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Vaccination coverage of rotavirus and Hepatitis A in a region of the Amazon without satisfactory sanitation

Cobertura vacinal de rotavírus e hepatite A em uma região na Amazônia desprovida de saneamento satisfatório

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ABSTRACT

Introduction: The National Immunization Program (PNI) represents a major advance in Brazilian public health. Despite this, there are several challenges to its real implementation and the achievement of vaccination targets, especially in remote areas such as the Amazon. **Objective:** To analyze the Vaccination Coverage (VC) of Human Oral Rotavirus Vaccine (HORV) and hepatitis A in the health region of Lower Amazonas, Pará, which lacks services considered satisfactory for basic sanitation. **Method:** A descriptive epidemiological study was conducted using a quantitative approach using secondary data obtained from the Information System of the National Immunization Program (PNI) between 2018 and 2022. **Results:** In the years evaluated, the study region had an average VC of 63.2% and 59.5% for HORV and hepatitis A, respectively. Of the 14 municipalities evaluated, which made up the Lower Amazon region, only five in 2018 and 2019, one in 2020, and four in 2022 reached the minimum 90% VC recommended by the Ministry of Health (MH) for HORV. The municipalities that met the ideal 95% VC established by the MH were four in 2018, two in 2019, and one in 2020 for hepatitis A. It is worth noting that during the height of the pandemic, VC declined considerably, reaching 54.8% for rotavirus and 47.5% for hepatitis A in 2021. **Conclusions:** Strategies to achieve the VC targets for HORV and hepatitis A in the Lower Amazon region should be encouraged on an emergency basis to prevent disease and promote health.

KEYWORDS: Epidemiology; Public Health; Immunizations

RESUMO

Introdução: O Programa Nacional de Imunizações (PNI) representa um avanço na saúde pública brasileira. Apesar disso, vários são os desafios para sua real efetivação e o alcance das metas vacinais, principalmente em áreas remotas como a Amazônia. **Objetivo:** Analisar a cobertura vacinal (CV) da vacina oral de rotavírus humano (VORH) e de hepatite A e rotavírus humano na região de saúde do Baixo Amazonas, Pará, desprovida de serviços considerados satisfatórios para o saneamento básico. **Método:** Realizou-se um estudo epidemiológico descritivo, com abordagem quantitativa por meio de dados secundários obtidos no Sistema de Informação do PNI entre 2018 e 2022. **Resultados:** A região de estudo apresentou nos anos avaliados uma CV média de 63,2% e 59,5% para VORH e hepatite A, respectivamente. Dos 14 municípios avaliados, que compuseram a região do Baixo Amazonas, apenas cinco em 2018 e 2019, um em 2020 e quatro em 2022 atingiram a CV mínima de 90% para a vacina VORH recomendada pelo Ministério da Saúde. Os municípios que atenderam a CV ideal de 95% para hepatite A estabelecida pelo MS foram quatro em 2018, dois em 2019 e um em 2020. Vale destacar que, durante o auge da pandemia, a CV decaiu consideravelmente, atingindo, no ano de 2021, um valor de 54,8% e 47,5% para VORH e hepatite A, respectivamente. **Conclusões:**

As estratégias para o alcance das metas de CV para o VORH e hepatite A na região do Baixo Amazonas devem ser incentivadas de forma emergencial visando a prevenção de doenças e a promoção da saúde.

PALAVRAS-CHAVE: Epidemiologia; Saúde Pública; Imunizações

INTRODUCTION

Vaccines are one of the greatest achievements in the field of public health and have had a substantial impact on infant morbidity and mortality and the control and eradication of diseases globally. Polio, measles, rubella, tetanus, and whooping cough were common diseases in Brazil and around the world, which ceased to be a public health problem due to the massive vaccination of the population over the years, with a low number of cases and eradication[1].

In Brazil, the National Immunization Program (PNI)[2] currently offers more than 15 vaccines available through the Unified Health System (SUS) for different age groups and life cycles, such as children, adolescents, adults, pregnant women and indigenous peoples[2]. The immunobiologicals available on the vaccination calendar, in the routine of Primary Health Care (PHC) services, aim to achieve high vaccination coverage (VC) to guarantee individual and collective protection against various diseases[2].

In order to subsidize the entire technical-administrative process and thus guarantee the quality of the immunobiologicals purchased and made available to the population, the PNI launched the Cold Chain Network in 1973, operated logistically by the Cold Chain, which aims to guarantee the conservation and quality of immunobiologicals at all logistical stages, from their production in the laboratory to their administration to the user[3]. The Cold Chain is a physical and technical-administrative structure, guided by the General Coordination of the National Immunization Program (CGPNI) of the Ministry of Health (MH), which permeates the three spheres of government - federal, state, and municipal[3]. The logistical process of this network involves the storage system, transportation, and handling of immunobiologicals under appropriate temperature conditions, from the producing laboratory to the moment of application to the user. It is worth noting that the last instance, the municipal level, plays a fundamental and strategic role in the VC of immunobiologicals applied in PHC services to SUS users[4].

At the local level, the vaccination rooms in the Basic Health Units (UBS) must be structured to use suitable refrigerated equipment and have trained professionals to ensure the success of the PNI. In turn, the population needs to be aware of and ensure access to the UBS to guarantee correct immunization, since vaccination is an effective and important way of preventing many diseases, especially in the first years of life[3].

VC is a strategic indicator of the PNI that shows the protection of the population collectively and allows for an epidemiological assessment of immunity by age group[4]. The MH has outlined a new strategy to increase VC in the country by 2023 and has established that the appropriate VC should be 80% for meningococcal and human papilloma virus (HPV) vaccines; 90% for human oral rotavirus vaccine (HORV), influenza, and bacillus Calmette-Guérin (BCG); and 95% for the other vaccines. It should be emphasized that the desired homogeneity, i.e. the annual average VC, should be at least 70% between municipalities[5].

In contrast to the targets set, over the last 10 years in Brazil there has been a drop in the VC of different immunobiologicals in all regions of the country, the highest being in the North and Northeast, and becoming more pronounced during the COVID-19 pandemic[4]. The reduction in VC and the heterogeneity between Brazilian regions allow for the existence of unprotected groups, in which the circulation of the pathogen can proliferate and cause outbreaks in the population.

The North Region, particularly the state of Pará, has seen more rapid reductions in VC[6]. In the western region of the state of Pará, the VC in the targets required by the MH for diseases transmitted by the oral-fecal route (for example: HORV and hepatitis A) is of fundamental importance for the prevention and control of diarrheal and epidemic outbreaks, given that this is the region with the worst basic sanitation rates in Brazil. Recent data from the Trata Brasil Institute showed that, in 2024, Santarém (a hub municipality in the western region of Pará) ranked 98th out of the 100 largest Brazilian cities in the sanitation ranking[7]. According to the Water and Sanitation Institute[8], only 10.84% of the population in Santarém has sanitary sewage collected by networks, the rest being sent to household septic tanks and/or other sanitation solutions.

In this scenario of fragile sanitation, oro-fecal microorganisms are a major threat to public health. Among the etiological agents that cause disease and are related to the lack of satisfactory sanitation systems, rotavirus and hepatitis A infection stand out, viral microorganisms that cause acute diarrheal diseases (ADD)[9,10]. Vaccination is the most effective way of preventing ADDs caused by these microorganisms and is available free of charge from the SUS. However, different factors have the potential to affect the use of immunization services, representing barriers to adherence and achieving vaccination targets[1]. In the Amazon region, geographical barriers experienced by residents of remote rural riverside communities are important points to consider when accessing PHC services[11], including immunization. The drop in VC makes children and the elderly especially susceptible to HORV and hepatitis A infections.

Given this context, the main objective of this study was to analyze the CV of HORV immunizations and hepatitis A in the

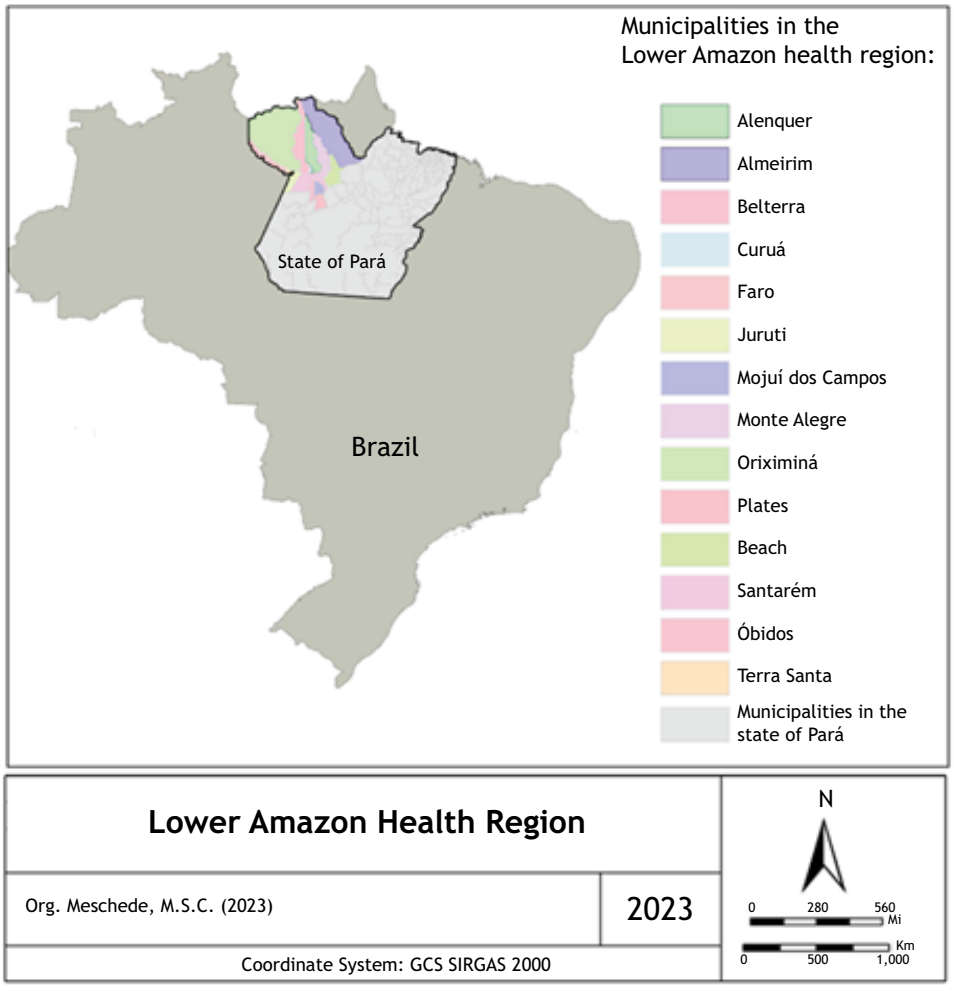
health region of Lower Amazon, western Pará, and to establish hypotheses of causal associations given the transmission mechanism and the lack of a satisfactory sanitation system in the study region.

METHOD

This is a descriptive, exploratory epidemiological study with a quantitative approach. The data used in this study was acquired from the PNI Information System, available from the SUS IT department (http://tabnet.datasus.gov.br/cgi/dhdat.exe?bd_pni/cpnibr.def) of the MH. This is an important basis for collecting secondary data and official health information, including VC rates, the number of doses, and the drop-out rate, according to the period and place of administration.

Data collection for this study took place in September 2023, with the time frame of the research being 2018 to 2022, the period before the COVID-19 pandemic and pandemic years. The information used referred to the VC for the rotavirus and hepatitis A vaccine in the municipalities that make up the Lower Amazon health region, west of the state of Pará - Alenquer, Almeirim, Belterra, Curuá, Faro, Juruti, Mojuí dos Campos, Monte Alegre, Oriximiná, Óbidos, Placas, Prainha, Santarém, and Terra Santa (Figure 1). The Lower Amazon region has a territorial area of 315.86 thousand km², representing 25% of the state and an average population of 785 thousand inhabitants, a demographic density of 2.5 inhabitants/km², and a human development index (HDI) of 0.691[12]. The municipality of Santarém is considered a hub for health services in the Lower Amazon region, as it has a greater number of medical specialties and advanced means of diagnosis and/or treatment. Some municipalities, such as Prainha and Curuá, are considered remote rural areas, as they are small villages scattered across a vast territory, with isolated populations and long distances from urban centers[13].

For this study, we considered the average VC of HORV and hepatitis A, according to the year and municipality of the Lower Amazon region, not considering, at this time, the analysis of the VC of immunobiologicals that are not related to oral-fecal cycles and/or sanitation issues such as: hepatitis C, pneumococcal, meningococcal, among others.



Source: Prepared by the authors, 2023.

Figure 1. Lower Amazon Health region, west of the state of Pará, 2023.

It should be noted that the VC data used in this study was taken directly from the aforementioned website with the VC already estimated by the MH. The VC is an indicator and can be calculated using the numerical ratio between the numerator (made up of the number of doses administered that completed the vaccination schedule for each vaccine) and the denominator (total number of people eligible for vaccination). The value obtained is multiplied by a constant.

The estimate of the HORV VC considers that the complete schedule consists of two doses exclusively by oral route, the first at two months and the second at four months of age with a minimum interval of 30 days between doses[3]. For the hepatitis A vaccine, the schedule is considered to be complete with one dose at 15 months of age, and it can be used from 12 months up to five years of age[3]. It is important to note that, for this study, the VC data was taken directly from the aforementioned website and the denominator that should make up the indicator is based on population estimates from the demographic census. Overestimated or underestimated denominators can distort the results, leading to insufficient VC being considered adequate to achieve collective protection and prevent the circulation of the etiological agent, which are limitations of the data in this survey.

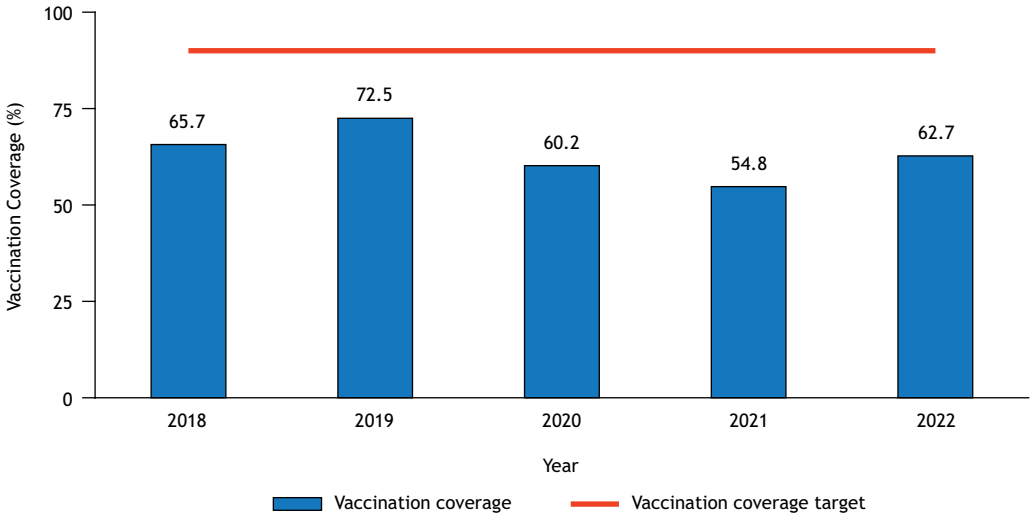
After collecting the data, Microsoft Excel software, version 2019, was used to store and analyze the data, and descriptive statistics were used to analyze, interpret and present the results. The VC was readjusted to 100% in all municipalities with coverage above this value. For this study, the MH's recommendations for meeting the VC targets were considered appropriate. Through the PNI, the MH establishes that the minimum VC limit for HORV should be 90% and 95% for hepatitis A[5].

The information obtained for this study came from a secondary database in the public domain, which, in accordance with Resolution 466 of December 12, 2012, of the National Health Council (CNS), does not require a Research Ethics Committee (CEP)[14].

RESULTS

The VC of human rotavirus during the years evaluated showed an average value of 63.1% in the Lower Amazon Health region. The results also showed that in 2021 there was the lowest VC (54.8%), followed by 2020 and 2022 with 60.2% and 62.7%, respectively. The years prior to the COVID-19 pandemic (2018 and 2019) had higher VC rates (between 65.7 and 72.5%), as shown in Figure 2. The results show that the HORV VC in all the municipalities in the Lower Amazon health region shows weaknesses in the years investigated, so that all the municipalities at some point in this research and the time frame investigated did not reach the target set by the MH of 90%.

It is worth noting that in the VC of the rotavirus vaccine in 2018 and 2019, some municipalities (Belterra, Curuá, Faro, Mojuí dos Campos, and Terra Santa) reached 100% of the vaccination targets. However, there was a predominance of percentages lower than the recommended VC for HORV (Alenquer, Almerim, Juruti, Monte Alegre, Óbidos, Oriximiná, Placas Prainha, and Santarém), resulting in an average value of 65.7%. Later, during the pandemic, in 2020 and 2021, VC fell in all municipalities, except for Mojuí dos Campos. During the COVID-19 pandemic, the worst VC of the rotavirus vaccine was linked to the municipalities of Curuá, Almerim, and Oriximiná. In 2022, the VC increased in all municipalities, apart from Juriti (74.4%), and Belterra, Faro, Mojuí dos Campos, and Placas reached the recommended targets. Table 1 shows the variation in HORV VC according to each municipality belonging to the Lower Amazon health region during the period under analysis.



Source: National Immunization Program Information System (SIPNI/CGPNI/DEIDT/SVS/MS).
*The vaccination coverage target for the ideal human oral rotavirus vaccine is 90%.

Figure 2. Average vaccination coverage of rotavirus vaccine for children under four months of age in the Lower Amazon-PA health region, 2018 to 2022.

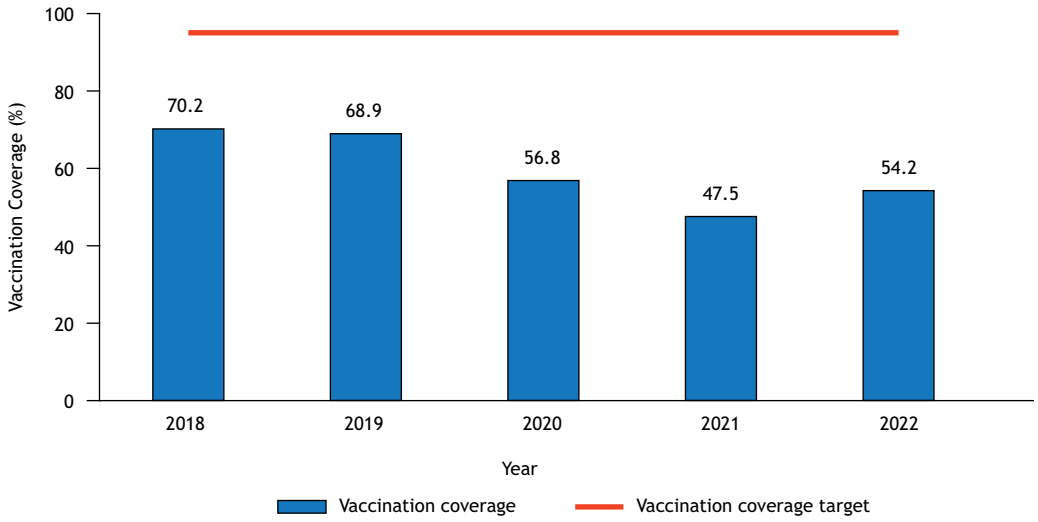
The VC of the hepatitis A vaccine in the years investigated showed an average value of 59.5% in the Lower Amazon Health region, with values ranging from 34.9% to 100%. The results showed that in 2021 there was the lowest VC, followed by 2022 and 2020. The years prior to the COVID-19 pandemic had higher VC rates, as shown in Figure 3.

When detailing the results obtained for the 14 municipalities in the health region, it can be seen that the VC for the hepatitis A vaccine was predominantly lower than the 95% target recommended by the MH during the study period. The VC for the hepatitis A vaccine was between 9.2% and 100% in the period and in the municipalities studied. In the years prior to the COVID-19 pandemic, only a few municipalities (Faro, Curuá, and Belterra) achieved the desired VC. Despite this, during the pandemic period, between 2020 and 2021, VCs fell considerably, showing the worst values on record. During the pandemic, only Mojuí dos

Table 1. Vaccination coverage of the rotavirus vaccine for children under four months of age by municipality in the Lower Amazon Region-PA, 2018 to 2022.

Municipality	2018	2019	2020	2021	2022
	Vaccination coverage (%)*				
Alenquer	72.9	75.4	55.3	50.2	52.8
Almeirim	80.6	70.6	46.7	44.9	62.0
Belterra	100.0	100.0	86.0	69.7	100.0
Curuá	100.0	100.0	49.0	14.2	89.8
Faro	100.0	92.2	59.5	64.5	90.6
Juruti	74.8	94.0	78.2	74.7	74.4
Mojuí dos Campos	100.0	65.5	100.0	77.0	100.0
Monte Alegre	74.9	71.7	59.1	58.7	77.1
Óbidos	77.9	87.2	84.4	60.2	68.0
Oriximiná	69.5	82.1	56.8	37.4	43.4
Plates	73.0	82.8	61.5	82.6	99.7
Beach	75.3	57.7	53.9	56.6	63.3
Santarém	47.8	61.3	53.8	53.3	55.8
Terra Santa	100.0	100.0	73.5	70.1	82.0

Source: National Immunization Program Information System (SI-PNI/CGPNI/DEIDT/SVS/MS).
*The vaccination coverage target for the ideal oral human rotavirus vaccine is 90%.



Source: National Immunization Program Information System (SI-PNI/CGPNI/DEIDT/SVS/MS).
*The ideal vaccination coverage target for the hepatitis A vaccine is 95%.

Figure 3. Average vaccination coverage of hepatitis A vaccine for children under 15 months of age in the health region of Lower Amazon-PA, 2018 a 2022.

Table 2. Hepatitis A vaccination coverage by municipality in the Lower Amazon Region-PA, 2018 to 2022.

Municipality	2018	2019	2020	2021	2022
	Vaccination Coverage (%)*				
Alenquer	72.2	65.1	59.2	45.4	49.1
Almeirim	87.0	72.9	49.5	35.0	58.2
Belterra	100.0	100.0	72.8	51.3	50.5
Curuá	100.0	100.0	34.9	9.2	85.6
Faro	100.0	75.8	61.4	71.8	73.8
Juruti	78.0	89.3	72.6	64.8	63.1
Mojuí dos Campos	100.0	60.3	100.0	63.0	92.6
Monte Alegre	85.1	73.9	61.1	54.0	72.2
Óbidos	71.8	77.3	84.7	54.9	56.3
Oriximiná	72.4	77.8	56.9	39.5	43.3
Plates	68.1	71.5	66.7	70.9	84.8
Beach	77.0	61.9	52.0	54.7	58.3
Santarém	57.3	58.7	46.6	43.1	46.6
Terra Santa	79.1	90.8	60.4	70.7	72.8

Source: National Immunization Program Information System (SI-PNI/CGPNI/DEIDT/SVS/MS).
*The ideal vaccination coverage target for the hepatitis A vaccine is 95%.

Campos had a desirable VC of 100% in 2020. It is worth noting that Curuá, in 2021, had the lowest VC observed of 9.2% for the hepatitis A vaccine. Table 2 shows the variation in VC for the hepatitis A vaccine according to each municipality in the Lower Amazon health region during the period under analysis.

DISCUSSION

The introduction of HORV in the PNI represented a significant advance in the health of the child population, since the national epidemiological profile shows a significant number of hospitalizations for gastroenteritis caused by human rotavirus in children under five[15]. With this, HORV is an important strategy for reducing morbidity, mortality, and hospitalizations and improving the quality of life of the child population[15]. In this study, the low VC obtained in addition to unsatisfactory basic sanitation conditions may represent causal associations that favor the transmission mechanism and the occurrence of an increase in rotavirus and hepatitis A cases in the study region.

Reaching the VC targets is still a challenging process, considering that Brazil is a country made up of cultural and geographical diversities and strategic actions must be established nationwide to increase VC evenly in all municipalities by 2025[5]. In this study, over the entire period analyzed, the average annual VC for HORV in the Lower Amazon region remained below the target recommended by the MH of 90%, ranging from 54.74% to 72.5%. Among the municipalities, the HORV VC showed that less than half managed to reach the desired vaccination target, and this occurred exclusively in 2018 and 2019, the period prior to the COVID-19 pandemic. The findings of this study corroborate the results of studies on the trend of VC in children aged zero to 12 months, carried out in the states of Piauí[16] and Minas Gerais[17]. In both, vaccination coverage for HORV was below the target set by the MH.

It should be noted that in the North region, particularly in the Lower Amazon, it is still possible to observe social vulnerabilities and inequalities, as well as precarious living conditions for the population, which influence the occurrence of diseases. Among the vulnerabilities, the precarious condition of basic sanitation stands out, given that most of the municipalities in the region are characterized as remote rural areas with low HDI. Another factor that contributes to a higher risk of the disease is the difficulty in accessing health actions and services, which are sometimes not as effective in the study region, thus creating gaps in care and coverage, such as vaccination and preventive health measures[11]. The unsatisfactory sanitary conditions in the region, combined with health problems, are aggravating factors for the occurrence of fecal-oral transmission of rotavirus. This can be seen in a study comparing Brazilian regions, which showed that one of the highest numbers of hospital admissions for gastroenteritis was recorded in the North[18].

Thus, the low VC for HORV is a worrying factor, since the lower the immunization, the greater the susceptibility to the viral agent, which is mainly responsible for infection of the digestive system in children under five, and the greater the risk of serious manifestations in those up to two years of age. In view of this, rotavirus infection is something that should be considered extremely relevant to public health in the Lower Amazon region, given the severity of the symptoms, such as dehydration, severe diarrhea, hydroelectrolytic disorders, and gastroenteritis, which can lead to death. In this way, establishing strategies to reach

vaccination targets is essential for reducing child morbidity and mortality from rotavirus[19,20].

The VC for the hepatitis A vaccine in this study, throughout the period analyzed, did not reach the targets set by the MH. The VC for the hepatitis A vaccine was between 47.51% and 70.19%. In addition, only seven municipalities reached the coverage idealized by the MH during the period analyzed. This distribution decreased between 2018 (n = 4) and 2020 (n = 1), culminating in no municipality reaching the target set in the last biennium (2021-2022). These findings corroborate the study by Brito and Souto[21] which showed that the VC for the hepatitis A vaccine was below that recommended by the PNI, and that, in the North and Northeast regions, social vulnerabilities and difficulties in accessing health services may have contributed to this scenario. Adequate VC for the hepatitis A vaccine is of the utmost importance, given that early childhood is a crucial time for children's growth and development in all aspects. In addition, children in this age group may be more vulnerable to infection by hepatitis A virus, the main form of transmission of which is via the fecal-oral route, and less frequently via blood. In countries with poor sanitary and economic conditions, there is greater susceptibility to the virus. In Brazil, even though vaccination is available free of charge through the SUS, there are locations with a higher risk of hepatitis A, especially in places with poor sanitation conditions[10,22,23]. It is worth noting that in 2015 there was an outbreak of hepatitis A in the Santarém region[10] and efforts were made to intensify vaccination and control the disposal of sanitary sewage in bathing areas.

In the period analyzed, there was a decrease in vaccination coverage between 2020 and 2021. This may be related to the critical health situation that has affected Brazil and the world. The COVID-19 pandemic brought a new reality and, in the face of the lack of a contingency plan, several strategies were adopted in an attempt to contain the spread of the disease's etiological agent, SARS-CoV-2, such as: social isolation, the closure of UBSs, and the prioritization of health services in the care of COVID-19 cases. These measures, coupled with the population's fear of leaving the house, contributed to an unexpected effect, which was the drastic drop in VC[24,25].

It should be borne in mind that at the height of the pandemic there was the phenomenon of the "infodemic", i.e. the emergence and dissemination of a large volume of information about COVID-19 on the internet. In addition, linked to this phenomenon, there was the spread of false information, or "fake news", which had more negative impacts of the health crisis on the population, given that COVID-19 was not known in depth. As a result, fear and doubt were spread among the population[26]. In counterpoint to this, the measures that had the most impact were the creation of the vaccine against the virus and the mass immunization of the population. Despite the success and speed with which the vaccine was created, the fake news phenomenon drastically influenced this process, and vaccine hesitancy emerged, at first for COVID-19, and later for any form of vaccine. In view of this, it can be seen that misinformation has led a large percentage of the population to be against vaccines, contributing to the drop in VC in the period[27,28].

In addition to this health panorama, the low VC for the two immunizers identified in this study may also be related to other factors such as: the low coverage of the health unit and the link with the population. Factors such as: availability of time to go to the health unit, cultural aspects (fear and hesitation about vaccination), as well as factors related to the organization of health services (such as opening hours incompatible with the mothers' routine) can also be highlighted. The latter also includes the lack of strategies aimed at attracting the target public and increasing VC, such as joint efforts at different times of the week and on different days of the week from the routine of the units[29,30]. These different challenges may be contributing to a decrease in VC and could lead to scenarios that are not suitable for vaccination in Brazil. It is necessary to overcome these challenges through intersectoral coordination actions and by improving access to health services, which should occur regardless of geographical location, to increase VC and ensure universal access to health services[29].

In the context of PHC, the National Primary Health Care Policy (PNAB) advocates in its guidelines the importance and necessity of an effective bond between the family health team and the population being monitored in order to guarantee the logitudinality of care[31]. It is also through this effective bond that it is possible to identify the limiting factors that exist in the context of the population being monitored and which can influence adherence to vaccination. Based on this, strategies and attitudes can be drawn up with the aim of guaranteeing and improving access to immunizers. In the North, this role should be even more prominent if we consider the geographical characteristics of the region, which can also have an impact on the way the immunization process takes place, given that it requires well-articulated logistics for the immunizer to reach the target audience. Considering the Amazonian context, it can be inferred that the implementation of the PNI must take place in a different way, precisely because of the geographical aspects of the region, marked by large territorial extensions, low population density and the difficult movement of both the population and the health team. Therefore, strategies that seek to reach the population are valid.

CONCLUSIONS

There was evidence of low VC in the Lower Amazonas health region for HORV and hepatitis A in the years investigated. The findings of this study reinforce the need to adopt strategies in the three spheres of government aimed at increasing rates and achieving the vaccination targets proposed by the MH. This is important given the characteristics and challenges of the place studied, which has had poor basic sanitation for decades, a factor that could be aggravated by the population's exposure to vaccine-preventable diseases such as rotavirus and hepatitis A. In this study, the low VC obtained in addition to unsatisfactory basic sanitation conditions are causal associations that may favor

the transmission mechanism and the occurrence of increased cases of rotavirus and hepatitis A in the study region.

With this in mind, the current research recommends the adoption of strategies to be followed by management bodies that make it possible to increase VC and the coverage of sewage collection and/or water treatment services. In addition, health education to combat fake news, evaluation of immunobiological distribution flows in remote rural contexts in the Amazon, training of Family Health Strategy (ESF) teams in the active search for unvaccinated cases and mechanisms to mitigate underreporting are strategies that can help improve VC. It should be noted that the HORV has limitations for use according to age, and it is essential that the multi-professional team of the ESF act to guarantee the appropriate time for its administration. Finally, it is suggested that further research be carried out on VC. Studies investigating the possible causes of low VC and events related to underreporting (records) are important to ensure that the PNI is strengthened in Brazil.

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Authors' Contribution

Freitas NS, Meschede SCM - Conception, planning (study design), data acquisition, analysis, interpretation, and writing of the paper. Mendes IR, Morais CG, Celere BS - Writing the article. All the authors approved the final version of the paper.

Conflict of Interest

The authors inform that there is no potential conflict of interest with peers and institutions, political or financial, in this study.