of the city of Buenos Aires is relatively high, outbreaks of vaccine-preventable diseases have occurred, as highlighted by the epidemic of measles in 1997–1998 (7). Therefore, vaccination coverage levels currently achieved among children living in Buenos Aires may be lower than thought, especially in recent years when the economic crisis has aggravated already poor socioeconomic conditions. Because no independent estimate of vaccination coverage has ever been obtained in Buenos Aires, we decided to conduct a population-based vaccination coverage survey.

The objectives of this study were to estimate the vaccination coverage among children aged 13–59 months residing in Buenos Aires for all recommended vaccinations in the NIS using survey methods, to compare the results with vaccination coverage rates estimated by the city health authority, and to identify risk factors associated with incomplete vaccination coverage.

TABLE 1. National Immunization Schedule for children aged less than 5 years, Argentina, 2002

Vaccine	Age					
	Birth	2 months	4 months	6 months	12 months	18 months
BCG[a]	1st dose					
Polio		1st dose	2nd dose	3rd dose		Booster
DTP[b]		1st dose	2nd dose	3rd dose		Booster
Hib[c]		1st dose	2nd dose	3rd dose		Booster
MMR[d,e]					1st dose	
Hepatitis B	1st dose	2nd dose		3rd dose		

[a] Bacillus of Calmette-Guerin.
[b] Combined diphtheria, tetanus and pertussis.
[c] *Haemophilus influenzae* type b.
[d] Combined measles, mumps and rubella.
[e] A second opportunity for vaccination against measles is provided through follow-up campaigns conducted every 3–4 years targeted to children aged 1–4 years.

METHODS

Study design

Overall design. This population interview-based survey used information obtained in face-to-face interviews with the primary caregiver of children aged 13–59 months residing in Buenos Aires. The study was designed to estimate vaccination coverage in two age groups (13–24 months and 25–59 months). The survey was conducted from 8 March to 20 April, 2002, as part of the public health program. A team of 17 professionally-trained interviewers contacted the households initially to enroll children aged 13–24 months. If no child aged 13–24 months resided at the address, they asked if a child aged 25–59 months resided there.

Survey instrument. The survey data collection form included demographic items about the child's date of birth, sex, country of birth, ethnicity, number and age of siblings, child care, and kindergarten attendance. Other items solicited information about the caregiver (age, marital status, employment and education), source of information about vaccinations, the type of vaccination provider used, and insurance coverage. Respondents were also asked about the reasons their child was not vaccinated (if they thought the child was not fully immunized). To assess the child's ethnicity, information on the country of birth of his or her grandparents was obtained. Vaccination providers were classified as public if the respondent mentioned only public hospitals or public healthcare centers at which the child was vaccinated. Otherwise they were classified as private or mixed when a combination of both private and public vaccination centers was mentioned.

The script for the interview was designed in collaboration with sociologists to ensure that all questions were understood. The survey instrument was tested in the field before the survey was launched.

Population and sample selection

The sample size of subjects in each age stratum was calculated for a precision of 4% in the estimate of vaccinated children, with a 95% confidence level assuming a 50% coverage rate (which yielded the lowest precision).

For health purposes, the city of Buenos Aires is divided into 12 program areas which are traditionally grouped in three main zones of the city (Northern, Central and Southern), each zone comprising four program areas. Independently from program areas, the city is divided into 21 school districts. Each school district is divided into fractions which in turn are subdivided into census tracts. There are 1 540 such tracts in the 21 school districts. Each census tract contains approximately 300 dwellings and may comprise one or more blocks (i.e., a group of buildings delimited by several streets). A cumulative community list by census tract, ranked by the percentage of households with unmet basic needs as an indicator of socioeconomic status, was obtained from the National Institute of Statistics and Census (4). This list was used to select a systematic random sample of census tracts. The probability that a census tract would be included was proportional to its population (8). To calculate the number of census tracts to be selected and to ensure that all areas and socioeconomic levels in the city were represented, the number of interviews within each age group for each selected census tract was set at three. When census tracts comprised more than one block, a number was assigned to each block. Subsequently, blocks in the selected census tracts were chosen randomly from maps using a random number.

The survey was conducted from a starting point on the northeast corner of each selected census block that was to be visited to identify eligible children. Interviewers proceeded counterclockwise around the first block, and if necessary, around the next nearest block and subsequent blocks to the north, until the specified number of eligible children was reached. If two or more children within the required age group were found, the child whose birthday was closest to the date of the interview was selected. Children were eligible if their parent or guardian was able to provide a vaccination card with the dates of vaccination. Whenever a child was found and his or her data collected, the interviewers were instructed to skip the next two dwellings to look for the next eligible child, to avoid clustering. When an eligible child was found, the interviewer asked to speak to the primary caregiver on the assumption that this person was mainly responsible for the child's vaccinations. If the primary caregiver was not available, the interviewers revisited the household later, or if this was not possible they interviewed another adult in the household if this person was able to provide the vaccination card.

Households from 215 selected census tracts were visited, and data from vaccination cards for 1 391 children were used to calculate vaccination coverage. Complete information for all other covariates was available for 1 189 children (85.5%), and this was the sample used for the analysis of risk factors.

Data collection

Vaccination coverage. The vaccine doses and dates of vaccination were abstracted from the vaccination card or any other written proof of vaccination.

Antigen-specific coverage was defined as the percentage of children in the sample who had received the recommended number of doses according to their age at the time of the survey. After the last measles outbreak in 1997 (7) until July 2000, an additional dose of measles vaccine was recommended at 6 months of age in Argentina. However, this dose was not considered fully protective and a second dose of measles vaccine was recommended at 12 months of age. For this reason, measles vaccination was considered valid only if any measles-containing vaccine had been administered when the child was 11 months of age or older.

Series-complete vaccination coverage was defined as the percentage of children in the sample who had received all recommended doses by the recommended ages at the time of the study. Complete vaccination for children aged 13–18 months was defined as receipt of the following vaccines: at least 1 BCG, 3 polio, 3 DTP, 3 Hib and 1 MMR. Because hepatitis B was added to the NIS in November 2000, only children born after that date were assumed eligible to receive 3 or more doses of hepatitis B vaccine for the purpose of this analysis. Complete coverage for those aged 19-59 months consisted of at least 1 BCG, 1 MMR, 4 polio, 4 DTP and 4 Hib doses. Data were reported for five age groups (13–18, 19–24, 25–35, 36–47 and 48–59 months) to better reflect age-specific coverage and cohort effects (9).

Risk factors for incomplete vaccination. We investigated factors associated with incomplete vaccination under two schedules. One was based on the vaccines which had been in the NIS for a long time (i.e., BCG, polio, DTP and measles); this schedule is referred to here as the long-standing program. The other comprised both vaccines in the long-standing program and those added more recently (i.e., BCG, polio, DTP, Hib, MMR and hepatitis B), and is termed here the current vaccination program.

Data from administrative sources. Vaccination coverage measured with the survey was compared with coverage estimated from government statistics (i.e., the administrative method). To estimate vaccination coverage, the government agency (Secretariat of Health, city of Buenos Aires) divides the number of doses administered by the target population for each dose. Official coverage rates obtained from the Secretariat of Health of Buenos Aires city for the year 2002 were used to compare BCG, polio, DTP, measles and hepatitis coverage with results of our survey.

Statistical analysis

Information from data collection forms was entered into an Epi-Info database. Paper forms were reviewed to validate and correct inconsistencies. Survey results were analyzed using Epi-Info Version 6 and the SAS statistical package (10, 11). In order to more accurately describe citywide vaccination coverage in children aged 13–59 months, data collected from both age groups were weighted for the population of children in each of the two age strata. Citywide coverage was weighted for the population of children under 5 years of age in each age stratum. McNemar's test was used to compare coverage rates for different vaccines.

Associations between incomplete vaccination and potential predictor variables were sought with the chi-squared or Fisher's two-tailed exact test. For ordinal predictors, chi-squared tests of linear trend were performed. Risk factors identified as significant ($P < 0.05$) for both schedules by univariate analysis were then tested in a multivariate logistic regression model to assess their effects after adjusting for the other covariates.

RESULTS

Immunization coverage

Citywide coverage. Children included in the analysis were distributed equally across all three zones of the city. Slightly more than half (55.6%) were boys, 40.9% of the caregivers reported no health insurance, and 61.5% of the children had received vaccinations through the public health care system only (Table 2). Of the families that used private vaccination services only, 34.8% lived in the Northern, 27.2% in the Central and 14.6% in the Southern zone of the city.

Among children aged 13–59 months, citywide antigen-specific vaccination

TABLE 2. Characteristics of the sample of children (*n* = 1 391) participating in the vaccination coverage survey, Buenos Aires 2002

Characteristic	*n*	%
Age (months)		
13–18	337	24.2
19–24	289	20.8
25–35	305	21.9
36–47	273	19.6
48–59	187	13.4
Sex		
Male	773	55.6
Female	618	44.4
Zone of residence		
Northern	436	31.3
Central	474	34.1
Southern	481	34.6
Child's country of birth		
Argentina	1334	95.9
Other countries	11	0.8
Unknown	46	3.3
Ethnicity		
2 grandparents born in Argentina	1140	82.0
3 grandparents born in any other Latin American country	164	11.8
Other	38	2.7
Unknown	49	3.5
Position in the family		
1st child	607	43.6
2nd child	383	27.5
3rd child or later	318	22.9
Unknown	83	6.0
Day care attendance		
No attendance	727	52.3
Public	336	24.2
Private	274	19.7
Unknown	54	3.9

Characteristic	*n*	%
Vaccination provider		
Public	855	61.5
Private	303	21.8
Both public and private	187	13.4
Unknown	46	3.3
Health insurance		
No health insurance	569	40.9
Union insurance	549	39.5
Private prepaid medicine	214	15.4
Unknown	59	4.2
Age (years) of the primary caregiver		
25	249	17.9
26–35	638	45.9
36	362	26.0
Unknown	142	10.2
Education of the primary caregiver		
No education /Incomplete primary	33	2.4
Primary complete	453	32.6
Secondary complete	484	34.8
Tertiary/University complete	267	19.2
Unknown	154	11.1
Employment of the primary caregiver		
Unemployed	766	55.1
< 40 hours/week	255	18.3
40 hours/ week	217	15.6
Unknown	153	11.0
Type of family		
Two-parent family	1085	78.0
Single-parent family	142	10.2
Unknown	164	11.8

TABLE 3. Vaccination coverage by age group, Buenos Aires, 2002

	Vaccination coverage (%)											
	13–18 m	(95% CI)	19–24 m	(95% CI)	25–35 m	(95% CI)	36–47 m	(95% CI)	48–59 m	(95% CI)	Citywide[a]	(95% CI)
Antigen-specific coverage												
BCG[b]	99.7	(99.1, 100)	99.3	(98.3, 100)	98.7	(97.4, 99.9)	98.5	(97.1, 99.9)	99.5	(98.4, 100)	99.0	(98.4, 99.6)
Polio[c]	91.4	(88.4, 94.4)	70.6	(65.3, 75.9)	82.0	(77.6, 86.3)	86.8	(82.8, 90.9)	88.8	(84.2, 93.3)	84.4	(82.4, 86.5)
DPT[c]	95.0	(92.6, 97.3)	71.6	(66.4, 76.9)	83.3	(79.1, 87.5)	84.6	(80.3, 88.9)	89.8	(85.5, 94.2)	85.1	(83.0, 87.0)
Hib[c]	88.1	(84.7, 91.6)	66.1	(60.6, 71.6)	74.1	(69.2, 79.0)	63.0	(57.2, 68.8)	58.8	(51.7, 65.9)	69.4	(66.0, 7-72)
Measles[b]	81.9	(77.8, 86.0)	91.3	(88.1, 94.6)	93.1	(90.3, 95.9)	95.2	(92.7, 97.8)	94.1	(90.7, 97.5)	92.1	(90.7, 93.5)
Rubella[b]	76.9	(72.3, 81.3)	87.9	(84.1, 91.7)	86.2	(82.3, 90.1)	76.5	(71.5, 81.6)	66.3	(59.5, 73.2)	78.9	(76.6, 81.3)
Mumps[b]	56.1	(50.8, 61.4)	85.5	(81.4, 89.6)	85.2	(81.2, 89.2)	75.5	(70.3, 80,6)	64.7	(57.8, 71.6)	74.9	(72.5, 77.3)
Hepatitis B	59.3	(54.1, 64.6)	27.0	(21.9, 32.1)	26.5	(21.6, 31.5)	25.6	(20.4, 30.9)	31.6	(24.8, 38.3)	31.8	(29.2, 34.3)
Series-complete coverage												
Long-standing program (BCG, polio, DTP, measles)	76.0	(71.4, 80.5)	65.1	(59.5, 70.6)	75.4	(70.5, 80.3)	78.4	(73.5, 83.3)	80.7	(75.0, 86.5)	76	(73.7, 8.4)
Current program (BCG, polio, DTP, Hib, MMR, Hep. B[d])	42.1	(36.8, 47.4)	55.7	(49.9, 61.5)	63.9	(58.5, 69.4)	46.9	(40.9, 52.8)	40.1	(33.0, 47.2)	51.1	(48.3, 54.0)
Current program without mumps (BCG, polio, DTP, Hib, MR, Hep.B[d])	58.5	(53.2, 63.7)	56.7	(51.0, 62.5)	63.9	(58.5, 69.4)	47.3	(41.3, 53.2)	41.2	(34.1, 48.3)	53.8	(50.9, 56.6)

[a] Weighted average among children 13–59 months old citywide.
[b] 1 dose all age groups.
[c] 3 doses 13–18 months and 4 doses 19–59 months.
[d] 3 doses of hepatitis B in children born after 1 November 2000.

coverage rates ranged from 99.0 % for BCG to 69.4 % for Hib (Table 3). Although citywide hepatitis B coverage was only 31.8%, coverage among children born after the vaccine was added to the NIS (November 2000) was 70.4% (95% CI 64.5%–76.3%). For those vaccines requiring a booster at 18 months (i.e., polio, DTP, and Hib), vaccination coverage decreased for the 19-to-24-month age group. In children older than 24 months, coverage rates for vaccines in the long-standing program, such as polio or DTP, increased steadily with the age of the child. However, they decreased for those vaccines added more recently to the schedule. Mumps coverage was lower than rubella coverage in the 13-to-18-month age group (McNemar's test, $P < 0.001$). Citywide vaccination coverage for other vaccines not included in the NIS was .8% (95% CI 14.6%–18.9%) for varicella (≥ 1 dose) and 3.5% (95% CI 1.9%–5.8%) for meningococcus B + C (≥ 2 doses). Pneumococcal vaccine coverage (≥ 3 doses) for children aged 13–18 months was 1.8% (95% CI 0.3%–3.2%).

Series-complete coverage. Series-complete vaccination coverage showed a different pattern for the long-standing program than for the current program. Although coverage in both programs was lower for the 19-to-24-month age group than for the 13-to-18-month age group, it increased steadily in the older age group under the long-standing program (trend test, $P = 0.02$). However, it decreased for children 36 months old or older under the current program.

Administrative data versus current survey data. Among children aged 13–18 months, the coverage estimates for the first dose of BCG, and the third dose of polio, DTP and Hib did not differ substantially between the survey results and the information based on city health authority estimates of the number of doses administered. Among children aged 19–24 months, the survey showed that 91.3% had received at least one dose of measles vaccine, compared with the reported coverage of 116% according to government statistics (Figure 1).

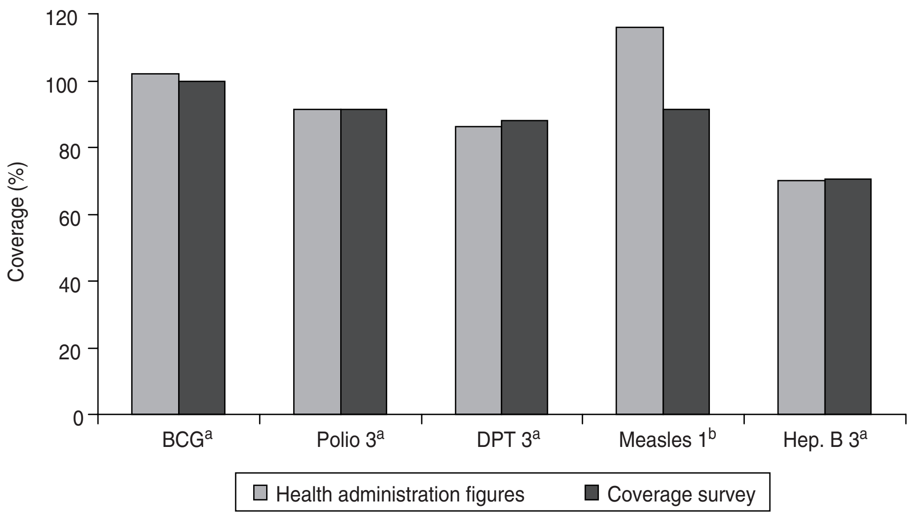
Risk factors for incomplete vaccination

According to the univariate analysis, the child's age, not being a first-born child, not attending day care, use of public vaccination providers only, being uninsured, and low educational level of the caregiver were factors significantly associated with incomplete vaccination under both the long-standing and the current program (Table 4). Children residing in the Northern zone of the city were also less likely to be fully vaccinated under the current program, and not having a two-parent family was a risk factor associated with incomplete vaccination under the long-standing program.

In addition, we observed a direct relationship between vaccination coverage and education of the caregiver for the long-standing program (trend test, $P = 0.006$) and for the current program (trend test, $P < 0.001$).

To determine independent risk factors for incomplete vaccination, a logistic regression model was tested with all the variables that were signifi-

FIGURE 1. Comparison of vaccination coverage rates calculated from health administration figures and observed in a coverage survey. Buenos Aires, 2002



BCG, bacillus of Galmette-Guerin; DTP, combined diphtheria-tetanus-pertussis; Hep. B, hepatitis B.
[a] Coverage survey, children aged 13–18 months.
[b] Coverage survey, children aged 19–24 months.

cant for coverage in the long-standing and the current program. In addition, the zone of the city was included because this variable was thought to be important for vaccination program managers. Because day care attendance was not significant in this model, it was excluded and a second model was tested with the variables age, zone of residence, position in the family, vaccination provider, health insurance, and education of the caregiver. Table 5 shows the adjusted odds ratios estimated from this final logistic regression model for both the long-standing and current programs. After adjustment for all the other variables included in the model, children using only one type of provider were more likely to be unvaccinated compared to children vaccinated by both public and private healthcare providers under both the long-standing ($P < 0.009$) and current programs ($P = 0.01$). Not being the firstborn child was also a risk factor for incomplete vaccination under the long-standing program ($P < 0.001$). Living in the Northern zone of the city ($P = 0.001$) and not having health insurance ($P = 0.02$) and lower educational level of the primary caregiver ($P = 0.04$) were also risk factors associated with incomplete vaccination under the current program.

The three most frequently reported reasons for undervaccination among the 172 respondents who stated that their child was not fully immunized were shortage of money (23.8%), unavailability of the vaccine at the center where the child was usually vaccinated (13.4%), and illness of the child (11.6%).

DISCUSSION

Vaccination coverage

This is the first survey conducted in Buenos Aires among children aged 13–59 months old that provides community-based information on both vaccination coverage and age-appropriate immunization status. In this population, citywide vaccination coverage for individual vaccines was 99% for BCG, 85% for DTP, 84% for polio and 92% for measles. For the more recently introduced vaccines, lower coverage rates were found (69% for Hib, 79% for rubella, 75% for mumps and 70% for hepatitis B). However, series-complete vaccination coverage remains low (51%) among children aged 13–59 months in Buenos Aires.

The higher coverage rates observed for measles vaccine compared with other vaccines administered during the first year of life, such as DTP or polio, may reflect the effect of the follow-up measles vaccination campaigns. The increase in coverage among younger cohorts for the vaccines added most recently to the NIS shows that the program has made progress in achieving its goals in recent years. The decrease in vaccination coverage among children aged 19–24 months for vaccines requiring a booster dose at 18 months (i.e., polio, DTP and Hib) shows that many children receive the booster dose after 24 months of age. This phenomenon accounts for the lowest series-complete coverage in this age group under the long-standing program. Under the current program, the lower coverage rates observed in the 13-to-18-month age group reflects the shortage of mumps vaccine in the public healthcare system in 2001 and 2002. Additionally, lower rates detected in the 48-to-59-month age group reflect the limited success of the program for recently introduced vaccines.

Factors associated with incomplete coverage

Our study also provides information about undervaccinated subgroups in the city of Buenos Aires. In consonance with our findings, low socioeconomic conditions have commonly been associated with lower routine vaccine coverage (12–16). Different coverage rates among children attending public versus private vaccination centers have been reported in other studies (17, 18). In our study, coverage was higher in children served by private facilities than in those served by public or other facilities, and coverage was highest in children served by both public and private facilities. These findings are consistent with those found in the National Immunization Survey of children aged 19–35 months in the USA in 1999 (13). Chil-

TABLE 4. Risk factors for incomplete vaccination with recommended vaccines for the long-standing program (BCG, polio, DTP, measles) and the current program (BCG, polio, DTP, Hib, MMR and hepatitis B) based on univariate analysis, Buenos Aires, 2002

	Long-established program			Current program[a]		
	Unvaccinated			Unvaccinated		
Factor	*n*	%	*P* value	*n*	%	*P* value
Age (months)						
13–18	81	24.0	<0.001	195	57.9	<0.001
19–24	101	34.9		128	44.3	
25–35	75	24.6		110	36.1	
36–47	59	21.6		145	53.1	
48–59	36	19.3		112	59.9	
Sex						
Male	205	26.5	0.2	377	48.8	0.5
Female	147	23.8		313	50.7	
Zone of residence						
Northern	123	28.2	0.1	238	54.6	0.04
Central	121	25.5		222	46.8	
Southern	108	22.5		230	47.8	
Child's country of birth						
Argentina	335	30.8	0.6	660	49.5	0.4
Other countries	4	25.1		8	61.5	
Ethnicity						
2 grandparents born in Argentina	562	49.3	0.8	283	24.8	0.6
3 grandparents born in any other Latin American country	83	50.3		43	26.1	
Other	21	55.3		12	31.6	
Position in the family						
1st child	120	19.8	<0.001	278	45.8	0.04
2nd child	108	28.2		197	51.4	
3rd child or later	102	32.0		172	53.9	
Day care attendance						
No attendance	210	28.9	0.001	368	50.6	<0.001
Public	63	23.1		188	56.0	
Private	63	23.0		109	39.6	
Vaccination provider						
Public	238	27.8	<0.001	464	54.2	<0.001
Private	75	24.8		135	44.6	
Both public and private	26	13.9		69	36.9	
Health insurance						
None	172	30.2	0.001	328	57.6	<0.001
Union-provided medicine	115	20.9		246	44.7	
Private prepaid medicine	50	23.4		87	40.7	
Age (years) of the primary caregiver						
25	69	27.7	0.4	136	54.6	0.1
26–35	159	24.9		315	49.4	
36	83	22.9		166	45.7	
Education of the primary caregiver						
No education /Incomplete primary	11	33.3	0.03	21	63.6	<0.001
Primary complete	132	29.1		256	56.4	
Secondary complete	106	21.9		227	46.9	
University complete	58	21.7		109	40.8	
Employment of the primary caregiver						
Not working	189	24.7	0.9	390	50.9	0.3
< 40 hours/week	62	24.2		117	45.7	
40 hours/ week	57	26.3		106	48.9	
Type of family						
Two-parent family	258	23.8	0.02	528	48.6	0.08
Single-parent family	46	32.4		80	56.3	

[a] 3 doses of hepatitis B in children born after 1 November 2000.

dren attending day care were more likely to be vaccinated in our study, probably because the vaccination card is checked at some day care facilities.

Other risk factors in our study, such as not being the firstborn child and lower educational level of the caregiver, were also found to be associated with incomplete immunization in a study by Bobo et al. (19). These same factors were associated with undervaccination among children by the age of 6 months in New Zealand (20). Although unemployment of the caregiver was found to be a risk factor associated with undervaccination in a similar study conducted in Italy (21), it was not associated with undervaccination in our study or in a study in Flanders, Belgium (22). In Buenos Aires, this may be related to the increasing unemployment levels due to the economic crisis in recent years. In contrast to other studies (14, 15, 23), our analysis did not show that young age of the caregiver was associated with incomplete vaccination. Single-parent families were more likely to have unvaccinated children, as shown in other studies (24, 25). Although ethnicity has been associated with undervaccination (13–16), we did not find a significant difference in ethnicity between vaccinated and unvaccinated children in Buenos Aires.

One unexpected finding was that when other socioeconomic variables were controlled for, children living in the Northern zone of the city, where the socioeconomic level of the population is higher, were less likely to be vaccinated. This may be related to the relative lack of public sector interventions promoting vaccination in this zone.

Approaches to assessing vaccination coverage

Different methods for the assessment of vaccine coverage have been proposed depending on specific situations (26–29). The World Health Organization (WHO) method of sampling 30 clusters of 7 children each (30) is difficult to use in big cities, and the confidence limits of the estimated cov-

TABLE 5. Odds ratio estimates for incomplete vaccination with recommended vaccines for the long-standing program (BCG, polio, DTP, measles) and the current program (BCG, polio, DTP, Hib, MMR and hepatitis B) based on a logistic regression model, Buenos Aires, 2000

	Long-established program		Current program[a]	
	Odds ratio	95% Wald Confidence limits	Odds ratio	95% Wald Confidence limits
Age (months)[b]	(*P* < 0.001)		(*P* < 0.001)	
13–18	1.06	(0.65, 1.72)	0.95	(0.63, 1.43)
19–24	2.00	(1.25, 3.21)	0.51	(0.34, 0.78)
25–35	1.07	(0.66, 1.74)	0.34	(0.23; 0.53)
36–47	0.87	(0.52, 1.45)	0.74	(0.49, 1.14)
48–59	1.00	Referent	1.00	Referent
Zone of residence[b]	(*P* = 0.05)		(*P* = 0.001)	
Northern	1.53	(1.07, 2.17)	1.77	(1.29, 2.42)
Central	1.39	(0.99, 1.96)	1.18	(0.88, 1.58)
Southern	1.00	Referent	1.00	Referent
Position in the family[b]	(*P* < 0.001)		(*P* = 0.06)	
2nd child	1.58	(1.14, 2.19)	1.33	(1.00, 1.76)
3rd child or later	1.87	(1.33, 2.63)	1.34	(0.99, 1.82)
1st child	1.00	Referent	1.00	Referent
Vaccination provider[b]	(*P* = 0.009)		(*P* = 0.01)	
Public	1.98	(1.20, 3.27)	1.76	(1.20, 2.59)
Private	2.26	(1.30, 3.92)	1.74	(1.13, 2.68)
Both private and public	1.00	Referent	1.00	Referent
Health insurance[b]	(*P* = 0.07)		(*P* = 0.02)	
None	1.22	(0.73, 2.05)	1.72	(1.10, 2.69)
Union-provided medicine	0.84	(0.53, 1.33)	1.20	(0.81, 1.78)
Private prepaid medicine	1.00	Referent	1.00	Referent
Education of the primary caregiver[b]	(*P* = 0.15)		(*P* = 0.04)	
No education /Primary incomplete	1.64	(0.70, 3.83)	2.04	(0.89, 4.68)
Primary complete	1.43	(0.93, 2.19)	1.55	(1.08, 2.24)
Secondary complete	1.02	(0.69, 1.53)	1.14	(0.81, 1.59)
University complete	1.00	Referent	1.00	Referent

[a] 3 doses of hepatitis B in children born after 1 November 2000.
[b] P-values in parentheses correspond to the chi-squared test for the factor.

erage (+10%) may be too wide to guide program activities (31). Random digital dialing (26, 32) is difficult to use in settings such as Buenos Aires because approximately 15% of people do not have a home telephone (33), and some people may be unwilling to participate in a coverage survey over the telephone. Vaccination coverage is frequently estimated from the number of doses administered (34). However, there are concerns about the accuracy of this approach (35). This method may not be accurate because of difficulties in calculating the denominator (influenced by population migration, for example) and the numerator (influenced by inclusion of doses given to older children, for example). Our study was nonetheless useful in validating the administrative coverage reported by the Secretariat of Health. The difference observed for measles vaccination is due to the fact that during 2002, many children received an additional dose of MMR vaccine to receive the mumps component because of the previous vaccine shortage. Therefore, the number of measles doses distributed increased while the target population remained stable, increasing the rate vaccination coverage as calculated from the health administration's figures.

Limitations

The results of our study are subject to some limitations. First, only children's vaccination cards were used to determine whether a child had been vaccinated. Having a vaccination card may be associated with a greater likelihood of being vaccinated (17, 36). However, counting only vaccine doses that were documented on a vaccination card (held by approximately 90% of children in Buenos Aires) seems to be the most accurate way to identify children in need of vaccination (37). In fact, parental recall of their child's vaccination history has been shown to be unreliable in many studies (36–38). Second, invalidity of doses because of errors in scheduling (e.g., vaccination before the minimum age for the dose or before the minimum interval to the next dose) was not considered in our analysis, except for measles vaccinations. However, this procedure is habitual in many coverage surveys (16, 22, 23).

Future perspectives for improving coverage

Continuous monitoring and adjustment of the vaccination program are required to accomplish the WHO objectives to eradicate poliomyelitis and eliminate diseases such as diphtheria, neonatal tetanus and measles (39). To reach these goals, minimum coverage levels for a community need to be met (2, 3). In Buenos Aires the thresholds for polio (80%–86%) and diphtheria (80%–85%) have been met. However, the targeted coverage rates for measles or pertussis (95%), mumps (90%) and rubella (85%) remain above the rates found in our study. Measuring coverage levels in the community is an important strategy for improving vaccination coverage rates (40). Sustained efforts by government, physicians and parents are needed to increase these coverage levels, especially for recently introduced vaccines such as Hib, mumps, rubella and hepatitis B. Physicians can encourage higher vaccination rates by following the standards for childhood vaccination and educating caregivers about them. The government should provide the resources (e.g., personnel and training) to ensure the implementation of programs aimed at making quality vaccination services more accessible in underserved sections of the community.

In conclusion, the results of this vaccination coverage survey provide baseline data and information on possible determinants of vaccination levels. This information can be used to develop intervention programs and evaluation activities. Further analyses that examine the ages when vaccines are administered would be useful to document age-appropriate vaccination coverage and vaccination delays.

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RESUMEN

La cobertura de la vacunación en niños de 13 a 59 meses de edad en Buenos Aires, Argentina, en 2002

Objetivos. Calcular la cobertura con el régimen de vacunación completo y con vacunas contra antígenos particulares en niños de 13 a 59 meses de edad en Buenos Aires; comparar los resultados de una encuesta comunitaria a domicilio con los porcentajes de cobertura indicados en los registros públicos; e identificar los factores que ponen a los niños en riesgo de no recibir todas las dosis de vacunas recomendadas bajo el régimen oficial.

Métodos. Se encuestaron sistemáticamente los corredores censales en Buenos Aires en marzo y abril de 2002. En cada cuadra de cada corredor censal se encuestó a tres niños entre las edades de 13 a 24 meses y de 25 a 29 meses. Se solicitaba ver una constancia de vacunación escrita. Se identificaron factores de riesgo asociados con la falta de vacunación completa mediante un análisis unifactorial y regresión logística multifactorial.

Resultados. Se encuestó a un total de 1 391 niños. La cobertura con vacunas contra antígenos particulares varió de 69,4% (IC95%: 66,7%–72%) en el caso de la vacuna contra *Haemophilus influenzae* tipo B a 99% (IC95%: 98,4%–99,6%) en el caso de la vacuna BCG. Exceptuando la vacuna contra el sarampión, las coberturas estimadas mediante la encuesta prácticamente no difirieron de las obtenidas de los registros sanitarios públicos. El análisis de regresión logística multifactorial reveló que la edad del niño ($P < 0{,}001$) y el proveedor de la vacuna (público o privado) ($P = 0{,}001$) eran factores de riesgo asociados con la vacunación incompleta. No ser el primer hijo ($P < 0{,}001$) se asoció con un régimen de vacunas incompleto en el contexto del programa de vacunación habitual. Ser residente de la zona norte de la ciudad ($P = 0{,}001$), no tener seguro ($P = 0{,}02$) y la baja escolaridad del principal guardián del niño ($P = 0{,}04$) fueron factores de riesgo asociados con la administración incompleta del régimen de vacunación bajo el programa de vacunación vigente.

Conclusión. A pesar de que los porcentajes de cobertura con algunas vacunas son altos, sigue siendo baja la frecuencia de la vacunación con el régimen completo en niños de 13 a 59 meses de edad en Buenos Aires. Para poder mejorar esta cobertura tendrá que haber mayor acceso a las vacunas, especialmente en los sectores de la comunidad que están expuestos a los factores de riesgo.