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The impact of strategies for increasing vaccination coverage in children: A community clinical trial

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ABSTRACT

The Brazilian National Immunization Program (PNI) has been consolidating itself as one of the most relevant interventions in public health. Paradoxically, great challenges arise for the PNI. The phenomenon of falling vaccine coverage is observed not only in Brazil, but in several countries. In the year 2021, faced with the unfavorable scenario of a drop in vaccination coverage, the State Department of Health, and the Federal University of Minas Gerais joined forces to implement a research-intervention project. This study aimed to evaluate the impact of this intervention on vaccination coverage in children under 2 years of age and on indicators of immunization work processes. This is a community clinical trial carried out in 212 municipalities in the state. Workshops were held and Municipal Action Plans were created. Vaccination coverage data were obtained from the National Immunization Program Information System (SIPNI) and evaluated using the Mann-Whitney U Test and the McNemar Test. Work process indicators were evaluated using the Friedman and Wilcoxon tests. The results demonstrate an important improvement for most of the indicators in the three analyzed times, with statistical significance and an increase in medians and interquartile ranges. Among the indicators that showed the best performance, it is possible to mention those related to the active search by the Community Health Agent. Regarding vaccine coverage, for all immunobiologicals analyzed, there was an increase in the percentage of municipalities that reached targets when comparing the years 2022 and 2021, except for hepatitis A. The intervention research had a positive impact on vaccine coverage of children under 2 years of age and on indicators of immunization work processes in municipalities in the state of Minas Gerais, Brazil.

1. Introduction

The National Immunization Program (PNI) of Brazil, coordinated by the Ministry of Health, jointly with state and municipal health departments, has been consolidating itself as one of the most relevant interventions in public health [1]. Created in 1973, the PNI is characterized as an efficient public policy, and increasingly impacts the morbidity and mortality profile of the population [1].

Paradoxically, great challenges arise for the PNI, despite all the achievements. Many diseases have become unknown, causing some people to be unaware of the severity represented by them, with consequent risk of reintroduction or resurgence of controlled or already eradicated diseases in the country [2]. We then begin to observe a phenomenon identified not only in Brazil, but in several countries,

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which refers to the decrease in the achievement of the recommended goals for the vaccination coverage rates, mainly from the year 2016 [3].

According to an ecological study carried out by Procianoy and collaborators (2022), involving the analysis of vaccination coverage for children up to 12 months of age, in the period from 2013 to 2020, throughout the national territory, it was possible to detect that, specifically in the year 2020, the reduction in vaccination coverage was significantly greater than in previous years [4].

Understanding the determinants that influence the drop in vaccine coverage is a complex process, which can be affected by numerous factors, such as: individual, environmental, related to vaccine hesitancy and care programs [5 6]. In the context of children under 2 years of age, various reasons can justify the low vaccination coverage among this population, some of which are: the need for awareness of parents or guardians to provide care/interventions and the way the health system is organized [7 8], especially Primary Care.

The World Health Organization (WHO) "Planning Guide for Reducing Missed Opportunities of Vaccination (MOV)" details the ten steps for implementing the MOV strategy [9]: Step 1: Plan a MOV assessment and intervention; Step 2: Prepare assessment and secure commitments for follow-up interventions; Step 3: Conduct fieldwork for rapid MOV assessment, Step 4: Analyze preliminary data and identify key themes; Step 5: Brainstorm proposed interventions and develop an action plan to the interventions; Step 6: Information session with the management of the Ministry of Health and immunization partners on the next steps; Step 7: Implement the interventions; Step 8: Provide supportive supervision and monitor progress; Step 9: Conduct rapid field evaluation of results/impact of interventions (after 12–18 months) and Step 10: Incorporate into long-term plans to ensure sustainability of gains. This document emphasizes the importance of using planning and building structured action plans to improve vaccine coverage. Still, according to Carlos Matus (1981), planning must be rescued as a method of government, a useful, flexible, and effective tool to deal with the needs of direction in each place of public administration. Situational strategic planning, in turn, is understood as a form of organization for action, and this would be its fundamental difference in relation to traditional planning [10].

In view of the above, to ensure that children under 2 years of age receive all recommended vaccines, it is necessary, in addition to monitoring, to adopt broader strategies [5] and evaluate them. Given the complex scenario of declining vaccination coverage that is taking place in Brazil (even more impacted by the COVID-19 pandemic), with the failure of current measures and with the proof of the difficulties faced by the PNI, there is a growing need to create, and evaluation of strategies aimed at increasing vaccination coverage among children under 2 years of age. Therefore, studies are needed to evaluate health interventions to increase vaccination coverage, as well as monitoring through indicators. In relation to such strategies, in addition to vaccine coverage analyses, the construction of indicators of immunization processes is also essential to measure the performance of municipalities, especially when they can promote changes in the work processes of health teams [11].

In the year 2021, through the integration between the State Department of Health of the State of Minas Gerais (SES-MG - *Secretaria de Estado de Saúde de Minas Gerais*) and the School of Nursing of the Federal University of Minas Gerais (EEUFMG - *Escola de Enfermagem da Universidade Federal de Minas Gerais*), a research-intervention project was implemented to improve immunization coverage for children, by holding Work Courses and building Action Plans targeted at each participating municipality.

Given the above, this article aims to evaluate the impact of the intervention proposed by the teaching-service integration project on vaccination coverage of children under 2 years of age and on the indicators of immunization work processes in the participating municipalities, before and after its achievement.

2. Method

This was a community clinical trial, of the before-after type, carried out in 212 municipalities in the state of Minas Gerais that made up the sample of the research-intervention led by SES-MG and EEUFMG entitled: "Strategies for Increasing Vaccination Coverage in Children under 2 years of age in the State of Minas Gerais, Brazil: An Intervention-Research".

Intervention research was carried out, which has as one of its main assumptions that the production of knowledge is not necessarily a step prior to the action with groups and communities, but the generation of knowledge during the action [12]. It uses transversality as a key principle for the intervention, involving the knowledge of all who make up the research field, thought of as co-authors of a practice of knowledge construction that is never separated from the intervention process itself [13].

Minas Gerais has 853 municipalities, with a territorial area of 586,5 millions km^2 and an estimated population of 21,4 million people (IBGE, 2021). According to the State Regionalization Master Plan (*Plano Diretor de Regionalização* - PDR), the territory is divided into 19 Regional Health Superintendencies (RHS) and 9 Regional Health Managements (RHM). This division represents a form of management that allows these territorial units to have attributions related to the coordination, implementation and monitoring of public health policies and actions within their area of coverage [14].

The study sample comprised the RHM/RHS and their municipalities with a decreasing trend for routine vaccination coverage in children, from 2015 to 2020 [11]: RHS Alfenas: 24 municipalities; RHS Barbacena: 31 municipalities; RHS Coronel Fabriciano: 35 municipalities; RHS Governador Valadares: 51 municipalities; RHM Ituiutaba: 9 municipalities; RHM Leopoldina: 15 municipalities; RHS Passos: 27 municipalities and RHM São João Del Rey: 20 municipalities, totaling 212 municipalities, represents 24.85% of the 853 municipalities in the state.

In total, seven Courses were held in the host municipalities, conducted by a team including professionals from the SES-MG and researchers from the EEUFMG, in March and June 2022. Regional and municipal representatives of Immunization, Health Surveillance, Primary Health Care, management, participated in these Courses. In addition, other external partners also participated, such as: Universities, Municipal Health Councils, Non-Governmental Organizations, Council of Municipal Health Secretariats (Conselho de Secretarias Municipais de Saúde - COSEMS), among others. There were a total of 515 participants. The Courses subsidized the municipalities for the construction of their Municipal Action Plans aimed at increasing vaccination coverage in children.

The planning of the Courses, applied in different scenarios, demanded a previous and meticulous organization by the SES-MG and EEUFMG. There was a complex agreement, from the construction of the research project and the constant communication and transversality of work between both. The team prepared a script for carrying out the Courses and an instructive material for agreeing on indicators with the municipalities.

In the Courses, it was not expected that the municipalities would be able to finalize their action plans. Participants returned to their workplaces, met with their peers and subsequently forwarded the finalized action plans to RHM/RHS, 15 days after the Course. The plans duly implemented in the territories made it possible to monitor indicators and visualize before and after results. This process generated effective changes in work practices and processes in the municipalities, being seen generally throughout the state of Minas Gerais, Brazil, although this study presents a specific sample of 212 priority municipalities.

The operationalization of the Courses took place according to the following methodology, with an approximate workload of 12 h each [15]:

(1): Motivational Moment: Welcome for the participants.

(2): Contextual Core: Raising awareness about the problem of low

vaccination coverage; presentation of vaccination coverage data for children under two years of age in the territory; presentation of the financial resources made available by the state of Minas Gerais, Brazil to promote immunization actions in municipalities; presentation of the Action Research Project.

(3): Integrator/Planning Core: problematizing questions for discussion, involving questions about human resources, infrastructure and logistics for vaccination, social communication, establishing partnerships, among others; initial explanation of the action plan model that should be constructed; division of municipalities into working groups to discuss and begin creating action plans.

(4): Integrator Center/Results: presentation of group discussions; reports of successful experiences from municipalities; agreement on deadlines for sending the finalized action plans to the respective RHM/RHS.

In this study, we used secondary data on vaccination coverage of 10 immunobiologicals recommended for children under 2 years of age, from January to December 2021 (pre-intervention period) and January to December 2022 (post-intervention period) in the state of Minas Gerais, Brazil.

For data analysis, the following immunobiologicals and vaccination schemes were considered: oral vaccine against rotavirus (2nd dose of rotavirus vaccine in the Unified Health System (SUS) and 2nd dose of rota-pentavalent vaccine in the private network), vaccine against meningococcal disease C (2nd dose of Meningococcal C and 2nd dose of Meningococcal ACWY from the private network), vaccine against pneumococcal disease (2nd dose of Pneumococcal 10 V and 2nd dose of Pneumococcal 13-valent vaccine from the private network), pentavalent vaccine (3rd dose of Pentavalent vaccine and the 3rd dose of Hexavalent vaccine from the private network), vaccine against Poliomyelitis (3rd dose of VIP and VOP, pentavalent, inactivated pentavalent from the private network and 3rd dose of hexavalent also from the private network), vaccine against yellow fever (single dose, initial dose and the 1st dose), 1st dose of the triple viral vaccine (1st dose of the triple viral vaccine, 1st dose of the quadruple virus and 1st dose of the tetraviral vaccine), 2nd dose of the triple viral vaccine (2nd dose of the triple viral vaccine, 2nd dose of the quadruple virus, 2nd dose and single dose of viral tetra), vaccine against hepatitis A (considered the 1st dose) and vaccine against varicella (1st dose Varicella, 1st dose of tetraviral, single dose of tetraviral and 1st dose of quadruple viral).

All information on immunobiological doses used in this study was taken from the Information System of the National Immunization Program (SIPNI) available at: <sipni.datasus.gov.br >. BCG and Hepatitis B vaccines were not evaluated, as these vaccines are mostly performed in maternity hospitals in the state of Minas Gerais, which could cause a bias in the analyzes.

Vaccination coverage (VC) was calculated using the 2019 population of the Information System on Live Births (*Sistema de Informações sobre Nascidos Vivos* - SINASC) as a denominator for the 2021 analyses. For the year 2022, the SINASC for the year 2020 was used, always considering the most up-to-date information. In the numerator, doses were used (immunizing dose or dose that completes the vaccination schedule) applied by age group and immunobiological, according to the National Vaccination Calendar of the Ministry of Health.

The National Immunization Program establishes differentiated coverage targets for the calculation and analysis of vaccine coverage, 90% for BCG and Rotavirus vaccines and 95% for other vaccines in the schedule for children under 2 years of age.

To monitor the execution and results of actions proposed in the Municipal Plans, a total of 8 immunization indicators were analyzed:

(1) Training/awareness for immunization services;
(2) Carrying out supervisions in vaccine rooms;
(3) Extramural vaccinations;
(4) Updating the missing vaccine card;
(5) Home visits by Community Health Agents to actively search for vaccination cards for children under 2 years of age in their area of coverage;
(6) Achieving coverage targets for vaccines recommended for children under 1 year old;
(7) Achievement of coverage targets for vaccines recommended for children aged 1 to under 2 years;
(8) Monthly meetings between the Immunization/Health Surveillance and Primary Care team to monitor short-term indicators.

The municipalities submitted to the intervention answered a questionnaire with the results of the indicators at three times: t1 (pre-intervention - moment of the Course), t2 (1st post-intervention monitoring – 3 months after the Course) and t3 (2nd post-intervention monitoring – 6 months after the course) and was based on the theoretical model developed by the authors (Fig. 1) and adapted from the World Health Organization [9], PES guidelines proposed by Carlos Matus [10] and the model proposed by Jordan and Mclaughlin (1999) [16].

Qualitative and quantitative variables related to respondents were analyzed. Some variation in the "n" of answers could have occured, due to the lack of answered questions on the forms. For quantitative variables, the Shapiro Wilk Test was applied, which assesses whether a sample has normal distribution [17]. To compare the results of the indicators before and after the intervention, the Friedman Test and the Wilcoxon Test were used [18]. For the entire analytical procedure, a significance level of 5% was adopted.

Vaccination coverage was also analyzed in the 8 priority RHM/RHS in children under 2 years old, comparing the year 2021 with the year 2022 (considering that the intervention under analysis was carried out in the year 2022). The number of municipalities in each RHM/RHS that reached the target for the analyzed immunobiologicals was also calculated. To verify the proportions of municipalities in the RHM/RHS that reached the goal, the McNemar Test was used.

Vaccination coverage data were presented in medians and interquartile ranges (IQ), due to their non-parametric nature. Initially, the differences between the median vaccination coverage before and after the intervention were evaluated using the Mann-Whitney U Test [19], considering the IQ and a significance level of 5% for all immunobiologicals analyzed. The percentage increase in coverage was also calculated using the following formula:

$$\frac{\textit{Median coverage before intervention} - \textit{Median coverage after intervention}}{\textit{Median coverage before intervention}} \times 100$$

This study is part of a teaching-service integration project, jointly carried out by the School of Nursing/Nucleus of Studies and Research in Vaccination/Federal University of Minas Gerais (NUPESV/EEUFMG) and the Superintendence of Epidemiological Surveillance/State Department of Health of Minas Gerais (SVE/SES-MG). It was approved by the UFMG Research Ethics Committee with the following registration: CAAE 58407122.4.0000.5149.

3. Results

The Table 1 shows the universe of municipalities that responded to the questionnaires with pre and post-intervention indicators, taking into account the total number of municipalities that belong to each RHS/RHM, in accordance with the Regionalization Master Plan of the State of Minas Gerais, Brazil.

To enable a better understanding of the entirety of the final selection of responding municipalities, it is possible to estimate the total number of children residing in the 8 priority RHS/RHM, according to the Live Birth Information System (SINASC), base year 2020. According to SINASC, approximately 41,261 children live in these municipalities, representing a total of 17.04% of children in the state of Minas Gerais.

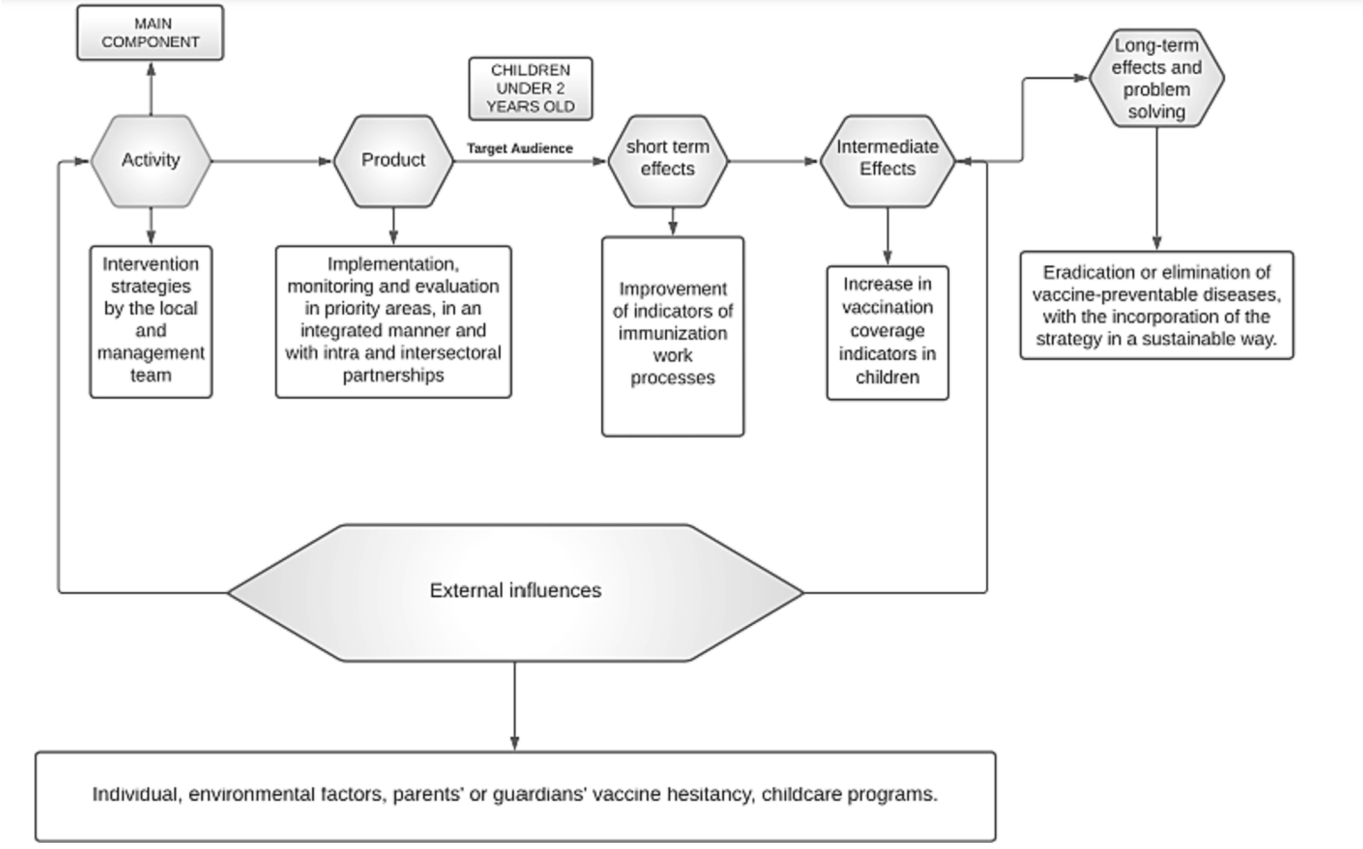

Fig. 1. Theoretical Model of Increased Vaccination Coverage in Children.

Table 1
Municipalities that answered the pre-intervention and post-intervention monitoring questionnaires according to Regional Health Superintendencies or Regional Health Managements (RHS/RHM).

Regional Health Superintendencies or Regional Health Managements (RHS/RHM)	Number of municipalities final (Responded to the questionnaires)	% of total RHM/ RHS municipalities
RHS Alfenas	21	87.5
RHS Barbacena	7	22.6
RHS Coronel Fabriciano	25	71.4
RHS Governador Valadares	3	5.8
RHM Ituiutaba	5	55.5
RHM Leopoldina	12	80.0
RHS Passos	18	66.6
RHM São João Del Rei	16	80.0
TOTAL	**107**	**100.0**

RHS Governador Valadares had the lowest percentage of responding municipalities because it was the first to implement the action, opting to work with only 10 municipalities initially. Subsequently, the Work Course was held with the other municipalities of the region.

The results of the analysis of qualitative variables (Table 2) showed that most respondents did not work with immunization before their current position in the pre-intervention and 2nd monitoring periods. The female sex stands out as a priority, representing more than 80% of the respondents in the three analyzed periods. In the pre-intervention and 1st monitoring periods, it was possible to observe that most respondents had completed higher education as a higher level of education. In the 2nd monitoring, the largest number of respondents declared having lato sensu specialization. About the institutional link, in the three periods, the effective positions were reported by most of the respondents. It should be noted that the initial orientation was that the respondents were municipal health managers or municipal immunization coordinators.

Table 2
Characterization of respondents in the three periods of analysis*.

	Pre intervention	*1st monitoring*	*2nd monitoring*
Prior to his current position, he worked with vaccination			
No	54 (50.5%)	51 (47.7%)	56 (61.5%)
Yes	53 (49.5%)	56 (52.3%)	35 (38.5%)
Sex			
Female	95 (88.8%)	96 (89.7%)	81 (89%)
Male	12 (11.2%)	11 (10.3%)	10 (11%)
Educational level			
High school	2 (1.9%)	2 (1.9%)	5 (5.5%)
University education	54 (50.5%)	57 (53.3%)	37 (40.7%)
Lato Sensu Specialization	48 (44.8%)	45 (42%)	46 (50.5%)
Master's degree	3 (2.8%)	3 (2.8%)	3 (3.3%)
Institutional bond			
Commission	9 (8.4%)	13 (12.0%)	17 (18.7%)
Contract	28 (26.2%)	27 (22.4%)	22 (24.2%)
Effective	70 (65.4%)	67 (62.6%)	52 (57.1%)
	0 (0 – 120)	12 (0 – 120)	0 (0 – 102)
Time working with vaccination (months)			
Respondent's age (years)	37 (34 – 42)	38 (34 – 42)	38 (34 – 43)

Note: *Data expressed as median (Q1-Q3).

Regarding the time working with vaccination, the highest average number of months reported by respondents was in the 1st monitoring (12 months), ranging from 0 (Q1) to 120 months (Q3).

The age of the respondents was similar in the three periods

evaluated, with an average of 37 and 38 years. The length of employment in the current position was longer in the pre-intervention period, with an average of 60 months (5 years), ranging from 12 to 132 months. The average number of people in the team was 5 members in the pre-intervention period and 1st monitoring, reducing to 4 people in the 2nd monitoring.

Table 3 presents the results of the indicators monitored with the municipalities in the pre-intervention (t1), 1st post-intervention monitoring (t2) and 2nd post-intervention monitoring (t3) periods. By using the Friedman Test, it was possible to obtain, in the end, the medians, the interquartile ranges (IQ) (Q1 – Q3) and the "p" value for each indicator. The Wilcoxon Test demonstrated which of the times the difference occurred (a, b or c).

These results showed an important improvement for most of the indicators when comparing t1, t2 and t3 ($p < 0.05$) and an increase in medians and IQ. The indicators that did not show statistical significance at the end of the analyzes were "performing supervisions in vaccine rooms" ($p = 0.148$) and "performing extramural vaccinations" ($p = 0.125$), despite already having high medians since the pre-intervention period.

Table 3
Evaluation of indicators referring to the pre-intervention period (t1), 1st post-intervention monitoring (t2), 2nd post-intervention monitoring (t3). Minas Gerais, 2022.

Indicator	Pre-Intervention (t1)	1st Post-Intervention Monitoring (t2)	2nd Post-Intervention Monitoring (t3)	p-value
Training/ awareness for immunization services (Absolute number)	1 (0–1)$_a$	2 (1–3)$_b$	1 (1–3)$_b$	**<0.001**
Carrying out supervisions in vaccine rooms (Percentage)	100 (30–67)	100 (67–100)	100 (100–100)	0.245
Extramural vaccinations (Absolute number)	3 (1–6)	4 (3–7)	3 (2–6)	0.125
Updating the vaccine card of absentees (Percentage)	30 (3–70)$_a$	60 (34–90)$_b$	80 (60–100)$_c$	**<0.001**
Home visits by Community Health Agents to actively search for vaccination cards for children under 2 years of age in their area of coverage (Percentage)	40 (0–90)$_a$	60 (30–100)$_b$	83.5 (72,3–100)$_c$	**<0.001**
Monthly meetings between the Immunization/ Health Surveillance and Primary Care team to monitor short-term indicators (Absolute number)	1 (1–3)$_a$	3 (1–3)$_b$	3 (2–3)$_b$	**<0.001**

*Note: Equal letters indicate times when the variable showed no difference.

For the indicator "training/awareness for immunization services", it was possible to observe an increase in medians when comparing the pre-intervention period with the 1st monitoring period, remaining stable in the 2nd monitoring. The difference occurred in relation to the pre-intervention period (a) with the periods of 1st and 2nd monitoring. There was no difference between the monitoring periods (b).

The indicator of "updating the vaccine card for absentee persons" showed a significant increase in medians and IQ over the three periods, corroborating the importance of active search actions for completeness of the vaccination card. The difference occurred in the three times analyzed: pre-intervention (a), 1st monitoring (b) and 2nd monitoring (c).

Similarly, the indicator "home visits by Community Health Agents to actively search for vaccination cards for children under 2 years of age in their area of coverage" also showed a considerable increase in medians in the analyzed periods. The difference also occurred in the three times: pre-intervention (a), 1st monitoring (b) and 2nd monitoring (c).

It is important to highlight that the Community Health Agent is a professional who is already part of the routine of primary health care teams in Brazil, being of fundamental importance for immunization actions, as well as in approaching the population in their territory.

For the indicator "holding monthly meetings between the Immunization/Health Surveillance and Primary Care team to monitor short-term indicators" there was an increase in the median in the pre-intervention period in relation to the period of the 1st monitoring, with maintenance of this level in the 2nd monitoring (increase of Q1). The difference in times occurred in the pre-intervention period (a) in relation to the 1st (b) and 2nd monitoring (b).

Regarding the analysis of vaccination coverage in the 8 priority RHM/RHS, comparing the year 2022 with 2021, it was observed that the highest percentage increase occurred with the varicella vaccine (16.81%), followed by the triple vaccine viral D2 (14.57%). The smallest percentage increase occurred with the yellow fever vaccine (1.18%) and with the rotavirus vaccine (5.71%). However, only the yellow fever vaccine was not statistically significant in the comparison between the two years ($p = 0.264$) (Table 4).

In Table 5, it is possible to observe that for all immunobiologicals analyzed there was an increase in the percentage of municipalities that reached vaccination coverage targets when comparing the years 2022 and 2021, except for hepatitis A, which maintained the same number of municipalities in the two years analyzed. The triple viral

Table 4
Vaccination coverage in children under 2 years of age in the following RHM/RHS: Alfenas, Barbacena, Coronel Fabriciano, Governador Valadares, Ituiutaba, Leopoldina, Passos and São João Del Rei – Minas Gerais, 2021 and 2022.

Immunobiological	Year		p-value	Increase (%)
	2021	2022		
Rotavirus	86.03(70–100)	90.94 (79.42–100)	**<0.001**	5.71
Meningococcus C	86.07 (70.20–100)	93.12 (79.29–100)	**<0.001**	8.19
Pneumococcal	84.84 (71.10–100)	94.42 (82.58–100)	**<0.001**	11.29
Pentavalent (DTP/ Hib/HB)	84.72 (70.25–100)	91.45 (78.69–100)	**<0.001**	7.94
Poliomielitis	84.70 (69.93–100)	92.34 (79.29–100)	**<0.001**	9.02
Triple Virus D1	88.74 (75.07–100)	94.92 (83.33–100)	**<0.001**	6.96
Yellow fever	84.55 (65.50–98.26)	85.55 (72.33–98,97)	0.264	1.18
D2 triple viral	70.99 (47.07–89.76)	81.33 (66.17–100)	**<0.001**	14.57
Hepatitis A	84.19 (68.18–100)	93.02 (81.59–100)	**<0.001**	10.49
Varicella	82.98 (66.79–99.52)	96.93 (81.98–100)	**<0.001**	16.81

Table 5
Number of municipalities in the RHM/RHS Alfenas, Barbacena, Coronel Fabriciano, Governador Valadares, Ituiutaba, Leopoldina, Passos and São João Del Rei that reached the goal of vaccine coverage according to immunobiological tests – Minas Gerais, 2021 and 2022.

Immunobiological	Year		p-value
	2021	2022	
Rotavirus	86(40.57)	111(52.36)	**0.008**
Meningococcus C	65(30.66)	99(46.70)	**<0.001**
Pneumococcal	72(33.96)	103(48.58)	**0.001**
Pentavalent (DTP/Hib/HB)	69(32.55)	99(46.70)	**0.002**
Poliomielitis	71(33.49)	100(47.17)	**0.002**
Triple Virus D1	86(40.57)	105(49.53)	0.056
Yellow fever	61(28.77)	63(29.72)	0.818
D2 triple viral	43(20.28)	67(31.60)	**0.002**
Hepatitis A	77(36.32)	77(36.32)	0.057
Varicella	72(33.96)	112(52.83)	**<0.001**

immunobiologicals (D1), yellow fever and hepatitis A did not show statistical significance.

4. Discussion

The downward trend in vaccine coverage in recent years, in the state of Minas Gerais, Brazil and worldwide, favors the formation of pockets of individuals susceptible to various vaccine-preventable diseases [20]. There are several reasons for reducing vaccination coverage over the years, acting jointly and synergistically with the consequent worsening of the scenario of vaccine-preventable diseases. In this scenario, the following stand out: the precariousness experienced by the Unified Health System (SUS); the implementation of the new immunization information system (SIPNI), which took place in 2013; social and cultural aspects that affect acceptance of vaccination; introduction by the PNI of several vaccines in the routine schedule in a short period; anti-vaccination movements and inconstancy in the availability of immunobiologicals in Primary Health Care services [6 7 8].

The scenario of falling vaccine coverage was further aggravated by the COVID-19 pandemic [4 21]. During the pandemic period, in Brazil, there was a 15.11% drop in coverage for MMR, followed by BCG, with a reduction of 14.87%, in addition to immunizations against yellow fever and rotavirus, with a reduction of 10. 44% and 9.56%, respectively. Another important finding of the studies is that social isolation was not the main limiting factor for vaccine coverage targets not being achieved in Brazil in 2020 [21]. In parallel with the COVID-19 pandemic, there was also a "pandemic of fear", which generated insecurity in parents and guardians about the completeness of the children's calendar [22].

In this context, the recognition of risk and the planning and evaluation of municipal actions to improve the coverage of immunobiologicals recommended by the PNI for children are essential. Knowledge of the indicators and actions proposed by the municipalities through the Action Plans also allowed SES/MG to recognize the needs of these locations and offer support for the improvement of vaccination indicators. It is essential that internal and external researchers are very engaged to enable reflective and cooperative moments, capable of producing knowledge and modifying health practices. In this sense, the proposition of joint construction valued co-responsibility and reflections for decision-making, as shown in other works [23 24].

The identification of the components of the groups with the object and with the valuation of the subjects was fundamental for the success of this work. Corroborating the idea of engagement of the group in question is not only the active participation in the stages of the Course, but also the delivery of Action Plans by all municipalities and the commitment to carry out fundamental activities for achieving the targets of the indicators to be monitored periodically.

The indicators that showed significant improvement and important differentiation in the three times analyzed after the intervention were precisely those related to the active search for the Community Health Agents. Throughout the SUS construction process, the importance of implementing the Community Health Agents Program in building the link between the community and health services is undeniable [25]. As attributes of their work, the Community Health Agents have cultural competence, community orientation and bond building, relating daily with the families in their territory and sharing technical and popular knowledge [26 27]. These data reinforce the importance of the role of the Community Health Agents in the active search and correct guidance on childhood vaccination, therefore, there is a need for investment in qualification and permanent education of these professionals [28].

Finally, regarding the limitations and perspectives in the development of this study, it should be noted that the distance of the RHM/RHS from the capital of Minas Gerais required the professionals to travel in person. In addition, the Courses were carried out in different settings and were conducted by different professionals, requiring constant communication and transversal work between the University and SES. Other limitations also concern the use of secondary data to analyze vaccination coverage, as researchers do not have full control of the records of each vaccination room. Despite potential limitations, this teaching-service integration project demonstrated applicability and positive results in the scenario of vaccination coverage of children in the state of Minas Gerais, as well as changes in the work processes of local teams. Thus, it is likely to be implemented in other RHM/RHS, as well as to adapt the same methodology to other life cycles (adolescents, adults, pregnant women, elderly people).

5. Final Considerations

The intervention research had an impact on vaccination coverage of children under 2 years of age and on indicators of immunization work processes in the State of Minas Gerais, Brazil (comparing the years 2021 and 2022).

There was also the relevance of teaching-service integration, fulfilling the prerogatives of transforming professional practices, organizing immunization work processes and academic improvement.

The increase in vaccination coverage implies the adaptation of broader strategies and improvements for public health, since immunization plays an important role in preventing preventable diseases and, consequently, in reducing child morbidity and mortality. In this sense, the monitoring of indicators and the construction of Action Plans based on the PES methodology were important allies in the resumption of the immunization work that had been hampered in the most critical period of the COVID-19 pandemic.

It is essential to stimulate the production of research that supports the development of strategies to know the clientele of health services and that evaluate, in a more detailed way, the vaccination coverage and the quick and more precise location of specific groups that are without vaccination protection, such as the children's audience.

It is also expected that the findings of this study will contribute to a better understanding of the immunization work processes and that the PES will be used at management levels to support the increase in vaccination coverage in children. Likewise, these findings can also be used to promote increased vaccination coverage in other life cycles (adolescents, adults, elderly, pregnant women, among others).

This strategy is based on the prerogative of changing work processes, that is, it involves few financial resources for municipalities. These are routines that should already be carried out by primary health care teams, although not systematized and measured as results until now.

CRediT authorship contribution statement

Janaina Fonseca Almeida Souza: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Thales Philipe Rodrigues da Silva:** Conceptualization, Formal analysis, Investigation,

Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Sheila Aparecida Ferreira Latchim:** Conceptualization, Investigation,Methodology,Validation, Visualization, Writing – review & editing. **Ed WilsonRodriguesVieira:** Conceptualization,Validation, Visualization, Writing – review & editing. **Eunice Francisca Martins:** Conceptualization,Validation, Visualization, Writing – review & editing. **Denisiane Geralda Araújo:** Conceptualization,Validation, Visualization, Writing – review & editing. **Bruna de Castro da Silva:** Conceptualization,Validation, Visualization, Writing – review & editing. **Elice Eliane Nobre Ribeiro:** Conceptualization,Validation, Visualization, Writing – review & editing. **Fernanda Penido Matozinhos:** Conceptualization,Data curation,Formal analysis, Investigation, Methodology, Projetct Administration, Supervision, Validation, Visualization, Writing – original draft, 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.

Data availability

No data was used for the research described in the article.

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"All authors attest they meet the ICMJE criteria for authorship"

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