Vaccination Coverage in Children Under 2 Years of Age: Poliomyelitis, Pentavalent and MMR Vacines

Cobertura Vacinal em Crianças Menores de 2 Anos: Poliomielite, Pentavalente e Tríplice Viral

Cobertura de Vacunación en Niños Menores de 2 Años: Poliomielitis, Pentavalente y Triple Viral

RESUMO

Objetivo: Analisar a série temporal da cobertura vacinal da Poliomielite, Pentavalente e Tríplice Viral em menores de 2 anos no município de Itabuna, Bahia. **Métodos:** Estudo ecológico com dados do Sistema de Informação do Programa Nacional de Imunização (SI-PNI), utilizando análise descritiva por frequências relativas e absolutas, tabelas e gráficos de linhas no software Jamovi 2.6.44. **Resultados:** Verificaram-se flutuações significativas nas coberturas vacinais, com instabilidade ao longo do período. Apenas a Tríplice Viral atingiu a meta da OMS (≥95%) em 2014. A Pentavalente mostrou estabilidade e tendência de crescimento após 2017, enquanto a Poliomielite apresentou os piores indicadores, com baixas coberturas e elevadas taxas de abandono. Em 2022, todas as vacinas superaram 68%, indicando tendência de recuperação. **Conclusão:** A baixa cobertura vacinal reflete desafios estruturais, como desinformação, barreiras de acesso e falhas logísticas, exigindo ações integradas na Atenção Primária, com busca ativa e vacinação extramuros.

DESCRITORES: Cobertura Vacinal; Programas de Imunização; Sistema de Informação em Saúde; Saúde Pública; Atenção primária à saúde.

ABSTRACT

Objective: To analyze the time series of vaccination coverage for Poliomyelitis, Pentavalent, and MMR vaccines in children under two years old in the municipality of Itabuna, Bahia. **Methods:** Ecological study using data from the National Immunization Program Information System (SI-PNI). Descriptive analysis was performed using absolute and relative frequencies, tables, and line charts in Jamovi software version 2.6.44. **Results:** Significant fluctuations were observed in vaccination coverage, showing instability over time. Only the MMR vaccine reached the WHO target (≥95%) in 2014. Pentavalent showed greater stability and a growth trend after 2017, while Poliomyelitis had the lowest coverage and highest dropout rates. In 2022, all vaccines exceeded 68%, suggesting recovery trends. **Conclusion:** Low vaccination coverage reflects structural challenges such as misinformation, access barriers, and logistical failures, reinforcing the need for integrated Primary Health Care actions, active case finding, and outreach vaccination strategies.

DESCRIPTORS: Vaccination Coverage; Immunization Programs; Health Information Systems; Public Health; Primary Health Care.

RESUMEN

Objetivo: Analizar la serie temporal de la cobertura vacunal de Poliomielitis, Pentavalente y Triple Viral en niños menores de dos años en el municipio de Itabuna, Bahía. **Métodos:** Estudio ecológico con datos del Sistema de Información del Programa Nacional de Inmunización (SI-PNI). Se realizó un análisis descriptivo mediante frecuencias absolutas y relativas, tablas y gráficos de líneas con el software Jamovi versión 2.6.44. **Resultados:** Se observaron fluctuaciones significativas en las coberturas vacunales, con inestabilidad a lo largo del período. Solo la Triple Viral alcanzó la meta de la OMS (≥95%) en 2014. La Pentavalente mostró mayor estabilidad y tendencia de crecimiento desde 2017, mientras que la Poliomielitis presentó los peores indicadores. En 2022, todas las vacunas superaron el 68%, indicando una tendencia de recuperación. **Conclusión:** La baja cobertura refleja desafíos estructurales como desinformación, barreras de acceso y fallas lo

DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345

gísticas, requiriendo acciones integradas en la Atención Primaria, búsqueda activa y vacunación extramuros.
DESCRIPTORES: Cobertura de Vacunación; Programas de Inmunización; Sistemas de Información en Salud; Salud Pública; Atención Primaria de Salud.

RECEIVED: 11/09/2025 **APPROVED:** 11/26/2025

How to cite this article: Januário ILS, Silva DO, Silva NC, Soares SSS, Santos GB, Silva MR. Vaccination Coverage in Children Under 2 Years of Age: Poliomyelitis, Pentavalent and MMR Vacines. Saúde Coletiva (Brazilian Edition) [Internet]. 2025 [cited year month day];16(103):18230-18345. Available from: DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345

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INTRODUCTION

Immunization is recognized as one of the main public health strategies and a fundamental right, being essential for the control, eradication, and prevention of infectious diseases. It is a measure that has excellent health outcomes, particularly in the primary prevention of various diseases. In pediatrics, it contributes to reducing infant mortality, strengthens the immune system, and ensures collective protection against outbreaks and epidemics[1].

According to the World Health Organization[1], advances in immunization, combined with improvements in health care, such as access to drinking water, basic sanitation, hygiene practices, and education, have contributed to a reduction in deaths among children under 5 years of age, from approximately 9.6 million in 2009 to 7.6 million in 2010.

Therefore, it is essential to promote awareness and health education among the population, especially through effective actions by the responsible agencies at the state and municipal levels, with the support of the Ministry of Health (MS). In this context, the National Immunization Program (PNI) stands out. Created in 1973 and officially implemented in 1975, it is responsible for defining the vaccination schedule for the Brazilian population, with the aim of controlling, eradicating, and eliminating vaccine-preventable diseases, as well as ensuring early immunization against diseases such as polio, measles, whooping cough, meningitis, hepatitis, among others[2].

The vaccination schedule in Brazil is structured based on age group and the immunological vulnerability of different population groups. In the first two years of life, 15 different immunobiologicals are recommended, 9 of which are indicated for children under one year of age and 6 for those under two years of age, with the purpose of preventing approximately 17 diseases. Among these vaccines, the following stand out: BCG (indicated for the prevention of severe forms of tuberculosis), hepatitis B, pentavalent (offers protection against diphtheria, tetanus, pertussis, hepatitis B, and *Haemophilus influenzae* type b infections), VIP (inactivated vaccine against poliomyelitis), pneumococcal conjugate, rotavirus (aimed at preventing viral gastroenteritis), meningococcal C, influenza (flu), yellow fever, MMR (measles, mumps, and rubella), MMRV (measles, mumps, rubella, and varicella), hepatitis A, and the DTP (diphtheria, tetanus, and pertussis) vaccine[2] .

Despite the relevance of this strategy and its free availability through the Unified Health System (SUS), epidemiological data point to a trend of stabilization and decline in vaccination coverage in recent years. This phenomenon was exacerbated by the COVID-19 pandemic, which overwhelmed health systems globally between 2020 and 2021. In 2023, for example, approximately 22 million children did not receive the first dose of the measles vaccine, surpassing the 19.3 million unvaccinated children in 2019, before the pandemic[(3,4)] .

In this scenario, vaccine-prevent-

able diseases are among the leading causes of child morbidity and mortality, especially in low- and middle-income countries. In Brazil, although it has been an international benchmark in immunization, the country has faced a decline in vaccination coverage and the return of previously controlled diseases[(1,5)].

Several factors contribute to this reduction, including geographical barriers, socioeconomic inequality, the mother's educational level, as well as the population's lack of knowledge about the benefits of vaccines, logistical and operational failures, and the absence of adequate records of doses administered. These aspects highlight the need for specific strategies targeting vulnerable populations and regions with less access to health services.

In the municipality of Itabuna, located in southern Bahia, immunobiologicals are managed by the Cold Chain Network of the Municipal Health Department, which distributes supplies to the city's 33 Basic Health Units. Data from the Ministry of Health reveal that, compared to the first four months of 2024 and 2025, there was an increase in vaccination coverage among children in Bahia, with the MMR vaccine reaching 74.49% in 2024 and 81.97% in 2025, polio from 74.14% to 79.34%, and the pentavalent vaccine from 82.37% to 84.22%. Even with this increase, the targets were not met.

To address this scenario, the PNI promotes national immunization campaigns aimed at preventing diseases such as influenza, polio, and COVID-19, with a view to achieving the targets and indicators set by the Ministry of Health. Vaccination coverage (VC), in this sense, is an important indicator of health service performance, reflecting the proportion of the target population that has been effectively immunized. A decline in childhood VC may result in the reintroduction of previously eliminated diseases such as measles, polio, rubella, and meningitis[(4,8)] .

The National Immunization Program Information System (SI-PNI) is responsible for monitoring and consolidating vaccination data at the national level. However, challenges remain regarding the quality of information, as demonstrated in a household survey conducted between 2017 and 2018 in 12 municipalities in rural Brazil, which highlighted operational difficulties in data entry and consolidation, as well as low adherence by some municipal administrations[((9))].

Recognizing that vaccination is an essential pillar of the right to health and one of the most effective interventions in reducing child morbidity and mortality, it is clear that it is important to investigate the dynamics of vaccination coverage in vulnerable populations. In this context, understanding temporal variations in adherence to basic immunizations allows for the identification of gaps in health services and supports more equitable and effective public policies. Given this, the present study aimed to analyze the time series of vaccination coverage for polio, pentavalent, and MMR vaccines in children under two years of age in the municipality of Itabuna, Bahia.

METHODS

This is an ecological time series study whose unit of analysis was the municipality of Itabuna, Bahia. This type of epidemiological study seeks to identify associations between aggregate variables, such as the relationship between exposure to risk factors and the occurrence of health outcomes, based on data aggregated by groups, such as state populations, m nicipalities, or geographic regions[(10)] .

The age group was chosen because most vaccines in the basic schedule are administered in the first two years of life, a fundamental stage for early protection and reduction of infant mortality. We chose to analyze three immunobiologicals recommended by the National Immunization Program (PNI), namely: the MMR vaccine, due to the reintroduction of measles in Brazil; and the pentavalent and inactivated polio (VIP) vaccines, as they are more commonly included in the routine vaccination schedule for children under two years of age. Thus, the CV was analyzed according to the variables year, immunobiologicals, and CV rate. Individuals aged 0 to 24 months were included in the study.

Secondary data publicly available in the National Immunization Program Information System (SI-PNI) were used, accessed through the Department of Informatics of the Unified Health System (DATASUS), extracted on May 20, 2025. Information on populations under two years of age was based on live birth data available in the Live Birth Information System (SINASC).

The dependent variable of the study was vaccination coverage by vaccine type (pentavalent, polio, and MMR). The independent variable corresponds to the years of the time series (2013 to 2022). Adequate CV was considered to be that which reached the 95% target, as established by the National Immunization Program[((11))] .

For the theoretical basis and construction of the literature review, scientific articles indexed in the Virtual Health Library (VHL) were consulted.

A descriptive analysis of the data was performed using absolute and relative frequencies (percentages), represented by tables and graphs, with the aid of Jamovi *software*, version 2.6.44. To assess the trend in the time series of vaccination coverage (VC) in children under two years of age, a line graph was used, as it is a statistical

DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345

model suitable for representing variations over time.

The trend was considered increasing when the value of $p < 0.05$ and the linear regression coefficient was positive (+); decreasing when $p < 0.05$ and the coefficient was negative (–); stationary when $p > 0.05$. The level of significance adopted was 5% ($\alpha = 0.05$).

The CV rate was calculated according to the following formula:

$$CV\ (\%) = \frac{\text{Number of doses applied of the indicated dose}}{\text{Target population}} \times 100$$

The vaccination dropout rate (DR), applicable to vaccines with more than one dose, was calculated using the following formula:

$$AB\ (\%) = \frac{(\text{1st dose administered} - \text{Last dose administered})}{\text{1st dose administered}} \times 100$$

The dropout rate indicates the proportion of children who started the vaccination schedule but did not complete it, and is therefore a relevant indicator for assessing adherence to the childhood vaccination schedule.

This study was based on secondary data in the public domain, obtained electronically from the Ministry of Health's Information Systems. As the data are aggregated by municipality and do not include information that allows for the individual identification of subjects, it was not necessary to submit the study to the Ethics Committee.

RESULTS

The overall analysis of CV for the three immunobiologicals selected over the time series from 2013 to 2022 reveals significant variations, as shown in Table 1.

The MMR vaccine had the highest coverage in 2014 with 97.5%, being the only one in that year to reach the WHO target of 95%. However, from 2015 onwards, there was a sharp decline, with 45.9% vaccination coverage (95% CI: 64.8%–86.4%), showing high variability over the years, with worrying fluctuations. Despite a gradual recovery until 2020, the median CV for this immunobiological product was 78.7%.

Regarding the coverage obtained for the polio vaccine, the lowest vaccination coverage rate was recorded in 2014, with only 17.4%, evidencing a critical scenario. In subsequent years, coverage showed a progressive recovery, reaching stability between 2017 and 2020, with values ranging from 81.4% to 78.3%. In 2021, there was a slight drop, followed by stabilization in 2022. The median vaccination coverage for the period was 67.1%.

The pentavalent vaccine showed a more consistent evolution when compared to other vaccines. The lowest vaccination coverage rate was recorded in 2016, at 51.80%, after a period of decline that began in 2015. From 2017 onwards, there was a trend of gradual recovery and better performance in the time series in 2020,

Table 1. Vaccination coverage for each immunological vaccine in children under two years of age in the municipality of Itabuna, Bahia (2013–2022). Itabuna, Bahia, 2025.

Anos	Cobertura Tríplice Viral	Cobertura Poliomielite	Cobertura Pentavalente
2013	78.3	48.6	72.8
2014	97.5	17.4	65.9
2015	45.9	30.2	59.0
2016	56.7	70.8	51.8
2017	80.3	81.4	74.5
2018	70.8	49.7	78.3
2019	86.8	68.0	78.6
2020	87.3	78.3	87.7
2021	73.0	66.1	69.0
2022	79.1	68.1	81.2

Source: Database of the National Immunization Program Information System, 2025.

In the descriptive analysis of the CV of the three vaccines studied, it was observed that, in at least half of the years analyzed, coverage values remained below 78.7% for the MMR vaccine, 67.1% for the polio vaccine (VIP), and 73.6% for the pentavalent vaccine. The polio vaccine had the lowest average vaccination coverage, as well as a wider confidence interval, reflecting greater instability in the data over time.

The MMR vaccine showed fluctuating performance, with moments of high coverage (97.5%) and others of sharp decline (45.9%), with an intermediate average, but still below the 95% target set by the Ministry of Health.

In contrast, the pentavalent vaccine showed the greatest consistency over the time series, presenting the lowest data dispersion and the highest percentiles (66.7%; 73.6%; 78.5%), characterizing a better overall performance, although still below the ideal vaccination coverage value.

DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345

Table 2. Trend coefficient for each immunobiological in children under two years of age in the municipality of Itabuna, Bahia (2013–2022). Itabuna, Bahia, 2025.

Preditor	Estimativas	Erro-padrão	t	p
Intercepto	2006.6169	5.8338	343.962	< .001
Cobertura Tríplice Viral	−0.0384	0.0749	−0.513	0.626
Cobertura Poliomielite	0.0637	0.0456	1.397	0.212
Cobertura Pentavalente	0.1404	0.1140	1.232	0.264

Source: Database of the National Immunization Program Information System, 2025.

Regarding the dropout rate (DR), the analysis was only feasible for the Pentavalent and Poliomyelitis immunobiologicals, since both have schedules with multiple doses administered within the age group investigated. For the pentavalent vaccine, there was a significant variation in rates over the time series, with a negative highlight for 2016 (31.48%), showing a high number of children who did not complete the vaccination schedule (Table 3).

On the other hand, the lowest dropout rate was recorded in 2021, with a rate of -0.47%, which may indicate inconsistencies in the data, such as duplicate records, typing errors, or vaccination delays compensated for in subsequent periods. Significant reductions in dropout rates were also observed in 2019 and 2022, suggesting improved performance in vaccination retention.

Table 3. Dropout rate for the pentavalent immunobiological in children under two years of age in the municipality of Itabuna, Bahia (2013–2022). Itabuna, Bahia, 2025.

Preditor	Estimativas	Erro-padrão	t	p
Intercepto	2006.6169	5.8338	343.962	< .001
Cobertura Tríplice Viral	−0.0384	0.0749	−0.513	0.626
Cobertura Poliomielite	0.0637	0.0456	1.397	0.212
Cobertura Pentavalente	0.1404	0.1140	1.232	0.264

Source: Database of the National Immunization Program Information System, 202.

With regard to the polio vaccine, the highest dropout rate was observed in 2021, reaching 80.30%, while the lowest occurred in 2015, with 59.90% (Table 4).

When analyzing the vaccination coverage data for the MMR, pentavalent, and polio vaccines together, it was observed that all vaccines showed significant fluctuations over the time series from 2013 to 2022, which shows persistent instability in vaccination coverage rates in the municipality of Itabuna. The MMR vaccine was the only one to reach the level recommended by the Ministry of Health (≥95%) in 2014 (Figure 1). However, it also showed the greatest variability among the immunobiologicals, with sharp declines in subsequent years.

The pentavalent vaccine showed a more stable evolution over time, with a growth trend especially from 2017 onwards, reaching the best rate among the three vaccines analyzed in 2022 (81.2%), although still below the recommended target. The polio vaccine, on the other hand, showed a slower recovery, marked by sharp fluctuations, standing out as one of the vaccines with the lowest performance over the period.

Some critical points stand out throughout the time series: between 2014 and 2015, all vaccines suffered significant declines in coverage, with the greatest impact on polio and MMR. The year 2015 represented the worst overall performance of the CV, as shown in Figure 1. In 2016, all vaccines had coverage rates below 75%, characterizing a period of greater vaccine vulnerability in the municipality.

Despite this worrying scenario, a recovery was observed in 2017, es-

Table 4. Dropout rate for the polio vaccine in children under two years of age in the municipality of Itabuna, Bahia (2013–2022). Itabuna, Bahia, 2025.

ANO	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1ª DOSE	37.623	37.932	24.407	15.353	36.331	33.430	41.935	33.507	28.521	30.168
3ª DOSE	13.019	11.529	9.786	4.772	8.135	7.954	9.003	7.108	5.616	6.267
TAXA DE ABANDONO	65,39616724	69,6061373	59,9049453	68,91812675	77,60865377	76,2069997	78,53105997	78,78652222	80,30924582	79,22633254

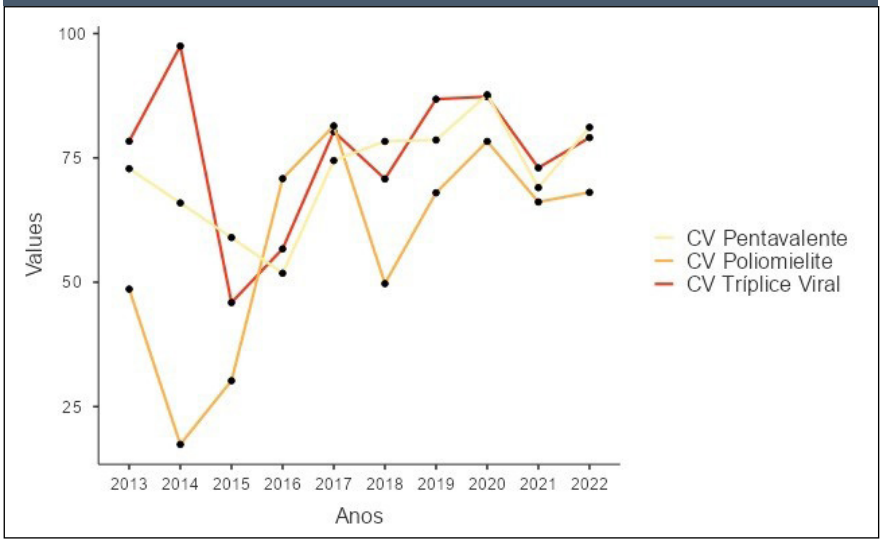
Source: Database of the National Immunization Program Information System.

DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345

pecially for the pentavalent vaccine, whose rates remained on an upward trajectory until the end of the series. Between 2020 and 2021, a period marked by the COVID-19 pandemic, a slight reduction in coverage was identified, possibly related to the limitations imposed on the health system. However, the decline was less pronounced than expected, signaling a satisfactory response from local services.

In 2022, all vaccines analyzed had coverage rates above 68%, with an indicative growth trend, possibly reflecting actions to resume vaccination and strategies to intensify vaccination coverage in the post-pandemic scenario.

Figure 1. Temporal evolution of vaccination coverage (%) for each immunobiological agent in children under two years of age in the municipality of Itabuna, Bahia (2013–2022). Itabuna, Bahia.



Source: Database of the National Immunization Program Information System, 2025.

DISCUSSION

Analysis of the time series of vaccination coverage (VC) in children under two years of age in the municipality of Itabuna (BA), from 2013 to 2022, revealed significant fluctuations and worrying gaps in adherence to mandatory immunobiologicals. None of the vaccines analyzed: MMR, Polio, and Pentavalent achieved the 95% vaccination coverage target in a sustained manner, as recommended by the National Immunization Program (PNI)[11] .

The Pentavalent vaccine performed best, with an average coverage of 71.9% and the lowest standard deviation (10.8), indicating greater stability over the historical series. The higher adherence to immunizations administered in the first months of life may be associated with more frequent visits to health services during this period[12] . However, the dropout rate for this vaccine reached 31.5% in 2016, revealing weaknesses in retention for the complete vaccination schedule.

In contrast, the polio vaccine presented the most critical indicators: lower average vaccination coverage (57.9%), higher standard deviation (21.0), and high dropout rates, reaching 80.3% in 2021. This scenario is worrying given the risk of reintroduction of the disease in regions with low coverage[(13)]. The situation observed in Itabuna reflects the national pattern of vaccination decline, which associates the phenomenon with factors such as vaccine hesitancy, misinformation, and weaknesses in the conduct of public immunization policies[6].

Vaccination coverage for the MMR vaccine also showed great instability. After reaching 97.5% in 2014, the only year in which the 95% target was achieved, there was a significant drop in 2015, with a reduction of almost 50% in coverage. The overall average was 75.6%, insufficient to ensure herd immunity against diseases such as measles, which requires high levels of immunization to prevent outbreaks[((14))]. The superior performance in 2014 may be related to intensified vaccination campaigns promoted in election years or specific health mobilization actions[15].

From the perspective of temporal evolution between 2013 and 2022, a growth trend was observed in vaccination coverage for the pentavalent and polio immunobiologicals. This behavior indicates gradual progress, although still insufficient to achieve the goals recommended by the National Immunization Program (PNI). In contrast, the MMR vaccine showed high instability throughout the period analyzed. In this regard, it is suggested that adherence to the vaccination schedule may be related to external factors, such as access to health services, the quality of local management, and health communication strategies[16] .

Regarding the historical overview of CV in the municipality, 2015 was the most critical year, with the worst rates for all three vaccines. This decline may be related to discontinuities in public immunization policies and logistical problems. During the COVID-19 pandemic (2020–2021), there was a moderate impact on coverage, with slight declines, followed by a partial recovery in 2022, possibly

DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345

due to local strategies to resume vaccination.

The descriptive analysis of the series also highlights a worrying aspect of the vaccination abandonment rate, especially in relation to polio, whose TA remained above 65% throughout the period, exceeding 78% between 2020 and 2022. These data suggest structural failures in adherence to the complete vaccination schedule. In relation to the pentavalent vaccine, although coverage remained more stable, high dropout rates were observed in certain years. Also noteworthy is the occurrence of negative TA values in 2020 and 2021, suggesting inconsistencies in the records, such as duplicate data, typing errors, or untimely vaccination.

These findings converge with studies that highlight that the decline in vaccination coverage is associated with logistical factors, regional inequalities, vaccine hesitancy, and discontinuity of public policies[6,17]. The WHO reinforces the need to maintain high coverage to ensure herd immunity and prevent the resurgence of eradicated diseases.

Fluctuations in vaccination coverage and high dropout rates, especially for multi-dose vaccines, require active surveillance, rapid response capacity, and mastery of the use and interpretation of data from information systems such as the SI-PNI[(17)] .

When comparing the performance of Itabuna, Bahia, to the national scenario, vaccination coverage averages of over 90% were identified for polio and pentavalent vaccines in Brazil, values considerably higher than those recorded in the municipality, whose averages were 67% and 71.9%, respectively. This discrepancy highlights regional inequalities and the need for specific local interventions[18].

Although 2020 was an atypical year, the data indicate that Itabuna maintained a certain stability in vaccination coverage. On the other hand, there was a significant change in dropout rates, reinforcing the influence of social and cultural barriers on the continuity of the vaccination schedule. Although the country as a whole suffered a sharp drop in vaccination coverage during the pandemic, Itabuna demonstrated resilience, benefiting from the strategy of providing opportunities to update vaccination records during COVID-19 vaccination[4] .

It should also be emphasized that the loss of essential childhood vaccines represents a serious public health problem, with a real risk of reintroducing vaccine-preventable diseases. Therefore, it is up to municipal management to adopt urgent measures focused on primary care in order to strengthen vaccination programs. Strategies such as actively seeking out the unvaccinated, vaccinating in schools and at strategic points in the city are viable alternatives for expanding coverage and reducing the vulnerability of the population[19].

Parents' lack of time is highlighted as one of the main factors contributing to vaccine hesitancy. Thus, facilitating access to services through extended hours and extramural strategies is essential. Additionally, other factors are known to directly impact vaccination indicators, such as the location of services, transportation difficulties, shortages of immunobiologicals, failures in information system connectivity, and, above all, the spread of fake news and misinformation about the vaccination process[19,20] .

Furthermore, a more decisive and evidence-based professional practice is needed, one that goes beyond the dimension of care and incorporates skills in management, indicator analysis, health communication, and continuing education(2021).

Finally, it should be noted that this study has the limitation of using secondary data from official information systems. Such data may contain inconsistencies due to typing errors, incomplete records, and delays in entering information, compromising, to a certain extent, the accuracy of the analysis.

CONCLUSION

In view of the findings, there is a clear need to strengthen surveillance and primary health care, with community outreach strategies such as educational campaigns, vaccination in schools, and active search for the unvaccinated. It is essential to improve technological and logistical infrastructure, ensure the availability of immunobiologicals, and continuously train health teams to ensure reliable records and effective communication with families.

Addressing these challenges requires intersectoral management, continuous investment, and a commitment to public health. Expanding vaccination coverage is essential to protect children and promote equity and health security. Given the central role of nursing in the vaccination process, it is important to strengthen its technical and managerial role, ensuring the coordination of logistical flows and the planning of actions appropriate to the local reality. Thus, nursing is consolidated as a strategic link between public policy and practice, contributing to access, adherence, and the effectiveness of immunization actions in primary care.

DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345

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DOI: 10.36489/saudecoletiva.2025v16i103p18230-18345