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ARTICLE

Incomplete childhood immunization with new and old vaccines and associated factors: BRISA birth cohort, São Luís, Maranhão State, Northeast Brazil

Incompletude vacinal infantil de vacinas novas e antigas e fatores associados: coorte de nascimento BRISA, São Luís, Maranhão, Nordeste do Brasil

No completar la vacunación infantil tanto de vacunas nuevas como antiguas y sus factores asociados: cohorte de nacimiento BRISA, São Luís, Maranhão, Nordeste de Brasil

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Abstract

This study estimated the percentages of incomplete immunization with new vaccines and old vaccines and associated factors in children 13 to 35 months of age belonging to a birth cohort in São Luís, the capital of Maranhão State, Brazil. The sample was probabilistic, with 3,076 children born in 2010. Information on vaccination was obtained from the Child's Health Card. The new vaccines, namely those introduced in 2010, were meningococcal C and 10-valent pneumococcal, and the old vaccines, or those already on the childhood immunization schedule, were BCG, hepatitis B, human rotavirus, polio, tetravalent (diphtheria, tetanus, pertussis, Haemophilus influenzae *b), yellow fever, and triple viral (measles, mumps, rubella). The study used hierarchical modeling and Poisson regression with robust variance. Prevalence ratios (PR) and 95% confidence intervals (95%CI) were calculated. Incomplete immunization was higher with new vaccines (51.1%) than with old vaccines (33.2%). Children 25 to 35 months of age (PR = 1.27; 95%CI: 1.14-1.41) and those in economic classes D/E (PR = 1.20; 95%CI: 1.06-1.35) were only significantly associated with new vaccines; low maternal schooling (PR = 1.58; 95%CI: 1.21-2.06), unavailability of outpatient and/or hospital care for the child (PR = 1.20; 95%CI: 1.04-1.38), and unavailability of the vaccine in health services (PR: 1.28; 95%CI: 1.12-1.46) were only associated with old vaccines. Immunization strategies should consider the vulnerability of older preschool-age children and those belonging to classes D and E, especially when new vaccines are introduced, as well as children of mothers with low schooling. Strategies should also address problems with the availability of health services and vaccines.*

Immunization Coverage; Immunization Programs; Child Health

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Introduction

Immunization is one of the safest and most cost-effective public health interventions for prevent deaths and improving quality of life, especially in populations with greater social vulnerability like those in situations of poverty [1]. Immunization makes an important contribution to achieving one of the Millennium Development Goals, namely the reduction in infant mortality, since unvaccinated children are susceptible to greater childhood morbidity and mortality [2].

In Brazil, access to vaccines is free through the National Immunization Program (PNI) [3], which sets the criteria for immunization coverage for the vaccines in the National Childhood Immunization Schedule, namely 90% for BCG (bacillus Calmette-Guérin) and human rotavirus vaccines; 95% for hepatitis B and polio, tetravalent (adsorbed diphtheria, tetanus, pertussis and *Haemophilus influenzae* b), meningococcal C, 10-valent pneumococcal, triple viral (measles, mumps, rubella) vaccines; and 100% for yellow fever vaccine [4]. Monitoring immunization coverage is important to verify whether these parameters are being reached [3].

The large and self-sustainable increase in the number of vaccines incorporated by PNI in the last decade [3] was made possible by the fact that immunization is one of the most cost-effective public health measures [2].

Estimates from an immunization survey conducted in Brazil's 26 state capitals and Federal District from August 2007 to May 2008 in children 18 to 30 months of age showed the following percentages of coverage for vaccines from the National Childhood Immunization Schedule in 2006: BCG (97%), polio (96%), DTP (diphtheria, tetanus, and pertussis) (94%), hepatitis B (91%), and triple viral (measles, mumps, rubella) (91%), indicating that only the first two reached the targets recommended by the Brazilian Ministry of Health [5] and that 17.4% of children failed to receive all the vaccines recommended up to 18 months of age. The survey estimated 28.3% incomplete childhood immunization in São Luís, Maranhão State [6], a similar percentage to that found in a household survey in the same city (28.1%) in 2006 [7].

Studies have suggested demographic and socioeconomic factors associated with higher percentages of incomplete childhood immunization, including: male gender [7], child's higher birth order [6,8], mother's work away from home [9], low maternal schooling [8,9], children of adolescent mothers [8], female heads of families [9], mother's black skin color [9], head-of-family's black skin color [7], and poorer economic classes [1,7]. However, other authors differ as to socioeconomic status by identifying higher percentages of incomplete immunization in children from wealthier economic strata [5,6].

The introduction of the meningococcal C and 10-valent pneumococcal vaccines in 2010 in the National Childhood Immunization Schedule for the first year of life led to the need to estimate percentages of incomplete immunization as well as to analyze factors associated with incomplete coverage with recently introduced vaccines. As far as we know this is the first study to assess incomplete coverage of new vaccines introduced in childhood immunization in Brazil.

We thus propose to estimate percentages of incomplete coverage of vaccines in the National Childhood Immunization Schedule for the first year of life and associated factors, both for the immunization schedule for new vaccines and the immunization schedule for old vaccines in children 13 to 35 months of age. The model includes socioeconomic and demographic factors, extensively explored in the literature, as well as factors that have received less attention, such as behavioral characteristics (smoking, alcohol consumption, and planning of pregnancy) and maternal reproductive characteristics (preterm birth and/or low birth weight and pregnancy in the first year after the index child's birth), and use of prenatal health services (trimester of first prenatal visit, number of visits, and health service used), and child's health (unavailability of outpatient care, hospital care, and vaccines).

Methods

Study design

The study consists of a prospective cohort (BRISA – *Brazilian Birth Cohorts Study in Ribeirão Preto and São Luís*), conducted in the two cities at two time points: birth and follow-up in the second year of life [10]. The current study used the data from the city of São Luís, for the two moments.

Study population and sample

In São Luís, the BRISA birth cohort consisted of a probabilistic sample of children and their mothers, who had given birth in 2010 in 10 different public and private hospitals with more than 100 deliveries per year each, which accounted for 94.7% of the births that year [10].

The sample selection was systematic and stratified proportionally according to the number of deliveries per hospital. A casual initial sample of one to three was picked for each hospital, and only newborn infants of families residing in the municipality were eligible [10].

A total of 7,133 births were selected, of which 5,475 were eligible, since the families lived in the municipality of São Luís. Of these, 5,236 interviews were conducted, with 239 losses (4.4%) due to refusals and early hospital discharge. The number of live born children whose mothers were interviewed was 5,166, of whom 3,308 returned for follow-up in the second year of life, while 1,858 (36%) failed to return due to refusals, failure to appear, or failure to locate the mothers [10] (Figure 1).

The study excluded 232 children (7%) whose mothers failed to present the Child's Health Card, resulting in a final sample of 3,076 children 13 to 35 months of age (Figure 1).

For the current study, we estimated that a minimum sample of 3,030 children would have 90% power to identify significant prevalence ratios of 1.2 or greater for factors associated with incomplete immunization, with a 1:1 ratio between exposed and unexposed, considering 39% expected prevalence of incomplete immunization [1,5,6,7,8,9], minimum 6% difference between prevalence rates, and 5% likelihood of type I error.

Data collection instrument and procedures

Data were collected at two moments:
(1) Birth – data were collected daily in the maternity wards or hospitals from January to December 2010 through interviews with the mothers in the first 48 hours postpartum, and the information was complemented from the mothers' and children's patient charts;
(2) Follow-up in the second year of life – data were collected from January 2011 to March 2013. All the mothers were invited by telephone contact or home visit to return for the follow-up. Information on immunization was obtained directly from the children's health cards.

Variables

The hierarchical analytical model was based on a theoretical model of the factors associated with incomplete childhood immunization [1,5,6,7,8,9,11], considering the hierarchical relationship between the variables associated with incomplete immunization (Figure 2) [1,6,7].

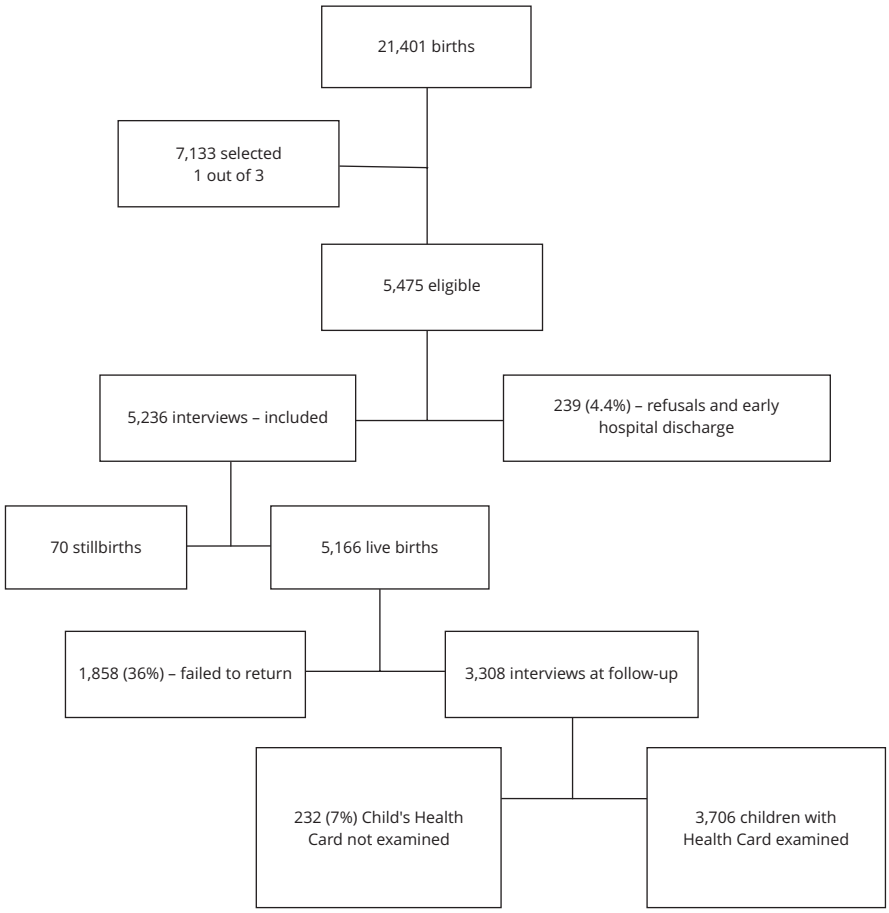
- **Dependent variables**

The outcome variables were the immunization schedule for new vaccines and the immunization schedule for old vaccines, both categorized as complete or incomplete.

The new vaccines variable was obtained from the two vaccines incorporated in 2010 into the National Childhood Immunization Schedule. Only the complete schedule qualified, as recommended by the National Immunization Program: two doses of the meningococcal C vaccine and three doses of the 10-valent pneumococcal vaccine [12]. Incomplete immunization with new vaccines was defined as failure to receive the recommended number of doses for at least one of the two vaccines.

Figure 1

Sampling flowchart for BRISA birth cohort, at birth and at follow-up in the second year of life. São Luís, Maranhão State, Brazil, 2010-2013.



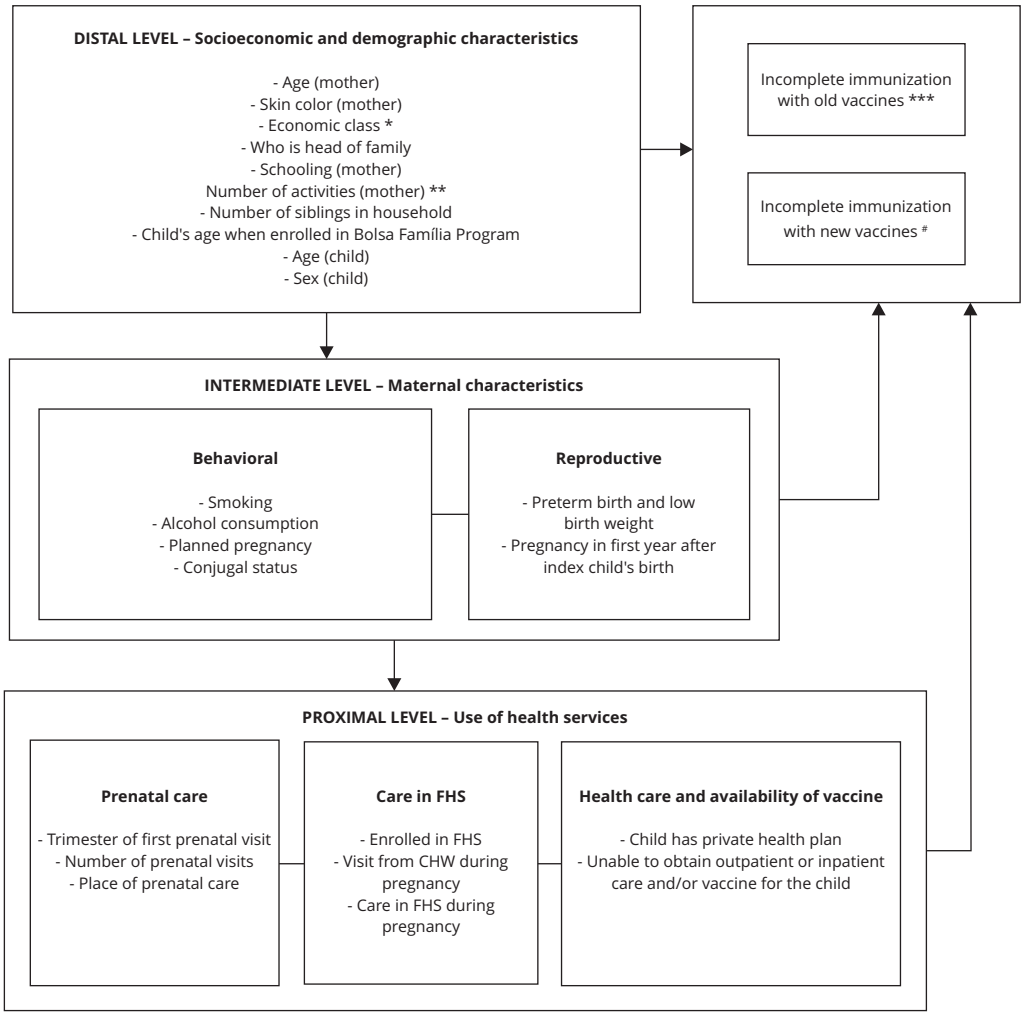
The old vaccines variable was obtained from the seven vaccines that were already part of the Ministry of Health's National Childhood Immunization Schedule in 2010. The recommended immunization schedule for each vaccine was categorized as complete or incomplete. Complete was defined as: one dose for BCG, three for hepatitis B, two for human rotavirus, three for polio, three for tetravalent (adsorbed diphtheria, tetanus, pertussis, *Haemophilus influenzae* b), one for yellow fever, and one for triple viral (measles, mumps, rubella) [12]. Incomplete immunization with old vaccines was defined as failure to receive the recommended number of doses of at least one of the seven vaccines.

- **Independent variables**

The independent variables were organized in three hierarchical levels.
(1) Distal level – consisting of socioeconomic and demographic variables from the birth questionnaire: mother's age in years (adult: > 19 versus adolescent: ≤ 19); mother's self-reported skin color (white, brown, or black); family's economic class according to the criteria of the Brazilian Market Research Association – ABEP (A/B, C, or D/E) [13]; head of household (interviewee's male partner/spouse, interviewee's mother/father, interviewee herself, other); maternal schooling in years (≤ 4, 5-8,

Figure 2

Theoretical-conceptual hierarchical model for analysis of factors associated with incomplete immunization with new and old vaccines in children 13 to 35 months of age. BRISA birth cohort, São Luís, Maranhão State, Brazil, 2010-2013.



CHW: community health worker; FHS: Family Health Strategy.

* Economic class as defined by the Brazilian Market Research Association (ABEP) [13];

** Number of activities by the mother, consisting of school, paid work, and/or housework. Mother does not do any of the above-mentioned activities (0), does one of the above (1), does two of the above (2), or does all three (3);

*** Incomplete immunization with the old vaccines: failure to receive at least 1 dose of BCG (bacillus Calmette-Guérin), 3 of hepatitis B, 2 of human rotavirus, 3 of polio, 3 of tetravalent (adsorbed diphtheria, tetanus, pertussis, *Haemophilus influenzae* b), 1 of triple viral (measles, mumps, rubella), or 1 of yellow fever vaccine. These vaccines were part of the official childhood immunization schedule throughout the year 2010;

Incomplete immunization with the new vaccines: failure to receive at least 3 doses of 10-valent pneumococcal or 2 doses of meningococcal C vaccines. These vaccines were incorporated into the official childhood immunization schedule in 2010.

9-11, ≥ 12); number of activities performed by the mother (0, 1, 2, or 3), which included school, paid work, and/or housework; number of index child's siblings living in the household (0, 1, 2-3, or > 3). The distal level also included variables from the follow-up questionnaire in the second year of life: child's sex (male or female); child's age in months (13-18, 19-24, or 25-35); child's enrollment in the *Bolsa Família* Program (child not enrolled, family enrolled before child's birth, child enrolled from 0-6, 7-12, or > 12 months of age).

(2) Intermediate level – consisting of maternal behavioral and reproductive characteristics from the birth questionnaire: conjugal status (married, common-law marriage, without partner); planned pregnancy (yes or no), low birth weight and/or preterm birth (yes or no). Preterm birth was defined as birth at gestational age less than 37 weeks, and low birth weight was defined as < 2,500g. Gestational age (GA) was based on date of last menstrual (DLMP) reported by the mother. Day 15 was used when the exact date was unknown but the month of last menstrual period was known. Birth weights considered inconsistent with GA were recoded as unknown. Cases of implausible GA (less than 20 weeks or more than 43 weeks) were also reclassified as unknown [10]. The intermediate level also included variables from the follow-up questionnaire: maternal smoking (does not smoke versus currently smokes); mother's alcohol consumption (does not drink versus currently drinks); new pregnancy within the first year after the index child's birth (no or yes).

(3) Proximal level – including use of health services (prenatal care, Family Health Strategy (FHS), and pediatric care reported by the mother. The variables used from the birth questionnaire were trimester of first prenatal visit (1st, 2nd, or 3rd); number of prenatal visits (≥ 6; < 6); place of prenatal care (public versus private sector); visit by community health worker (CHW) during pregnancy (yes or no); care in FHS during pregnancy (yes or no). The variables used from the follow-up questionnaire were enrollment in the FHS (yes or no); private health plan for the child (yes or no); use of inpatient, outpatient, or immunization services by the child (yes, no due to lack of vaccine, no for other reasons).

Statistical analysis and data processing

We verified whether there were differences in the percentages of follow-up according to selected variables. Those with statistically significant differences according to the chi-square test (economic class, maternal schooling, number of prenatal visits, and place of prenatal care) were included in a logistic model to predict each child's probability of appearing. Next, the weighting factor was calculated as the inverse of the probability of appearing.

Descriptive analyses were performed, with estimates of the absolute and relative frequencies for the independent variables, with the latter weighted, plus prevalence rates of incomplete immunization for the two outcomes (new vaccines and old vaccines) and according to individual vaccine.

Bivariate and multivariate analyses were performed with Poisson regression with robust variance and hierarchical modeling in order to estimate prevalence ratios (PR) between the independent variables and each type of incomplete immunization [14]. Each level of the model included the variables belonging to the respective level that showed p-value less than 0.20 in the bivariate analysis. In the adjusted model, for each level, only the variables with p-value less than 0.05 were kept. For each hierarchical level, we simultaneously introduced only variables from the same level, in addition to those from previous levels that were significant. The estimates for each variable obtained in the model for the respective hierarchical levels were considered. Adjustments were made for the child's age in all the hierarchical levels, since the opportunities for immunization were not the same for all children according to age, since immunization status as of the moment of the interview was used.

The models were weighted by the inverse of the probability of appearing for the follow-up in the second year of life, through a set of svy commands, assigning greater weight to children that were similar to those that failed to appear for follow-up.

Level of significance was set at 5%, with 95% confidence intervals (95%CI). No colinearity was identified between the explanatory variables. Statistical analyses used Stata version 12.0 (StataCorp LP, College Station, USA).

Ethical aspects

The research project was approved by the Institutional Review Board of the University Hospital, Federal University of Maranhão (HUUFMA), case review 223/2009. Mothers that agreed to participate in the study signed the free and informed consent form.

Results

Immunization with new vaccines was more incomplete (51.1%) than with old vaccines (33.2%). The BCG (0.5%) and polio vaccines (4.2%) showed the lowest percentages of incompleteness, while meningococcal C (32.2%) and 10-valent pneumococcal (48.9%) showed the highest (Table 1).

In the unadjusted analysis, the highest percentages of incompleteness for new vaccines were in children 25 to 35 months of age, belonging to classes D/E, enrolled in the *Bolsa Família* Program after one year of age, living with one or more siblings in the household, without a private health plan, with difficulty using health services (outpatient and inpatient), and whose mothers had zero to four years of schooling, smoked, lived in common-law marriage or without a partner, had not planned the pregnancy, had become pregnant in the first year after the index child's birth, had begun prenatal care in the third trimester, had fewer than six prenatal visits, had prenatal care in the public healthcare sector, and had not received care from the FHS during pregnancy (Table 2).

In the adjusted hierarchical analysis, incompleteness for new vaccines was 1.27 times higher in children 25 to 35 months of age (PR = 1.27; 95%CI: 1.14-1.41) and 1.20 times higher in children from socioeconomic classes D/E (PR = 1.20; 95%CI: 1.06-1.35). Incompleteness increased proportionally to the number of the child's siblings in the household, by 29% for those living with one sibling (PR = 1.29; 95%CI: 1.19-1.40), 33% with two or three siblings (PR = 1.33; 95%CI: 1.24-1.52), and 36% with more than three siblings (PR = 1.36; 95%CI: 1.11-1.67). Incompleteness was also more frequent in children whose mothers were adolescents (PR = 1.15; 95%CI: 1.05-1.27), smoked (PR = 1.22; 95%CI: 1.07-1.40), had not planned the pregnancy (PR = 1.09; 95%CI: 1.00-1.18), had become pregnant in the first year after the index child's birth (PR = 1.16; 95%CI: 1.03-1.29), had begun prenatal care late (3rd trimester) (PR = 1.27; 95%CI: 1.07-1.52), and had had fewer than six prenatal visits (PR = 1.16 95%CI: 1.06-1.25) (Table 2).

In the unadjusted analysis, old vaccines showed higher incompleteness in children from socioeconomic classes D/E, that lived with one or more siblings in household, of mothers with zero to four or five to eight years of schooling, and whose mothers smoked, consumed alcohol, or were in common-law marriages or without partners. Children whose mothers had not planned the pregnancy, had become pregnant in the first year after the index child's birth, had begun prenatal care in the second or third trimester, had fewer than six prenatal visits, and had not received a home visit by a community health worker during pregnancy showed higher percentages of incomplete immunization. Higher incompleteness was also seen in children without private health plans, who had difficulty using outpatient and inpatient health services, and that attended health services where there was a shortage of vaccines (Table 3).

In the adjusted hierarchical analysis, incompleteness of old vaccines was 26% more frequent in children of adolescent mothers (PR = 1.26; 95%CI: 1.10-1.45), 1.58 times greater when mothers had fewer than five years of schooling (PR = 1.58; 95%CI: 1.21-2.06), and 52% greater in children whose mothers smoked (PR = 1.52; 95%CI: 1.28-1.82). The proportion of incompleteness increased with the number of siblings in the household, by 32% for children living with one sibling (PR = 1.32; 95%CI: 1.17-1.49), 55% for those with two or three siblings (PR = 1.55; 95%CI: 1.34-1.80), and 81% for those with more than three siblings (PR = 1.81; 95%CI: 1.41-2.33). Incompleteness was also greater in children whose mothers had not planned the pregnancy (PR = 1.18; 95%CI: 1.05-1.31), had become pregnant in the first year after the index child's birth (PR = 1.22; 95%CI: 1.04-1.43), had had fewer than six prenatal visits (PR = 1.25; 95%CI: 1.11-1.40), and who had initiated prenatal care in the third trimester (PR = 1.40; 95%CI: 1.06-1.86). Shortage of vaccine in health services was associated with 28% more incomplete immunization (PR = 1.28; 95%CI: 1.12-1.46) and the unavailability of

Table 1

Characteristics of children 13 to 35 months of age and incomplete immunization. BRISA cohort, São Luís, Maranhão State, Brazil, 2010-2013.

Variables	n (N = 3,076)	% *
Distal level – socioeconomic and demographic charateristics		
Mother's age (n = 3,076)		
Adult	2,537	82.6
Adolescent	539	17.4
Mother's skin color (n = 3,037)		
White	539	17.3
Brown	2,089	69.3
Black	409	13.4
Economic class ** (n = 3,076)		
A/B	564	16.5
C	1,783	59.8
D/E	729	23.7
Who is head of family (n = 3,058)		
Interviewee's spouse/partner	1,846	61.0
Interviewee's mother/father	537	17.4
Other	397	12.9
Interviewee	278	8.7
Mother's schooling in years (n = 3,043)		
≥ 12	419	12.3
9-11	2,244	75.5
5-8	310	9.9
0-4	70	2.3
Number of activities by mother *** (n = 3,076)		
0	96	3.0
1	1,798	58.3
2	1,062	34.8
3	120	3.9
Number of child's siblings living in the household (n = 3,076)		
0	1,517	49.9
1	991	32.2
2-3	493	15.6
> 3	75	2.3
Child's age, in months, when enrolled in *Bolsa Família* Program (n = 2,957)		
Not enrolled	2,148	72.1
Familiy enrolled before child was born	359	12.3
0-6	113	3.9
7-12	169	5.9
> 12	168	5.8
Child's age in months (n = 3,076)		
13-18	2,061	67.7
19-24	713	22.8
25-35	302	9.5
Child's sex (n = 3,076)		
Male	1,572	51.3
Female	1,504	48.7

(continues)

Table 1 (continued)

Variables	n (N = 3,076)	% *
Intermediate level – maternal characteristics		
Behavioral		
Smokes (n = 3,048)		
No	2,904	95.5
Yes	144	4.5
Alchool consumption (n = 3,048)		
No	2,396	78.8
Yes	652	21.2
Planned pregnancy (n = 3,073)		
No	974	31.9
Yes	2,099	68.1
Conjugal status (n = 3,076)		
Married	656	20.6
Common-law marriage	1,826	60.2
Without partner	594	19.2
Reproductive history		
Preterm and/or low birth weight (n = 2,687)		
No	2,258	84.3
Preterm	220	8.0
Low birth weight	86	3.1
Preterm and low birth weight	123	4.6
New pregnancy in firts year after birth of index child (n = 3,050)		
No	2,789	91.7
Yes	261	8.3
Proximal level – use of health services		
Prenatal care		
Trimester of firts prenatal visit (n = 2,983)		
1st	2,097	70.9
2nd	833	27.4
3rd	53	1.7
Number of prenatal visits (n = 2,957)		
≥ 6	1,968	69.5
< 6	989	30.5
Place of prenatal care (n = 3,038)		
Private sector	489	13.1
Public sector	2,549	86.9
Care in FHS		
Enrolled in FHS (n = 3,073)		
Yes	583	19.1
No	2,490	80.9
Visit by CHW during pregnancy (n = 3,074)		
Yes	970	32.5
No	2,104	67.5
Care in FHS during pregnancy (n = 3,073)		
Yes	352	11.5
No	2,721	88.5
Healthcare and availability of vaccine		
Child has private health plan (n = 3,076)		
Yes	821	25.8
No	2,255	74.2

(continues)

Table 1 (continued)

Variables	n (N = 3,076)	% *
Proximal level – use of health services		
Healthcare and availability of vaccine		
Use of outpatient, inpatient, and immunization services by child (n = 3,076)		
Yes	2,185	71.2
No, for other reasons	418	13.6
No, for lack of vaccine	473	15.2
Outcomes for individual vaccines – incomplete immunization #		
BCG	17	0.5
Polio	135	4.2
Hepatitis B	178	5.8
Tetravalent	251	7.9
Yellow fever	310	9.5
Triple viral	341	10.6
Human rotavirus	591	18.8
Meningococcal C	1,012	32.2
10-valent pneumococcal	1,537	48.9
Immunization schedule, old vaccines ##	1,045	33.2
Immunization schedule, new vaccines ###	1,605	51.1

CHW: community health worker; FHS: Family Health Strategy.

Note: differences between the sums of the absolute values and the total sample are due to missing data;

* Estimates weighted for sampling losses;

** Economic class according to the Brazilian Market Research Association (ABEP) [13];

*** Number of activities done by mother, consisting of school, paid work, and/or housework. Mother does not do any of the above-mentioned activities (0), does one (1), does two (2), or does all three (3);

Incomplete immunization according to Brazilian Ministry of Health guidelines;

Incomplete immunization with old vaccines: failure to receive at least 1 dose of BCG (bacillus Calmette-Guérin), 3 of hepatitis B, 2 of human rotavirus, 3 of polio, 3 of tetravalent (adsorbed diphtheria, tetanus, pertussis, and *Haemophilus influenzae* b), 1 of triple viral (measles, mumps, rubella), or 1 of yellow fever vaccine. These vaccines comprised the official childhood immunization schedule throughout 2010;

Incomplete immunization with new vaccines: failure to receive at least 3 doses of 10-valent pneumococcal or 2 of meningococcal C vaccines. These vaccines were incorporated into the official childhood immunization schedule in 2010.

outpatient and/or inpatient care for the child was associated with 20% greater incompleteness (PR = 1.20; 95%CI: 1.04-1.38) (Table 3).

Discussion

Incomplete childhood immunization in São Luís was more common for new vaccines (51%) than for old vaccines (33%).

This study identified different factors associated with new vaccines and old vaccines: older children and classes D/E were variables associated with more incomplete immunization for new vaccines, while low maternal schooling, unavailability of outpatient and/or inpatient care for children, and unavailability of vaccine in health services were associated with more incomplete immunization with old vaccines. In addition, some factors were associated with incomplete immunization with both new vaccines and old vaccines: living with one or more siblings in the household, children of adolescent mothers, and mothers that smoked, had not planned the pregnancy, had become pregnant in the first year after the index child's birth, had had fewer than six prenatal visits, and had initiated prenatal care in the third trimester.

Table 2

Unadjusted and adjusted analysis of characteristics of children 13 to 35 months of age and incomplete immunization with new vaccines at the three hierarchical levels. BRISA birth cohort, São Luís, Maranhão State, Brazil, 2010-2013.

Variables	Incomplete immunization with new vaccines *				
		Unadjusted		Adjusted **	
	% ***	PR (95%CI) ***	p-value ***	PR (95%CI) ***	p-value ***
Distal level – socioeconomic and demographic charateristics					
Mother's age			0.162		**0.002**
Adult	50.5	1.00		1.00	
Adolescent	53.8	1.06 (0.97-1.16)		**1.15 (1.05-1.27)**	
Mother's skin color			0.620		
White	50.0	1.00			
Brown	51.6	1.03 (0.93-1.13)			
Black	49.2	0.98 (0.86-1.12)			
Economic class #			**< 0.001**		**0.004**
A/B	45.8	1.00		1.00	
C	50.1	1.09 (0.98-1.21)		1.04 (0.97-1.20)	
D/E	57.2	**1.24 (1.11-1.39)**		**1.20 (1.06-1.35)**	
Who is head of family			0.591		
Interviewee's spouse/partner	50.1	1.00			
Interviewee's mother/father	51.9	1.03 (0.94-1.14)			
Other	51.3	1.02 (0.91-1.14)			
Interviewee	54.2	1.08 (0.95-1.22)			
Mother's schooling in years			**< 0.001**		
≥ 12	42.2	1.00			
9-11	51.2	**1.21 (1.06-1.37)**			
5-8	56.9	**1.34 (1.15-1.57)**			
0-4	67.9	**1.60 (1.31-1.97)**			
Number of activities by mother ##			0.085		
0	58.1	1.00			
1	52.5	0.90 (0.75-1.08)			
2	48.4	0.83 (0.68-1.00)			
3	47.6	0.82 (0.62-1.06)			
Number of child's siblings living in the household			**< 0.001**		**< 0.001**
0	44.6	1.00		1.00	
1	56.0	**1.25 (1.15-1.36)**		**1.29 (1.19-1.40)**	
2-3	60.0	**1.34 (1.22-1.48)**		**1.33 (1.24-1.52)**	
> 3	61.4	**1.37 (1.12-1.68)**		**1.36 (1.11-1.67)**	
Child's age, in months, when enrolled in *Bolsa Família* Program			**0.043**		
Not enrolled	50.1	1.00			
Familiy enrolled before child was born	55.1	1.10 (0.99-1.22)			
0-6	42.5	0.84 (0.67-1.06)			
7-12	49.1	0.98 (0.83-1.15)			
> 12	58.2	**1.16 (1.01-1.33)**			
Child's age in months			**< 0.001**		**< 0.001**
13-18	48.8	1.00		1.00	
19-24	53.2	1.09 (0.99-1.18)		1.07 (0.98-1.17)	
25-35	61.9	**1.26 (1.14-1.40)**		**1.26 (1.14-1.39)**	
Child's sex			0.851		
Male	51.2	1.00			
Female	50.9	1.00 (0.93-1.08)			

(continues)

Table 2 (continued)

Variables	Incomplete immunization with new vaccines *				
		Unadjusted		Adjusted **	
	% ***	PR (95%CI) ***	p-value ***	PR (95%CI) ***	p-value ***
Intermediate level – maternal characteristics					
Behavioral					
Smokes			**< 0.001**		**0.003**
No	50.3	1.00		1.00	
Yes	64.2	**1.27 (1.11-1.46)**		**1.22 (1.07-1.40)**	
Alchool consumption			0.722		
No	50.7	1.00			
Yes	51.5	1.01 (0.93-1.10)			
Planned pregnancy			**0.002**		**0.028**
No	46.7	1.00		1.00	
Yes	53.2	**1.13 (1.05-1.23)**		**1.09 (1.00-1.18)**	
Conjugal status			**0.019**		
Married	45.8	1.00			
Common-law marriage	52.5	**1.14 (1.04-1.26)**			
Without partner	52.1	**1.13 (1.01-1.28)**			
Reproductive history					
Preterm and/or low birth weight			0.641		
No	50.5	1.00			
Preterm	51.8	1.02 (0.89-1.17)			
Low birth weight	47.3	0.92 (0.74-1.18)			
Preterm and low birth weight	45.1	0.89 (0.72-1.09)			
New pregnancy in firts year after birth of index child			**0.001**		**0.009**
No	50.1	1.00		1.00	
Yes	59.9	**1.19 (1.07-1.33)**		**1.16 (1.03-1.29)**	
Proximal level – use of health services					
Prenatal care					
Trimester of firts prenatal visit			**< 0.001**		**0.002**
1st	49.7	1.00		1.00	
2nd	52.7	1.06 (0.97-1.14)		0.93 (0.85-1.01)	
3rd	74.3	**1.49 (1.26-1.76)**		**1.27 (1.07-1.52)**	
Number of prenatal visits			**< 0.001**		**0.001**
≥ 6	47.3	1.00		1.00	
< 6	58.4	**1.22 (1.13-1.31)**		**1.15 (1.06-1.25)**	
Place of prenatal care			**< 0.001**		
Private sector	42.5	1.00			
Public sector	52.3	**1.23 (1.10-1.39)**			
Care in FHS					
Enrolled in FHS			0.814		
Yes	51.5	1.00			
No	50.9	0.98 (0.90-1.08)			
Visit by CHW during pregnancy			0.051		
Yes	53.6	1.00			
No	49.8	0.92 (0.86-1.00)			
Care in FHS during pregnancy			**0.023**		
Yes	56.6	1.00			
No	50.2	**0.88 (0.80-0.98)**			

(continues)

Table 2 (continued)

Variables	Incomplete immunization with new vaccines *				
		Unadjusted		Adjusted **	
	% ***	PR (95%CI) ***	p-value ***	PR (95%CI) ***	p-value ***
Proximal level – use of health services					
Healthcare and availability of vaccine					
Child has private health plan			**< 0.001**		
Yes	43.3	1.00			
No	53.7	**1.24 (1.13-1.35)**			
Use of outpatient, inpatient, and immunization services by child			**0.001**		
Yes	50.0	1.00			
No, for other reasons	58.2	**1.16 (1.05-1.27)**			
No, for lack of vaccine	49.4	0.98 (0.88-1.09)			

95%CI: 95% confidence interval; CHW: community health worker; FHS: Family Health Strategy; PR: prevalence ratio.

Note: significant estimates in bold (p < 0.005).

y in Ribeirão Preto and São Luís;

* Incomplete immunization with new vaccines: failure to have receive at least 3 doses of 10-valent pneumococcal or 2 doses of meningococcal C vaccine, according to Brazilian Ministry of Health guidelines. Vaccines incorporated into the National Childhood Immunization Schedule in the year 2010;

** Estimates of association adjusted for variables from the same level and for significant variables from the previous levels;

*** Estimates weighted for sampling losses;

Economic class according to the Brazilian Market Research Association (ABEP) [13];

Number of activities done by mother, consisting of school, paid work, and/or housework. Mother does not do any of the above-mentioned activities (0), does one (1), does two (2), or does all three (3).

The study's limitations include lack of information on the dates when the vaccine doses were administered, thus preventing analyses of valid and/or on-schedule doses. The study only used the criterion of number of doses administered, without analyzing the respective dates [3]. Sampling losses were weighted by the inverse of the probability of appearing at the follow-up in the second year of life, and this probability was estimated from the variables associated with follow-up, seeking to reduce the selection bias and increase the findings' external validity.

Meanwhile, the study's strengths include the prospective longitudinal design, random sampling of births of children of mothers residing in São Luís in 2010, and the large sample size, which tends to increase the estimates' precision. Probabilistic sampling was used to reduce selection bias, and information on immunization was obtained from the child's health card, which can reduce possible measurement bias. We opted for Poisson regression with robust adjustment of variance due to the high prevalence of both outcomes, which could lead to overestimating the risk [14]. A hierarchical approach was used to facilitate interpretation of the observed associations [15] and minimize confounding. Associations with immunization were investigated that have received little attention in the literature, like some maternal behavioral characteristics (smoking and planning of pregnancy) and maternal reproductive characteristics (pregnancy in the first year after the index child's birth); and use of prenatal health services (fewer than six prenatal visits and first prenatal visit in the third trimester) and the child's health (unavailability of outpatient and/or inpatient care for the child and unavailability of vaccine in the health services). One characteristic not found in other studies is the evaluation of incomplete immunization with vaccines recently incorporated into the childhood immunization schedule.

Higher incompleteness rates were found with the meningococcal C and 10-valent pneumococcal vaccines, which were only incorporated into childhood immunization in Brazil in 2010 [12]. This could be related to various factors, such as: discontinuity in the supply of these new vaccines [3], delay in training the health professionals, and lack of indication of these new vaccines by health professionals, due to lack of awareness of them [16]. In addition, since the new vaccines are injectable, some parents may have resisted vaccinating their children, especially with the 10-valent pneumococcal vaccine, because it was scheduled in such a way that the third dose coincided with two other injectable

Table 3

Unadjusted and adjusted analysis of characteristics of children 13 to 35 months of age and incomplete immunization with old vaccines at the three hierarchical levels. BRISA birth cohort, São Luís, Maranhão State, Brazil, 2010-2013.

Variables	Incomplete immunization with old vaccines *				
		Undajusted		Adjusted **	
	% ***	PR (95%CI) ***	p-value ***	PR (95%CI) ***	p-value ***
Distal level – socioeconomic and demographic charateristics					
Mother's age			0.115		**0.001**
Adult	32.6	1.00		1.00	
Adolescent	36.2	1.10 (0.97-1.26)		**1.26 (1.10-1.45)**	
Mother's skin color			0.427		
White	30.9	1.00			
Brown	33.6	1.08 (0.94-1.25)			
Black	34.7	1.12 (0.92-1.35)			
Economic class #			**0.019**		
A/B	29.0	1.00			
C	33.0	1.13 (0.97-1.32)			
D/E	36.7	**1.26 (1.07-1.49)**			
Who is head of family			0.177		
Interviewee's spouse/partner	32.5	1.00			
Interviewee's mother/father	35.4	1.09 (0.95-1.25)			
Other	30.6	0.94 (0.79-1.11)			
Interviewee	37.5	1.15 (0.97-1.37)			
Mother's schooling in years			**< 0.001**		**< 0.001**
≥ 12	29.4	1.00		1.00	
9-11	31.9	1.08 (0.91-1.29)		0.99 (0.83-1.18)	
5-8	42.9	**1.46 (1.18-1.79)**		1.20 (0.96-1.49)	
0-4	54.7	**1.86 (1.42-2.44)**		**1.58 (1.21-2.06)**	
Number of activities by mother ##			0.864		
0	36.9	1.00			
1	32.8	0.89 (0.67-1.18)			
2	33.5	0.90 (0.68-1.21)			
3	34.1	0.92 (0.63-1.34)			
Number of child's siblings living in the household			**< 0.001**		**< 0.001**
0	28.1	1.00		1.00	
1	35.8	**1.27 (1.13-1.44)**		**1.32 (1.17-1.49)**	
2-3	41.9	**1.49 (1.31-1.72)**		**1.55 (1.34-1.80)**	
> 3	52.7	**1.87 (1.47-2.40)**		**1.81 (1.41-2.33)**	
Child's age, in months, when enrolled in *Bolsa Família* Program			0.052		
Not enrolled	31.9	1.00			
Familiy enrolled before child was born	33.7	1.05 (0.89-1.23)			
0-6	38.8	1.21 (0.94-1.55)			
7-12	29.2	0.91 (0.71-1.16)			
> 12	41.3	1.29 (1.06-1.57)			
Child's age in months			0.552		
13-18	33.5	1.00			
19-24	31.7	0.94 (0.83-1.07)			
25-35	35.1	1.04 (0.88-1.24)			
Child's sex			0.927		
Male	33.2	1.00			
Female	33.3	0.99 (0.89-1.10)			

(continues)

Table 3 (continued)

Variables	Incomplete immunization with old vaccines *				
		Undajusted		Adjusted **	
	% ***	PR (95%CI) ***	p-value ***	PR (95%CI) ***	p-value ***
Intermediate level – maternal characteristics					
Behavioral					
Smokes			**< 0.001**		**< 0.001**
No	32.3	1.00		1.00	
Yes	52.3	**1.61 (1.35-1.92)**		**1.52 (1.28-1.82)**	
Alchool consumption			0.012		
No	32.1	1.00			
Yes	37.4	**1.16 (1.03-1.31)**			
Planned pregnancy			**< 0.001**		**0.009**
No	28.5	1.00		1.00	
Yes	35.5	**1.24 (1.10-1.40)**		**1.18 (1.05-1.31)**	
Conjugal status			**0.022**		
Married	28.7	1.00			
Common-law marriage	33.9	**1.18 (1.02-1.36)**			
Without partner	35.7	**1.25 (1.06-1.48)**			
Reproductive history					
Preterm and/or low birth weight			0.283		
No	32.9	1.00			
Preterm	36.8	1.11 (0.92-1.34)			
Low birth weight	24.9	0.75 (0.51-1.10)			
Preterm and low birth weight	35.5	1.07 (0.83-1.38)			
New pregnancy in firts year after birth of index child			**0.010**		**0.009**
No	32.6	1.00		1.00	
Yes	40.4	**1.23 (1.05-1.45)**		**1.22 (1.04-1.43)**	
Proximal level – use of health services					
Prenatal care					
Trimester of firts prenatal visit			**< 0.001**		**0.038**
1st	30.4	1.00		1.00	
2nd	39.2	**1.28 (1.15-1.43)**		1.08 (0.96-1.22)	
3rd	53.5	**1.75 (1.34-2.29)**		**1.40 (1.06-1.86)**	
Number of prenatal visits			**< 0.001**		**< 0.001**
≥ 6	29.5	1.00		1.00	
< 6	41.8	**1.41 (1.27-1.56)**		**1.25 (1.11-1.40)**	
Place of prenatal care			0.078		
Private sector	29.4	1.00			
Public sector	33.8	1.14 (0.98-1.34)			
Care in FHS					
Enrolled in FHS			0.576		
Yes	32.2	1.00			
No	33.5	1.03 (0.90-1.18)			
Visit by CHW during pregnancy			**0.042**		
Yes	35.8	1.00			
No	32.1	**0.89 (0.80-0.99)**			
Care in FHS during pregnancy			0.050		
Yes	37.9	1.00			
No	32.6	0.86 (0.74-1.00)			

(continues)

Table 3 (continued)

Variables	Incomplete immunization with old vaccines *				
		Undajusted		Adjusted **	
	% ***	PR (95%CI) ***	p-value ***	PR (95%CI) ***	p-value ***
Proximal level – use of health services					
Healthcare and availability of vaccine					
Child has private health plan			**< 0.001**		
Yes	26.8	1.00			
No	35.5	1.32 (1.15-1.50)			
Use of outpatient, inpatient, and immunization services by child			**< 0.001**		**< 0.001**
Yes	30.3	1.00		1.00	
No, for other reasons	40.3	**1.33 (1.16-1.52)**		**1.20 (1.04-1.38)**	
No, for lack of vaccine	40.8	**1.34 (1.18-1.53)**		**1.28 (1.12-1.46)**	

95%CI: 95% confidence interval; CHW: community health worker; FHS: Family Health Strategy; PR: prevalence ratio.

Note: significant estimates in bold (p < 0.005).

* Incomplete immunization with old vaccines: failure to have received at least 1 dose of BCG (bacillus Calmette-Guérin), 3 of hepatitis B, 2 of human rotavirus, 3 of polio, 3 of tetravalent (adsorbed diphtheria, tetanus, pertussis, and *Haemophilus influenzae* b), 1 triple viral (measles, mumps, rubella), or 1 of yellow fever vaccine according to the Ministry of Health guidelines. These vaccines were part of the official childhood immunization schedule throughout 2010;

** Estimates of association adjusted for variables from the same level and for significant variables from the previous levels;

*** Estimates weighted for sampling losses;

Economic class according to the Brazilian Market Research Association (ABEP) [13];

Number of activities done by mother, consisting of school, paid work, and/or housework. Mother does not do any of the above-mentioned activities (0), does one (1), does two (2), or does all three (3).

vaccines [12]. Parents' lack of awareness of these new vaccines may also have compromised the demand for and adherence to them. Parents may fail to vaccinate their children out of fear of multiple injections [17] and adverse reactions [18].

The BCG and polio vaccines showed lower estimated incompleteness rates [6,7,19,20]. BCG is administered in a single dose to the newborn while still in-hospital. The oral polio vaccine was administered in the first year,3 which facilitated adherence, and this vaccine is also promoted in annual vaccination drives during which children have their immunization updated [5].

Prior to the current study, population-based studies in São Luís that obtained information from the child's health card showed different incompleteness rates for old vaccines, which were highest in the year 1994 (47.3%) [19], decreasing in 2006 (28.1%) [7], 2007 (28.3%) [5], and in the current study. This reduction may have been due to the FHS, implemented in São Luís in 1996, and the *Bolsa Família* Program, created in 2003, since both may have helped improve childhood immunization coverage [20,21].

Compared to other studies in Brazil, the current study showed higher incompleteness with old vaccines (33%) [6,7]. An immunization survey in 26 state capitals and the Federal District in 2007 showed far lower incompleteness estimates at 18 months of age in Teresina, Piauí State (5%), Cuiabá, Mato Grosso State (6%), Brasília (6%), and Curitiba, Paraná State (2%), and higher in Recife, Pernambuco State (41%) and Macapá, Amapá State (38%) [5]. International studies have also reported lower incompleteness, as in Australia (6%), in children up to twelve months of age [22], as well as in less developed countries like Mozambique (28.3%) [23] and Kenya (23.3%) [24], in children under two years. Low immunization coverages can lead to an accumulation of susceptible individuals and greater risk of spread of vaccine-preventable diseases [2].

Among the factors associated with incomplete immunization specifically with new vaccines, the study showed higher incompleteness in children from classes economic D and E. This may be explained by the "inverse equity hypothesis" proposed by Victora et al. [25], according to which a new public health intervention initially favors the wealthier and only later reaches the poorer population. It may also be due to the greater likelihood of health services' use by the more privileged socioeconomic classes [26], which could favor referring children for immunization. Since mothers from

underprivileged classes access health services less, they may also have failed to spontaneously seek these new vaccines, due to lack of awareness.

Incomplete immunization with new vaccines alone was also identified with the 25 to 35 month age bracket, which suggests difficulty for the children to receive these vaccines during their implementation phase, when the 10-valent pneumococcal and meningococcal C vaccines were only made available to children up to 24 months of age, and after 12 months the child only received one dose of them [3].

For factors associated with incomplete immunization with old vaccines only, children of mothers with low schooling (0 to 4 years) tend to have lower immunization coverage. Silva et al. [19] found this in São Luís in 1994. Nearly two decades later, this barrier has still not been overcome. Other studies have shown the same result [8,9].

Among the factors that have received less attention and are associated with incomplete immunization with old vaccines only, we identified the mother's difficulty in obtaining outpatient and inpatient care for the child, since difficulty in using healthcare services can lead to missed opportunities for immunization, and this can jeopardize compliance with the childhood immunization schedule [27]. These same variables were not associated with new vaccines, probably due to health professionals' unawareness of these vaccines.

Another factor that has received little attention and that was only associated with incompleteness with old vaccines was the lack of vaccine in immunization services. Shortages and discontinuity in immunization services can also mean missed opportunities for immunization [3]. The lack of association with new vaccines may also have resulted from mothers' initial unawareness of these vaccines, resulting in not appearing at health services to obtain these vaccines for their children.

As for factors associated with incomplete immunization with both new vaccines and old vaccines, lower immunization was observed in children of adolescent mothers, corroborating other studies [8,28]. Teenage pregnancy can be unfavorable to the children's health [29,30], given the mother's emotional immaturity [31] and lack of experience in caring for the child [32].

This study suggests that the more the children living with the mother, the higher the likelihood of the child's incomplete immunization for both outcomes, old and new vaccines. Barata et al. [6] in Brazil and international studies [8,9,28] have reported similar findings. A mother with many children is likely to have less available time and more difficulty in appearing at the health unit, or may not have anyone to leave the other children with to take the child for vaccination.

Among the maternal characteristics, one that has received less attention in studies is smoking, which in this study was associated with incompleteness with both old vaccines and new vaccines. Mother's smoking may indicate insufficient self-care, and this behavior may be reflected in less care for the child, including incomplete immunization. Self-care is revealed in activities that individuals perform consciously, voluntarily, and intentionally in their own benefit with the purpose of maintaining life, health, and well-being [33], and the same is true for immunization and the child's health.

Another aspect with little attention in studies is children born of unplanned pregnancies, who showed higher incompleteness rates for both old vaccines and new vaccines. Some mothers may have difficulty in accepting and coping with an unplanned pregnancy, which could be reflected in less care for the child's health [34], including immunization.

A new pregnancy soon after the index child's birth, another characteristic that has received little attention in other studies, was also associated with higher percentages of incomplete immunization with both old and new vaccines. After the birth of a new child, the mother has to meet all the demands from the prenatal care, plus caring for two children under three years of age, which demands more time. Studies have already shown that the more siblings a child has, the less likely the child is to be completely immunized [1].

Another aspect associated with higher percentages of incomplete immunization with old and new vaccines was the mother initiating prenatal care in the third trimester or having fewer than six prenatal visits. These findings may result from the fact that pregnant women who have adequate prenatal care are more likely to be more concerned about their health and thus show greater adherence to health services, including their children's immunization.

In order to promote greater protection of children against vaccine-preventable diseases, it is important for immunization strategies to address the vulnerability of older children belonging to

underprivileged socioeconomic classes and that live with more siblings, whose mothers are adolescents, smokers, had not planned the pregnancy, became pregnant in the first year after the child's birth, began prenatal care late in the pregnancy and had fewer than six visits, especially when new vaccines are being introduced in the National Childhood Immunization Schedule, as well as children of mothers with low schooling. Strategies should also focus on the vulnerability resulting from the mother's difficulty in obtaining outpatient and hospital care for the child, as well as the shortage of vaccines in health services.

Contributors

F. S. Silva and R. C. S. Queiroz participated in the study conception and project, data analysis and interpretation, writing of the article, and approval of the final version for publication. E. B. A. F. Thomaz, M. R. F. C. Branco, V. M. F. Simões, M. R. C. Ribeiro, M. A. Batalha, Y. C. Barbosa, W. R. M. Araújo and A. A. M. Silva participated in the data analysis and interpretation, relevant critical revision of the intellectual content, and approval of the final version for publication. All authors takes responsibility for all aspects of the research, guaranteeing the accuracy and integrity of all parts of the work.

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References

1. Barata RB, Pereira SM. Desigualdades sociais e cobertura vacinal na cidade de Salvador, Bahia. Rev Bras Epidemiol 2013; 16:266-77.
2. World Health Organization. Immunization: national programmes and systems. http://www.who.int/immunization/en/ (accessed on 06/Feb/2017).
3. Ministério da Saúde. Manual de normas e procedimentos para vacinação. Brasília: Ministério da Saúde; 2014.
4. Departamento de Articulação Interfederativa, Secretaria de Gestão Estratégica e Participativa, Ministério da Saúde. Caderno de diretrizes, objetivos, metas e indicadores: 2013-2015. Brasília: Ministério da Saúde, 2013. (Série Articulação Interfederativa, 1).
5. Moraes JCR. Inquérito de cobertura vacinal nas áreas urbanas das capitais, Brasil: cobertura vacinal 2007. São Paulo: Centro de Estudos Augusto Leopoldo Ayrosa Galvão; 2007.
6. Barata RB, Ribeiro MCSA, Moraes JC, Flannery B. Socioeconomic inequalities and vaccination coverage: results of an immunisation coverage survey in 27 Brazilian capitals, 2007-2008. J Epidemiol Community Health 2012; 66:934-41.
7. Yokokura AVCP, Silva AAM, Bernardes ACF, Lamy Filho F, Alves MTSSB, Cabra NAL, et al. Cobertura vacinal e fatores associados ao esquema vacinal básico incompleto aos 12 meses de idade, São Luís, Maranhão, Brasil, 2006. Cad Saúde Pública 2013; 29:522-34.
8. Mutua MK, Kimani-Murage E, Ettarh RR. Childhood vaccination in informal urban settlements in Nairobi, Kenya: who gets vaccinated? BMC Public Health 2011; 11:6.
9. Wiysonge CS, Uthman OA, Ndumbe PM, Hussey GD. Individual and contextual factors associated with low childhood immunisation coverage in sub-Saharan Africa: a multilevel analysis. PLoS One 2012; 7:e37905.
10. Silva AAMD, Batista RFL, Simões VMF, Thomaz EBAF, Ribeiro CCC, Lamy Filho F, et al. Changes in perinatal health in two birth cohorts (1997/1998 and 2010) in São Luís, Maranhão State, Brazil. Cad Saúde Pública 2015; 31:1437-50.

11. Queiroz LLC, Monteiro SG, Mochel EG, Veras MADSM, Sousa FGMD, Bezerra MLDM, et al. Cobertura vacinal do esquema básico para o primeiro ano de vida nas capitais do Nordeste brasileiro. Cad Saúde Pública 2013; 29:294-302.
12. Ministério da Saúde. Portaria nº 3.318, de 28 de outubro 2010. Institui em todo o território nacional o Calendário Básico de Vacinação da Criança, o Calendário do Adolescente e o Calendário do Adulto e Idoso. Diário Oficial da União 2010; 29 out.
13. Associação Brasileira de Empresas de Pesquisa. Critério de classificação econômica Brasil. http://www.abep.org/criterio-brasil (accessed on 02/Feb/2017).
14. Hirakata VN. Estudos transversais e longitudinais com desfechos binários: qual a melhor medida de efeito a ser utilizada? Rev HCPA & Fac Med Univ Fed Rio Gd do Sul 2009; 29:174-6.
15. Westreich D, Greenland S. The table 2 fallacy: presenting and interpreting confounder and modifier coefficients. Am J Epidemiol 2013; 177:292-8.
16. Domingues CMAS, Teixeira AMS. Coberturas vacinais e doenças imunopreveníveis no Brasil no período 1982-2012: avanços e desafios do Programa Nacional de Imunizações. Epidemiol Serv Saúde 2013; 22:9-27.
17. Logullo P, Carvalho HB, Saconi R, Massad E. Fatores que afetam a adesão ao calendário de vacinação contra o sarampo em uma cidade brasileira. São Paulo Med J 2008; 126:166-71.
18. Figueiredo GLA, Pina JC, Tonete VLP, Lima RAG, Mello DF. Experiências de famílias na imunização de crianças brasileiras menores de dois anos. Rev Latinoam Enferm 2011; 19:598-605.
19. Silva AAM, Gomes UA, Tonial SR, Silva RA. Cobertura vacinal e fatores de risco associados à não vacinação em localidade urbana do Nordeste brasileiro 1994. Rev Saúde Pública 1999; 33:147-56.
20. Guimarães TMR, Alves JGB, Tavares MMF. Impacto das ações de imunização pelo Programa Saúde da Família na mortalidade infantil por doenças evitáveis em Olinda, Pernambuco, Brasil. Cad Saúde Pública 2009; 25:868-76.
21. Andrade MV, Chein F, Souza LRD, Puig-Junoy J. Income transfer policies and the impacts on the immunization of children: the Bolsa Família Program. Cad Saúde Pública 2012; 28:1347-58.
22. Hull BP, Lawrence GL, MacIntyre CR, McIntyre PB. Immunisation coverage in Australia corrected for under-reporting to the Australian Childhood Immunisation Register. Aust N Z J Public Health 2003; 27:533-8.
23. Jani JV Schacht C, Jani IV, Bjune G. Risk factors for incomplete vaccination and missed opportunity for immunization in rural Mozambique. BMC Public Health 2008; 8:161.
24. Maina LC, Karanja S, Kombich J. Immunization coverage and its determinants among children aged 12-23 months in a peri-urban area of Kenya. Pan Afr Med J 2013; 14:3.
25. Victora CG, Vaughan JP, Barros FC, Silva AC, Tomasi E. Explaining trends in inequities: evidence from Brazilian child health studies. Lancet 2000; 356:1093-8.
26. Travassos C, Castro MSM. Determinantes e desigualdades sociais no acesso e na utilização de serviços de saúde. In: Giovanella L, organizadora. Políticas e sistemas de saúde no Brasil. Rio de Janeiro: Editora Fiocruz; 2008. p. 183-203.
27. Silva ZP, Ribeiro MCS, Barata RB, Almeida MF. Perfil sociodemográfico e padrão de utilização dos serviços de saúde do Sistema Único de Saúde (SUS), 2003-2008. Ciênc Saúde Coletiva 2011; 16:3807-16.
28. Pearce A, Law C, Elliman D, Cole TJ, Bedford H. Factors associated with uptake of measles, mumps, and rubella vaccine (MMR) and use of single antigen vaccines in a contemporary UK cohort: prospective cohort study. BMJ 2008; 336:754-7.
29. Simões VMF, Silva AAM, Bettiol H, Lammy-Filho F, Tonial SR, Mochel EG. Características da gravidez na adolescência em São Luís, Maranhão. Rev Saúde Pública 2003; 37:559-65.
30. World Health Organization. Pregnancy: adolescent pregnancy. http://www.who.int/mediacentre/factsheets/fs364/en/ (accessed on 12/Feb/2017).
31. Bigras M, Paquette D. Estudo pessoa-processo-contexto da qualidade das interações entre mãe-adolescente e seu bebê. Ciênc Saúde Coletiva 2007; 12:1167-74.
32. Hoga LAK. Maternidade na adolescência em uma comunidade de baixa renda: experiências reveladas pela história oral. Rev Latinoam Enferm 2008; 16:280-6.
33. Bub MBC, Medrano C, Silva CD, Wink S, Liss PE, Santos EKA. A noção de cuidado de si mesmo e o conceito de autocuidado na enfermagem. Texto Contexto Enferm 2006; 15:152-7.
34. Dourado VG, Pelloso SM. Gravidez de alto risco: o desejo e a programação de uma gestação. Acta Paul Enferm 2007; 20:69-74.

Resumo

Neste estudo, foram estimados percentuais de incompletude vacinal e fatores associados ao esquema vacinal para novas vacinas (EVNV) e esquema vacinal para antigas vacinas (EVAV) em crianças de 13 a 35 meses de idade de uma coorte de nascimento em São Luís, Maranhão, Brasil. A amostra foi probabilística, com 3.076 crianças nascidas em 2010. Informações sobre vacinação foram obtidas da Caderneta de Saúde da Criança. As vacinas consideradas para o EVNV foram meningocócica C e pneumocócica 10 valente, e para EVAV, vacinas BCG, hepatite B, rotavírus humano, poliomielite, tetravalente (vacina difteria, tétano, coqueluche e Haemophilus influenzae *b), febre amarela, tríplice viral (vacina sarampo, caxumba, rubéola). Empregou-se modelagem hierarquizada e regressão de Poisson com variância robusta. Estimaram-se razões de prevalência (RP) e intervalos de 95% de confiança (IC95%). Incompletude vacinal foi maior para EVNV (51,1%) em relação ao EVAV (33,2%). Crianças com 25 a 35 meses de idade (RP = 1,27; IC95%: 1,14-1,41) e pertencer às classes D/E (RP = 1,20; IC95%: 1,06-1,35) se associaram somente ao EVNV; enquanto baixa escolaridade materna (RP = 1,58; IC95%: 1,21-2,06), indisponibilidade de atendimento ambulatorial e/ou hospitalar para a criança (RP = 1,20; IC95%: 1,04-1,38) e de vacina nos serviços de saúde (RP = 1,28; IC95%: 1,12-1,46), apenas ao EVAV. Faz-se importante considerar, nas estratégias de vacinação, a vulnerabilidade de crianças com mais idade e pertencentes às classes D e E, especialmente quando novas vacinas são introduzidas, e ainda de filhos de mães que possuem baixa escolaridade. Assim como, quando há menor disponibilidade de serviços de saúde para a criança e de vacina.*

Cobertura Vacinal; Programas de Imunização; Saúde da Criança

Resumen

En este estudio se estimaron porcentajes de vacunación no completada y los factores asociados al esquema de vacunas para nuevas vacunas (EVNV) y al de antiguas vacunas (EVAV), en niños de 13 a 35 meses de edad de una cohorte de nacimiento en São Luís, Maranhão, Brasil. La muestra fue probabilística, con 3.076 niños nacidos en 2010. La información sobre la vacunación se obtuvo de la cartilla de salud del niño. Las vacunas consideradas para el EVNV fueron la meningocócica C y neumocócica 10 valente, y para EVAV, vacunas BCG, hepatitis B, rotavirus humano, poliomielitis, tetravalente (vacuna difteria, tétanos, tosferina y Haemophilus influenzae *b), fiebre amarilla, triple viral (vacuna contra el sarampión, paperas, rubeola). Se empleó un modelo jerarquizado y la regresión de Poisson con variancia robusta. Se estimaron razones de prevalencia (RP) e intervalos de 95% de confianza (IC95%). La vacunación no completada fue mayor para EVNV (51,1%), en relación con el EVAV (33,2%). Ser niños de 25 a 35 meses de edad (RP = 1,27; IC95%: 1,14-1,41) y pertenecer a las clases D/E (RP = 1,20; IC95%: 1,06-1,35) se asociaron solamente al EVNV; mientras que la baja escolaridad materna (RP = 1,58; IC95%: 1,21-2,06), indisponibilidad de atención ambulatoria y/o hospitalaria para el niño (RP = 1,20; IC95%: 1,04-1,38) y de la vacuna en los servicios de salud (RP = 1,28; IC95%: 1,12-1,46), solamente al EVAV. Es importante considerar, en las estrategias de vacunación, la vulnerabilidad de los niños con más edad y pertenecientes a las clases D y E, especialmente cuando se introducen las nuevas vacunas, incluyendo también a los hijos de madres con baja escolaridad. También es problemática la existencia de una menor disponibilidad de servicios de salud para el niño y de la vacuna.*

Cobertura de Vacunación; Programas de Inmunización; Salud del Niño

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