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Factors associated with the completeness of the vaccination schedule of children at 12 and 24 months of age in a Brazilian medium-size municipality

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ABSTRACT

Purpose: To analyse the factors associated with the completeness of the vaccination schedule of children at 12 and 24 months of age, in a Brazilian municipality.
Design and methods: Cross-sectional study conducted in Araraquara-São Paulo with a probabilistic sample of 388 children born in 2015. The completeness of the vaccination schedule at 12 and 24 months of age was considered a dependent variable. Socioeconomic and demographic characteristics, use of health services and vaccination were the independent variables. For analysis, descriptive statistics and Poisson regression with robust variance were used.
Results: The completeness of the vaccination schedule at 12 and 24 months of age was identified in 77.1% and 68.8% of children, respectively. Coverage at 12 months was greater among children of mothers who received guidance from health professionals on vaccination or had health problems during childbirth or in the first seven days. Those who reported a previous episode of adverse reaction to the vaccine, coverage was lower. Coverage at 24 months was greater among those who received guidance from health professionals on vaccination or had health problems during childbirth or in the first seven days. Those who reported a previous episode of adverse reaction to the vaccine, coverage was lower.
Conclusions: This study points to the importance of guiding health professionals, particulary nurses, on the vaccination and vaccine safety.
Clinical implications: It is necessary the competent act of the health professionals in of immunization programs, as they are able to provide clear and accurate information of the vaccination.

Introduction

Vaccination, an important public health intervention, has provided great benefits for the individual and for society. In addition to the individual benefits, most vaccines provide important social benefits, such as the indirect effect of protection, in which immunized people protect the unvaccinated, such as babies of an age not recommended for the vaccine and those with delayed vaccination, reducing in this way the exposure to vaccine-preventable diseases and, consequently, reducing the burden of the disease and its financial costs (Thompson et al., 2018).

Worldwide, vaccination prevents two to three million deaths per year, however, 1.5 million deaths could be prevented by increasing vaccine coverage (Organização Pan-americana da Saúde, 2020), which constitutes a major challenge for health systems. Since 2010, the global coverage of three doses of Tetanus, Diphtheria and Pertussis vaccine (TDP) and one dose of measles vaccine has been around 86%, which requires efforts to achieve and sustain better vaccine coverage in order to increase protection against vaccine-preventable diseases (Feldstein et al., 2017).

In Brazil, actions developed by the National Immunization Program (PNI) have guaranteed vaccine coverage above 95%, contributing to the reduction of child morbidity and mortality in the last 40 years. However, there has been a considerable drop in coverage of the 3rd dose of TDP and 1st of the measles vaccine, reaching in 2018 only 88.77% of children (Departamento de informática do SUS, 2020a).

This decrease in vaccination coverage may be related to several factors, which generally involve socioeconomic and demographic aspects, access to and link to health and knowledge services, and the mother's or guardian's attitude towards vaccination (Tauil et al., 2016). These factors can behave in different ways according to the context and its social determinants (Glatman-freedman & Nichols, 2012).

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It is worth mentioning the conflicting associations with vaccine acceptance, reflecting differences in beliefs about vaccines in the socioeconomic strata (Kennedy et al., 2011); religious belief, in which different types of religions influence the decision to vaccinate (Antai, 2009); the use of the internet, which in the face of the relentless search for knowledge, becomes a vehicle for information that can result in increased public distrust in vaccination in several countries (Harmsen et al., 2013); and the perception of the risk of adverse events as predictors of vaccine behaviour (Healy & Pickering, 2011).

In addition to all these challenges, the emergence of the pandemic caused by the new coronavirus (COVID-19), currently makes routine vaccination a major challenge for public health. WHO and UNICEF have warned of the alarming decline in the number of children receiving recommended vaccine doses. According to new data from WHO and UNICEF, this situation threatens to reverse all the hard-won progress over time to reach more children and adolescents with a wider range of vaccines, which has already been hampered by a decade of paralyzed coverage (World Health Organization, 2020a).

Thus, the objective of the study was to analyse the factors associated with the completeness of the vaccination schedule of children at 12 and 24 months of age in a Brazilian municipality.

Methods

A cross-sectional study with analysis of primary data from a probabilistic sample of children living in the city of Araraquara-SP, born in 2015 was conducted. Araraquara is located in the central region of the State of São Paulo, southeastern Brazil, being one of the most developed and richest regions in the country. It has a population of about 210,000 inhabitants, with approximately 3000 live births per year. The Municipal Human Development Index is 0.815 and 97.2% of its population lives in the urban area (Atlas do Desenvolvimento Humano no Brasil, 2020). The municipality has a successful vaccination program and has high vaccination coverage so that vaccine-preventable diseases have been controlled since the 1990s (Departamento de informática do SUS, 2020b). Since 1987, there has been an electronic immunization registry for the population, called the Juarez System. Currently, the Juarez System has also been used as an electronic municipal health registry, including consultation data and compulsory reporting of diseases.

The study population consisted of children born in 2015, living in the city of Araraquara and registered in the Juarez System. To calculate the minimum sample size, a confidence coefficient was considered, whose value was 1.96 for an alpha of 0.05; outcome frequency of 40% (Ferreira et al., 2018); and maximum error in absolute value of 0.05 (Berquo et al., 1981). Thus, a minimum sample size $= (1.96^2 \times 0.4 \times 0.6)/0.05^2 = 369$ was obtained.

The stratified probabilistic sample was captured from the Juarez System, through a draw without replacement. In order to obtain a representative sample, the municipality was divided into geographic units, formed by a grouping of census sectors (Instituto Brasileiro de Geografia e Estatística, 2011). In this way, each of the 15 geographical units of Araraquara represented a stratum. The final population for the random sample was 3054 children, of which 450 children were drawn, considering an increase of 20% of the calculated minimum sample size.

Children born in 2015, living in Araraquara and who had a vaccination record at the time of the interview were included. Children who were not accompanied by their biological mother at the time of the interview, who moved to another municipality before reaching 24 months of age, institutionalized children, and those who died before reaching 24 months of age were excluded.

Data collection was carried out from August to October 2018, by 10 field interviewers and four supervisors, who underwent theoretical-practical training, with a 10-h workload distributed over two consecutive days. The application of questionnaires and standardization of interviews were addressed in order to control the quality of information. A pilot study was carried out to adapt the instrument, which involved 20 mothers from the municipality of Araraquara, not included in the study.

To assess the completeness of the vaccination schedule (dependent variable), the following definitions recommended by the National Immunization Program (PNI) were used:

- Complete vaccination schedule at 12 months: one dose of BCG vaccine, three doses of Pentavalent vaccine (tetanus, diphtheria, and pertussis (TDP); Haemophilus influenzae type b-Hib, hepatitis B- HEP B), three doses of Poliomyelitis (inactivated-VIP), two doses and a booster of Pneumococcal 10 vaccine, two doses of Rotavirus Human vaccine, two doses and a reinforcement of Meningococcal C vaccine (conjugated), a dose of Yellow Fever vaccine and a dose of Triple Viral vaccine (measles, mumps, and rubella);
- Complete vaccination schedule at 24 months: in addition to the previously taken vaccines at 12 months, the schedule includes a reinforcement with the TDP vaccine, a reinforcement of the poliomyelitis vaccine (attenuated OPV), a dose of hepatitis A vaccine and a dose of tetra viral vaccine.

Valid doses were those that respected the minimum and maximum ages of dose application, as well as the appropriate interval between doses for vaccines with a multidose schedule.

The independent variables were selected and categorized, according to national studies (Barata et al., 2002, 2012; Buffarini et al., 2020; Ferreira et al., 2018; Tauil et al., 2016; Yokokura et al., 2013), Brazilian Institute of Geography and Statistics (IBGE)(Instituto Brasileiro de Geografia e Estatística, 2020), health guidelines of the Ministry of Health of Brazil (Brasil, 2013) and distributed in the following blocks: **i) sociodemographic and economic aspects** – age; mother's race/skin colour (self-reported), marital status and education of the mother, receiving benefits through the Bolsa Familia conditional cash transfer program (Social protection strategy aimed at promoting social and humanitarian development. It promotes access to public services (health, education and social protection), food and nutritional security, combats hunger and encourages the sustainable formation of families in poverty and extreme poverty (Paes-Sousa et al., 2011)), total family income, if the mother has other children, birth weight and the child's sex; **ii) behavioural aspects** - belief/religion, mother's smoking and alcohol consumption and child attendance at daycare/school in the first two years; **iii) aspects related to health services** - mother's relationship with health unit professionals (assessed by the mother's self-report as: excellent; good; reasonable; bad or indifferent), average time between residence and health unit, type of service in which the child is registered, type of health unit that the child was followed in the first two years of life, medical consultation of the mother in the last six months, total prenatal consultations, exclusive breastfeeding time, depression postpartum, mother's health problems during delivery or in the first seven days of life, hospitalization of the child in the first two years of life; **iv) aspects related to vaccination** - condition of the child's health handbook (without any erasure or wrinkled or dirt; with only one erasure or one wrinkled or one dirt; with two or more erasure and/or wrinkled and/or dirt), guidance from health professionals during prenatal or after the delivery about their children's vaccination, local of vaccination, anterior adverse reaction to any vaccine, overall amount of time they are willing to wait for another vaccine, habit of vaccination in campaigns, attitude when facing a new vaccine, intended delay or the decision to not vaccinate, source of information used to know about vaccines, not vaccination of the children because of any received information, there should be more vaccines available.

The data obtained were described using absolute and relative frequencies according to each study variable. To analyse the completeness of the vaccination schedule (dependent variable), Poisson regression analyses with robust variance were performed. For inclusion in the adjusted model, variables with $p < 0.20$ were considered. To remain in the final model, a significance level of 5% was considered. Besides, crude and adjusted prevalence ratios and their respective 95% confidence intervals were presented. The data were analysed using *software* Stata®, version 14.

The project was approved by the Research Ethics Committee, according to the recommendations of Resolution No. 466/2012 - National Health Council for Scientific Research in Human Beings. Only children whose mothers signed the Free and Informed Consent Form were interviewed and included in the study. Data confidentiality and confidentiality and use for scientific purposes were guaranteed.

Results

Four hundred and fifty children were recruited to participate in the study, but 62 were excluded because they were not accompanied by their biological mother ($n = 44$) or the child's vaccination record was not available ($n = 18$). Thus, the final sample had 388 children, with the completeness of the vaccination schedule present in 77.1% ($n = 299$) of children at 12 months of age, and 68.8% ($n = 267$) at 24 months.

Table 1 shows the socioeconomic, demographic, and behavioural characteristics of the children and their respective mothers according to the completeness of the vaccination schedule. As presented in Tables 1, 37.89% (147/388) of the mothers were older than 35 years old; 59.54% (231/388) self-reported white; 81.70% (317/388) lived with partners; 63.92% (248/388) had between 8 and 11 years of study; 84.79% (329/388) did not receive benefits from a Bolsa Familia

Table 1
Completeness of the vaccination schedule of children 12 and 24 months of age according to socioeconomic, demographic and behavioural characteristics, Araraquara-SP, 2018.

	N	Completeness of the vaccination schedule			
		12 months		24 months	
		Yes (%)	PR (95%CI)	Yes (%)	PR (95%CI)
Mother's age					
<30 years	104	79.81	1	70.19	1
30 to 35 years	137	76.64	0.96 (0.84–1.10)	69.34	0.99 (0.83–1.17)
>35 years	147	75.51	0.95 (0.83–1.08)	67.35	0.96 (0.81–1.14)
Mother's race/skin colour					
White	231	76.19	1	65.80	1
Non-white	157	78.34	1.03 (0.92–1.15)	73.25	1.11 (0.97–1.27)
Marital status					
Without partner	71	78.87	1	73.24	1
With partner	317	76.66	0.97 (0.85–1.11)	67.82	0.93 (0.79–1.09)
Mother's education					
<8 years	31	83.87	1	74.19	1
8 to 11 years	248	76.21	0.91 (0.77–1.08)	69.35	0.93 (0.75–1.17)
>11 years	109	77.06	0.92 (0.76–1.11)	66.06	0.89 (0.69–1.14)
Bolsa Familia income Transfer Program					
No	329	77.51	1	68.09	1
Yes	59	74.58	0.96 (0.82–1.13)	72.88	1.07 (0.90–1.27)
Total family income					
<1909 reais	186	80.11	1	72.58	1
1909 to 4770 reais	141	70.21	0.88 (0.77–1.00)	63.12	0.87 (0.74–1.01)
4771 to 7632 reais	25	92.00	1.15 (1.00–1.32)	80.00	1.10 (0.89–1.37)
> 7632 reais	24	75.00	0.94 (0.73–1.19)	62.5	0.86 (0.62–1.19)
Other children					
None	132	75.00	1	63.64	1
1 child	162	81.48	1.09 (0.96–1.23)	75.31	1.18 (1.01–1.38)
≥2 children	94	72.34	0.96 (0.82–1.13)	64.89	1.02 (0.84–1.24)
Child birth weight					
<2500	39	74.36	1	71.79	1
≥2500	343	77.55	1.04 (0.86–1.26)	68.51	0.95 (0.77–1.18)
Gender of child					
Female	196	78.06	1	69.90	1
Male	192	76.04	0.97 (0.87–1.09)	67.71	0.97 (0.85–1.11)
Mother's belief/region					
No religion/atheist	21	85.71	1	76.19	1
Protestantism	143	77.62	0.91 (0.74–1.10)	67.83	0.89 (0.68–1.16)
Catholicism	179	77.65	0.91 (0.75–1.10)	70.95	0.93 (0.72–1.20)
Umbanda/Candomblé	7	85.71	1.00 (0.70–1.42)	71.43	0.94 (0.55–1.59)
Spiritist doctrine	22	68.18	0.79 (0.57–1.11)	59.09	0.78 (0.51–1.18)
other religions	16	62.50	0.73 (0.48–1.11)	56.25	0.74 (0.45–1.21)
Mother's smoking habit					
Never	312	77.24	1	68.59	1
Ex-smoker	21	61.90	0.80 (0.57–1.13)	61.90	0.90 (0.64–1.27)
Current smoker	55	81.82	1.06 (0.92–1.22)	72.73	1.06 (0.89–1.27)
Mother's alcohol consumption					
No	275	77.82	1	69.45	1
<Once a week	76	73.68	0.95 (0.82–1.10)	65.79	0.95 (0.79–1.13)
≥Once a week	37	78.38	1.01 (0.84–1.21)	70.27	1.01 (0.81–1.27)
Insertion of the child in a nursery/school in the first two years of life					
No	165	75.15	1	64.24	1
Yes	223	78.48	1.04 (0.93–1.17)	72.20	1.12 (0.98–1.29)

Table 2
Completeness of the vaccination schedule for children at 12 and 24 months of age according to aspects related to health services and health condition, Araraquara-SP, 2018.

	N	Completeness of the vaccination schedule			
		12 months		24 months	
		Yes (%)	PR (95%CI)	Yes (%)	PR (95%CI)
Relationship between mother and health professionals at the Public Health Unit					
Excellent	175	76.00	1	69.71	1
Good	159	76.73	1.01 (0.90–1.14)	66.04	0.95 (0.82–1.10)
Fair	33	78.79	1.04 (0.85–1.26)	72.73	1.04 (0.83–1.31)
Poor	14	85.71	1.13 (0.90–1.42)	78.57	1.13 (0.84–1.51)
Indifferent	7	85.71	1.13 (0.82–1.54)	71.43	1.02 (0.63–1.65)
Average time between residence and Health Unit					
≥30 min	22	72.73	1	63.64	1
<30 min	366	77.32	1.06 (0.82–1.38)	69.13	1.09 (0.79–1.50)
Type of service in which the child is registered					
ESF	173	80.35	1	70.52	1
Health Center	178	71.91	0.89 (0.79–1.01)	64.61	0.92 (0.79–1.06)
Private Clinic	37	86.49	1.08 (0.93–1.25)	81.08	1.15 (0.96–1.38)
Type of Health Unity that the child was followed during the first two years of life					
Public only	192	78.13	1	70.83	1
Private only	67	80.60	1.03 (0.90–1.20)	68.66	0.97 (0.80–1.17)
Public and private (mixed)	129	73.64	0.94 (0.83–1.07)	65.89	0.93 (0.80–1.08)
Mother's medical consultation in the last six months					
No	127	74.02	1	66.93	1
Yes	261	78.54	1.06 (0.94–1.20)	69.73	1.04 (0.90–1.21)
Total prenatal consultations					
<6 consultations	16	68.75	1	56.25	1
≥6 consultations	361	77.84	1.13 (0.81–1.58)	69.53	1.24 (0.80–1.92)
Don't know/don't remember	10	–	–	–	–
Does not apply	1	–	–	–	–
Exclusive breastfeeding time					
<6 months	227	75.77	1	66.52	1
≥6 months	156	78.85	1.04 (0.93–1.16)	71.79	1.08 (0.94–1.23)
Postpartum depression					
No	367	76.57	1	68.12	1
Yes	21	85.71	1.12 (0.93–1.34)	80.95	1.20 (0.95–1.48)
Health problems of the mother during childbirth or in the first seven days					
No	339	74.93	1	66.67	1
Yes	49	91.84	1.22 (1.10–1.35)	83.67	1.25 (1.09–1.45)
Child hospitalization in the first two years of life					
No	345	77.39	1	69.86	1
Yes	43	74.42	0.96 (0.80–1.16)	60.47	0.87 (0.67–1.11)

conditional cash transfer program; 49.47% (186/376) had total family income <1909 reais; 41.75% (163/388) had another child; 46.13% (179/388) of the women were Catholic; 80.41% (312/388) non-smokers; 70.88% (275/388) did not consume alcohol. In regard to the children, 10.21% (39/382) were born weighing <2500 g; 50.51% (196/388) were female and 57.47% (223/388) attended daycare.

Regarding aspects related to health services and the mother's health condition, 45.10% (175/388) reported having an excellent relationship with health professionals; 94.33% (366/388) reported an average time of <30 min between the residence and the health unit; 67.27% (261/388) attended medical consultations in the last six months; 95.76% (361/377) had ≥6 prenatal consultations; 94.59% (367/388) did not have postpartum depression and 87.37% (339/388) did not have problems in childbirth or the puerperium. As for children, 45.88% (178/388) were registered at the Health Center; 49.48% (192/388) were followed up only in the public health system during the first two years of life; 59.27% (227/383) were exclusively breastfed for less than 6 months and 11.10% (43/388) were hospitalized in the first years of life (Table 2).

Table 3 shows the aspects related to vaccination, in which, 69.60% (270/388) of the mothers presented the child's health handbook without any damage, 82.41% (314/381) received guidance from health professionals about vaccination in the prenatal period or after delivery, 91.15% (350/384) vaccinated their children in a public health, 59.43% (230/387) were willing to wait <30 min to get a vaccine, 97.16% (377/388) had the habit of vaccinating in campaigns, 64.58% (248/384) soon took their child to vaccinate when a new vaccine becomes available, 87.37% (339/388) did not delay any vaccine on purpose or did not stop vaccinating, 95.36% (370/388) did not stop vaccinating because of some information, 81.44% (316/388) thought they should have more vaccines available, 75.51% (293/388) did not report any adverse reaction to the vaccine in their child, 54.64% (212/388) had as their main source of information other people and not health professionals.

In the unadjusted analysis (Tables 1 to 3) for the completeness of the vaccination schedule at 12 months, the variables with a value of $p < 0.20$, that is, considered in the multiple model, were: total family income (1909 to 4770 reais - PR: 0.88; IC95%: 0.77; 1.00 and 4771 to 7632 reais - PR: 1.15; IC95%: 1.00; 1.32); mother's belief/religion (Spiritist RP: 0.79; 95% CI: 0.57; 1.11 and other religions RP: 0.73 95% CI: 0.48; 1.11); mothers who had another child (PR: 1.09; 95% CI 0.96–1.23; race/skin colour (PR: 1.03; IC95% 0.92; 1.15); type of services in which the child is registered (PR: 0.89; CI95%: 0.79; 1.01); health problems of the mother during childbirth or in the first seven days (PR: 1.22; 95% CI: 1.10; 1.35); adverse reaction previous to any vaccine (PR: 0.77; 95% CI: 0.66; 0.91); intentional vaccination delay or non-vaccination (PR: 0.71; 95% CI: 0.56; 0.92); professional guidance on vaccination during prenatal care or after delivery (PR: 1.24; 95% CI: 1.02–1.49); and, mothers who saw the need to have more vaccines (PR: 1.13; 95% CI: 0.96; 1.34).

For the analysis not adjusted for the completeness of the vaccination schedule at 24 months (Tables 1 to 3), the variables with a p value <0.20 were: total family income (PR: 0.87; 95% CI: 0.74; 1.01); mothers who had another child (PR: 1.18; 95% CI: 1.01; 1.38); race/skin colour (PR: 1.11; 95% CI: 0.97; 1.27); insertion of the child in daycare/school (PR:

Table 3
Completeness of the vaccination schedule for children at 12 and 24 months of age according to aspects related to health services and health condition, Araraquara-SP, 2018.

	N	Completeness of the vaccination schedule			
		12 months		24 months	
		Yes (%)	PR (95%CI)	Yes (%)	PR (95%CI)
Condition of the child's health handbook					
With two or more erasure and/or wrinkled and/or dirt	45	75.56	1	71.11	1
With only one erasure or one wrinkled or one dirt	73	75.34	1.00 (0.81–1.23)	68.49	0.96 (0.75–1.23)
Without any erasure or wrinkled or dirt	270	77.78	1.02 (0.86–1.23)	68.52	0.96 (0.79–1.18)
Guidance from health professionals during prenatal care or after delivery on your child's vaccination					
No	67	64.18	1	55.22	1
Yes	314	79.30	1.24 (1.02–1.49)	71.02	1.29 (1.02–1.61)
Don't know/don't remember	7	–	–	–	–
Vaccination site					
Public Health Unit	350	76.29	1	68.86	1
Private clinic	34	82.35	1.08 (0.91–1.27)	67.65	0.98 (0.77–1.25)
Doesn't know	4	–	–	–	–
Adverse reaction to some vaccine					
No	293	81.57	1	72.70	1
Yes	95	63.16	0.77 (0.66–0.91)	56.84	0.78 (0.65–0.94)
Maximum time willing to wait to apply a vaccine					
Less than 30 mins	230	77.83	1	68.26	1
30–60 min	76	78.95	1.01 (0.89–1.16)	75.00	1.10 (0.94–1.29)
More than 60 min	81	72.84	0.94 (0.81–1.09)	64.20	0.94 (0.78–1.13)
Doesn't know	1	–	–	–	–
Habit of vaccinating in campaign					
No	11	63.64	1	36.36	1
Yes	377	77.45	1.22 (0.78–1.91)	69.76	1.92 (0.87–4.21)
Attitude facing of a new vaccine					
Soon takes to vaccinate	248	77.42	1	70.16	1
It prefers to wait	136	75.74	0.98 (0.87–1.10)	65.44	0.93 (0.80–1.08)
Doesn't know	4	–	–	–	–
Intentionally delay vaccination or decide to not vaccinate					
No	339	79.94	1	71.09	1
Yes	49	57.14	0.71 (0.56–0.92)	53.06	0.75 (0.57–0.98)
Most used source of information to know about vaccine					
Professional of Health	176	78.98	1	71.02	1
Others	212	75.47	0.96 (0.86–1.06)	66.98	0.94 (0.82–1.08)
Stop vaccinating their son for some information that got					
No	370	76.76	1	68.65	1
Yes	18	83.33	1.09 (0.88–1.34)	72.22	1.05 (0.78–1.41)
There should be more vaccines available					
No	72	69.44	1	62.50	1
Yes	316	78.80	1.13 (0.96–1.34)	70.25	1.12 (0.93–1.36)

1.12; CI95%: 0.98; 1.29); type of services in which the child is registered (PR: 1.15; IC95%: 0.96; 1.38); mother's health problems during delivery or in the first seven days (PR: 1.25; 95% CI: 1.09; 1.45); adverse reaction previous to any vaccine (PR: 0.78; 95% CI: 0 to 9 0.65; 0.94); intentional vaccination delay or non-vaccination (PR: 0.75; 95% CI: 0.57; 0.98); professional guidance on vaccinations during prenatal care or after delivery (PR: 1.29; 95% CI: 1.02; 1.61); and, postpartum depression (PR: 1.20; 0.19 CI95%: 0.95; 1.48).

In the final model (Table 4), the following exposures were shown to be associated with the completeness of the vaccination schedule, regardless of the other variables. At 12 months, the completeness of the vaccination schedule was higher among children of mothers who received guidance from health professionals on vaccination in 21% (PR: 1.21; 95% CI: 1.01; 1.45). Children of women who had maternal health problems during childbirth or in the first seven days also had greater completeness of the vaccination schedule (PR: 1.27; 95% CI: 1.15; 1.45). Children of women who reported a previous episode of adverse reaction to some vaccine presented less completeness of the vaccination schedule (PR = 0.79 95% CI: 0.67; 0.93). At 24 months, the completeness of the vaccination schedule was higher among children

Table 4
Factors associated with the completeness of the vaccination schedule of children at 12 and 24 months of age, Araraquara-SP, 2018.

	Completeness of the vaccination schedule	
	12 months	24 months
	Adjusted PR (95%CI)	Adjusted PR (95%CI)
Guidance from health professionals during prenatal care or after delivery on their child's vaccination		
No	1	1
Yes	1.21 (1.01–1.45)	1.27 (1.02–1.60)
Adverse reaction to some vaccine		
No	1	1
Yes	0.79 (0.67–0.93)	0.80 (0.67–0.97)
Health problems of the mother during childbirth or in the first seven days		
No	1	1
Yes	1.27 (1.15–1.41)	1.31 (1.14–1.50)

of mothers who received guidance from health professionals on vaccination in 27% (PR: 1.27; 95% CI: 1.02; 1.60). Children of women who had maternal health problems during childbirth or in the first seven days also had greater completeness of the vaccination schedule (PR: 1.31; 95% CI: 1.14; 1.50). Children of women who reported a previous episode of adverse reaction to some vaccine presented less completeness of the vaccination schedule (PR = 0.80; 95% CI: 0.67; 0.97).

Discussion

The present study analysed the completeness of the vaccination schedule of 388 children from a representative sample of children from a Brazilian municipality. Of these, more than two thirds had a complete vaccination schedule, reflecting high coverage. The small difference, found between the categories of the different exposures analysed, suggests a good performance of the municipal vaccination program. Araraquara is a medium-sized Brazilian city, HDI above the national average, and has an immunization program with excellent performance, so that preventable diseases have been controlled since the 1990s (Departamento de informática do SUS, 2020b). High vaccination coverage has already been reported in this municipality between 1998 and 2013 (Ferreira et al., 2018; Tauil et al., 2016).

This success is also due to the progress achieved with the implementation of the Unified Health System (SUS) in Brazil, which provided the expansion and decentralization of health services, in addition, guaranteeing the population, the principles of free universal access to health care and, in particular, to vaccination (Paim et al., 2011). Since the 1990s, vaccination coverage in children under one year old has been above 95%, which indicates the high adherence of the Brazilian population to vaccination and the good performance of the National Immunization Program (PNI) (Domingues & Teixeira, 2013).

The main results of the research point out the importance of the guidance of health professionals on vaccination in the prenatal period or after delivery, maternal health problems during delivery or in the first seven days and reports of an adverse reaction to a vaccine in the child were associated with the completeness of the vaccination schedule at 12 and 24 months of age, with the latter showing an inverse association. These results are consistent with the characteristics of existing health services in the municipality, which in addition to an excellent immunization program also presents an excellent program of assistance for prenatal, childbirth, and the puerperium.

As in Araraquara, a recent survey conducted in Pelotas (RGS), a medium-sized municipality in the southern region of the country, pointed to the presence of high vaccination coverage, with percentages above 95% in 2015 (Silveira et al., 2020). These results did not differ from the study carried out in 27 Brazilian capitals that showed that more than 82% of children received all vaccines recommended between 2007 and 2008 (Barata et al., 2012). In addition, other previous surveys also in Brazilian state capitals showed high coverage for the complete basic scheme, ranging from 71.9% in São Luís, Maranhão (Yokokura et al., 2013) to 95.3% in Curitiba, Paraná (Luhm et al., 2011).

Besides that, in general, some studies have demonstrated different situations in vaccine coverage over the decades, while in the 1990s it is possible to observe better coverage among the wealthier, in the years 2000–2010 this coverage is presented more evenly with trends in the richest capitals with the lowest coverage among the very rich and very poor and, after 2015, important falls in vaccination coverage in the entire population (Barata et al., 2002; Domingues & Teixeira, 2013; Moraes et al., 2000; Silveira et al., 2020).

It is worth mentioning that in the present study, socioeconomic status was not associated with vaccination. However, studies carried out in Brazilian capitals and in the city of Pelotas found that the portion of the population with better socioeconomic conditions had lower vaccination coverage. In both studies, the highest economic level had the lowest vaccine coverage (Barata et al., 2012; Buffarini et al., 2020).

Mothers who received guidance from health professionals, on vaccination during prenatal care or after delivery were predisposed to maintaining the updated vaccination status of their children. Health professionals, especially nurses, indeed play an important role in the context of immunization programs, based on the knowledge of the population in the assisted area and in respect for their beliefs. A prospective randomized study showed that participants in nurse-managed programs had almost twice the rate of completing the vaccination against Hepatitis B virus when compared to other standard control programs" (Nyamathi et al., 2009).

Also, the great challenge of vaccination hesitation requires nurses to be sensitive to parents' fears, as they play an important role in listening to parents concerns and in providing education about vaccines and the risks of non-immunization (Kubin, 2019). In addition, they are active as disseminators of information about the benefits, safety, and importance of the vaccine, in addition to possible adverse events and how to proceed with them. Thus, it is necessary for health professionals to make a continuous effort in establishing a relationship of trust with parents, capable of transmitting the importance of health care and providing greater reliability in vaccination (Favin et al., 2012; Fu et al., 2017; Shibli et al., 2017).

In this context, immunization programs need to organize and implementations to train health professionals about vaccination, in order to ensure updated knowledge about vaccines and their practices (Favin et al., 2012; Shibli et al., 2017). Because, negative or wrong professional orientations can cancel with a positive or correct professional orientation (Dubé et al., 2013). In this way, health professionals remain the most reliable advisors and influencers in the decisions of vaccination (Paterson et al., 2016).

In addition, children whose mothers experienced health problems during childbirth or in the first seven days after the baby's birth had greater coverage of the updated vaccination schedule. An explanatory hypothesis would be that these women, probably with a fear of possible loss, tend to develop greater care for their children, care that includes vaccination. Furthermore, it presupposes that these problems bring mothers closer to greater access to information about caring for their health and that of their child. A fact that suggests a change in behaviour regarding the care of the child, since they require greater assistance from health professionals, especially nurses, or even, who are afraid that the problems they had, affects the child's health.

The report of previous adverse reactions to the vaccine contributed to a lower coverage of the vaccine schedule of the children studied, which can be explained by the fact that mothers who attribute the possible reactions to the vaccine, quickly lose confidence in immunobiologicals. This can trigger delays or non-vaccination, and consequently, problems for public health, such as decreased coverage and the resurgence of the disease (Di Pasquale et al., 2016). Therefore, the risk of adverse events after vaccination is a factor present in the context of vaccine hesitation in some immunization programs (Dubé et al., 2014).

Thus, it is necessary that the maternal perception of the risks of vaccination be guided by receiving information on the benefit and safety of the vaccine (Mostafapour et al., 2019). In addition, effective surveillance of post-vaccine adverse events (AEFIs) is essential, which acts in a timely and transparent manner in monitoring and investigating possible AEFIs. In the municipality of Araraquara, a study that described AEFIs that occurred in children up to two years old between 2000 and 2013, showed that the post-vaccine adverse event surveillance system based on the electronic immunization record is useful and highly sensitive. to describe the vaccine safety profile in a medium-sized municipality (Sato et al., 2018).

Clinical implications

The present study indicates the importance of health services, especially health care providers such as pediatric nurses, in the success of immunization programs. In addition to demonstrating associated

factors, such as adverse events after vaccination and maternal health problems during childbirth or in the first seven days, there are important aspects directly related to nursing performance that can directly affect vaccination coverage worldwide. Still, it signals the important role of nurses in the context of vaccination, in listening to parents' fears about vaccination and in orienting the benefits and risks of immunization. In clinical practice, with the recommendation for countries to urgently identify obstacles and implement targeted approaches to increase and maintain vaccination coverage in immunization programs (World Health Organization, 2020b), also, with the emergence of the COVID-19 pandemic, which may lead to falls in the number of children vaccinated in the world, due to interruptions in immunization services and actions, it is necessary the competent act of the health professionals, as they are able to provide clear and accurate information about the benefits and risks of the vaccine and also identify possible barriers to access and propose a strategy to achieve high and homogeneous vaccination coverage (Habersaat & Jackson, 2020).

Limitations

The cross-sectional design of the study can be considered a limitation in the search for a causal relationship, however, this design allowed the analysis of a probabilistic sample of children born in 2015 in the municipality of Araraquara and presented results consistent with the literature. For the control and quality assurance of study data, interviewers with previous experience in research and in the knowledge area of the study were selected, as well as field supervision during the entire data collection process. It is also worth mentioning that the municipality studied has a very successful Municipal Immunization Program, with the presence of a structured and consolidated electronic immunization record.

Conclusion

The main results of the study indicate the importance of guiding health professionals, especially nurses, in health care concerning vaccination schemes and vaccine safety. Still, professional guidance may be considered a proxy for the importance of the population's bond with health services.

Ethical approval

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Authors' contribution

Érica Marvila Garcia: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Supervision; Validation; Writing - original draft; Writing - review & editing.

Claudia Nery Teixeira Palombo: Investigation; Supervision; Validation; Writing - review & editing.

Eliseu Alves Waldman: Methodology; Writing - review & editing.

Ana Paula Sayuri Sato: Conceptualization; Data curation; Formal analysis; Funding acquisition; Methodology; Project administration; Supervision; Validation; Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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