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Effect of the Covid-19 Pandemic on Vaccination Coverage of the Population Under 2 Years of Age, Ibarra- Ecuador

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Abstract

This study analyzes the impact of the Coronavirus (SARS-CoV-2) pandemic on the coverage of the regular vaccination schedule in children under two years of age in the canton of Ibarra, Ecuador, between 2018 and 2021.The research design is quantitative, descriptive, and cross-sectional, with data obtained from administrative records and surveys directed at vaccination pr ogram managers.The findings reveal a substantial decline in vaccination coverage during the pandemic, with statistically significan t differences observed between the periods 2018-2020, 2019-2020, 2018-2021, 2019-2021, and 2020-2021 ($p < 0.001$). The coverage among children under one year of age decreased from 176.1% in 2018 to 134.9% in 2021, while among girls, it dropped from 160.5% to 121.1%, indicating a downward trend also among those over one year of age. A statistically significant disparity was observed between urban and rural areas, with a decline more pronounced in urban regions during the 2020-2021 period ($p = 0.048$). Furthermore, three socioeconomic quintiles (1, 2, and 4) exhibited coverage rates below 50% during the specified period. The primary barriers identified included reassignment of health personnel to the care of patients with severe acute respiratory syndrome (88.8%), mobility restrictions (77%), and vaccine shortages (66.6%).Consequently, the pandemic exerted a detrimental influenc e on childhood vaccination coverage, thereby heightening the risk of immunopreventable diseases and underscoring the imperative for the formulation of strategies to ensure the sustainability of immunization programs in emergency contexts.

Keywords: *Vaccination, Access Barriers, COVID-19 Pandemic, Ibarra Canton, Equity, Vaccination Coverage.*

Introduction

On December 31, 2019, an outbreak of an unknown viral respiratory disease was reported in the city of Wuhan, China (Zhu et al., 2020). The etiology of the outbreak was later identified as a novel virus, known as SARS-CoV-2, which causes a disease referred to as "covid-19." In the ensuing months, the rapid propagation of the virus led the World Health Organization (WHO) to

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designate the disease as a public health emergency of international concern on January 30, 2020, and subsequently, on March 11, 2020, to categorize it as a global pandemic (WHO, 2020).

The health crisis engendered by the pandemic had substantial ramifications for health systems globally. Among the numerous repercussions, a substantial impact was observed on the coverage of childhood vaccination programs, resulting in a decline in immunization rates and exposing millions of children to vaccine-preventable diseases (Moreno-Montoya et al., 2022; DeSilva et al., 2022). According to the Pan American Health Organization (PAHO), in 2020, approximately 2.7 million children in the Americas did not receive the requisite vaccines, which would have ensured their protection against various immunopreventable diseases (PAHO, 2022).

Impact of the Pandemic on Childhood Immunization Programs

Historically, vaccination has been identified as one of the most effective public health strategies for reducing infant mortality and preventing infectious diseases. However, the pandemic led to disruptions in immunization programs due to multiple factors, including the reassignment of health workers to care for patients with severe acute respiratory syndrome (SARS-CoV-2) and subsequent restrictions on mobility, fear of contagion, and misinformation (Ji et al., 2022).

In Latin America, the pandemic resulted in a substantial decline in vaccination coverage. In countries such as Brazil, Colombia, and Peru, there were declines in immunization of up to 20% compared to the years prior to the pandemic (Santos et al., 2021; Vásquez-Uriarte et al., 2020). A similar phenomenon was observed in Ecuador, where recent studies indicated a decline in childhood vaccination coverage during the 2020-2021 period, particularly affecting the most vulnerable segments of the population (Suarez et al., 2022).

In this context, the city of Ibarra, Ecuador, was no exception. The repercussions of the pandemic have been profound, resulting in a substantial decline in adherence to the standard immunization schedule for children under two years of age. This has led to a notable gap in vaccination coverage, which has the potential to heighten the risk of outbreaks for preventable diseases such as measles, polio, and diphtheria (Ministry of Public Health of Ecuador, 2022).

Justification of the Study

The present study is of great relevance because childhood vaccination is a fundamental intervention for the reduction of mortality and the prevention of infectious diseases. According to the World Health Organization (2021), achieving a 95% vaccination coverage is imperative to ensure herd immunity and prevent the resurgence of preventable diseases. However, the ongoing global health crisis caused by the novel severe acute respiratory syndrome (SARS-CoV- 2) has led to a significant setback in the progress made in recent years. This underscores the need to comprehensively evaluate its impact and formulate strategies to bolster immunization programs in emergency contexts.

This study aims to contribute to the scientific evidence base, informing decision-making in public health and providing input for the development of strategies to recover vaccination coverage in vulnerable populations.

General Objective

To analyze the effect of the COVID-19 pandemic on the vaccination coverage of the population under 2 years of age in the city of Ibarra, Ecuador, during the years 2018 to 2021.

Methods

Applied research was carried out with a quantitative and descriptive approach. The research design is non-experimental and cross-sectional. To identify access barriers, 15 people responsible for immunizations in Zonal Coordination 1 of the MSP were used as the unit of analysis. To analyze the vaccination coverage variable, the administrative record of the databases of the National Immunization Strategy was used, of children under 2 years of age, vaccinated during the year 2018, 2019, 2020 and 2021, through which it represents a total of 238,297 doses applied.

This research had a non-probabilistic census sampling, because the information of the total of the populations studied was available. Child population under or equal to 2 years of age who received vaccines from the regular vaccination schedule in the health facilities of the Ministry of Public Health in the city of Ibarra between 2018 and 2021.

Immunization managers designated by the Ministry of Public Health in the Districts and Zonal Coordination 1 between 2020 and 2021. Children under 2 years of age who were vaccinated in the private sector. Immunization managers who did not authorize their informed consent to participate in the research.

The collection of data on the variables included in the daily immunization records of children under two years of age was accomplished through the implementation of indirect observation. The survey technique was administered to immunization managers with the objective of identifying potential barriers to vaccination coverage.

Two instruments were used in this research. The first was the MSP Form 502/2019, known as the Daily Vaccination Record (Annex 01), accompanied by the Regular Vaccination Schedule, which is mandatory throughout the National Health System of Ecuador (Annex 02). The second instrument was a survey designed by the author to identify the barriers that hindered compliance with the goals of the regular vaccination schedule during the 2020-2021 pandemic (Annex 03).

Instrument No. 1 is Form MSP 502/2019, also known as the Daily Vaccination Record. Approved in 2019, this form is used to record information related to the regular vaccination schedule on a daily basis. The Ministry of Public Health of Ecuador validated and published this form, which has the objective of collecting information related to the activities of the Regular Immunization Program. This instrument is part of the country's efforts to maintain and improve the vaccination coverage of the population, dividing it according to life cycles and according to the planned vaccination schedule.

The form, which is comprised of 75 items, is administered individually and is estimated to require approximately 30 minutes to complete. It is accompanied by its own set of instructions for completion (Annex 04). The instrument is designed for application to the entire Ecuadorian population, and the personnel responsible for its administration include nurses, responsible doctors, and other health professionals who have received training for this purpose. The evaluation of the form is clinical in nature, with a particular focus on the domain of immunization.

The form is structured in A4 format, with the pertinent information presented horizontally. At the top of the form, there are the logo of the governing institution of the National Health System and that of the National Immunization Strategy. The form is divided into two sections to facilitate understanding and completion. The initial block is designated for the inscription of general data, including the names and surnames of the vaccinated individual, their residential address, identification documents such as their national ID or passport, contact telephone number, the name of the healthcare facility, and the date of completion of the registry.

Additionally, it gathers sociodemographic data, including age, sex, ethnic origin, nationality, vaccination history, and pathological history. The second block of the form contains 75 columns that collect specific information on the different types of biologics administered, organized according to the life cycle and the regular vaccination schedule. This comprehensive approach enables meticulous oversight of administered vaccines, thereby ensuring that the vaccination scheme of the country at large fulfills its coverage and monitoring objectives.

Instrument No. 2. The survey is designed to identify barriers that hinder adherence to the objectives of the regular vaccination schedule during the 2020-2021 pandemic.

The survey was administered anonymously and confidentially to 15 vaccination managers and comprised two pages with four sections (A, B, C, and D). The application was designed to be completed individually, free from syntax or grammatical errors, and comprised 40 items, 23 of which were closed questions in the format of a multiple-choice Likert scale with a hierarchical structure, thereby facilitating the respondents' selection of their answers. The questions were meticulously crafted to minimize the effort required from the participants, as they did not necessitate the formulation of answers through writing or verbalization. Instead, respondents were instructed to select the option that best delineated their circumstances. The questions were formulated to be clear, simple, and concrete, ensuring that respondents with specialized knowledge on the subject could answer without difficulty.

The data collection method employed was manual, with respondents utilizing paper and pencil. The estimated time required for completion of the questionnaire was 15 minutes. The initial set of questions presented four possible answers: Never, Regular, Infrequent, and Very Frequent. In the subsequent set of questions, three options were presented: Yes, No, and Don't Know. Participants were instructed to indicate their responses by placing a cross (X) in the designated box. To expedite the data processing, a pre-coding system was implemented for the closed questions, assigning a numerical code to each answer option.

The survey encompassed the exploration of the following variables: The closure of health facilities, educational institutions, and the implementation of restricted hours of operation in health facilities were of particular interest. The survey also addressed the following questions: Was there a lack of equipment for storing vaccines (cold chain)?Was there a deficit of human talent to vaccinate? Did users not attend the health facility when they were scheduled to be vaccinated? Did users reject health personnel for home vaccination for fear of infection? Was there a lack of communication or effective promotion about vaccination days in the community? Was there a rejection of vaccination due to beliefs or myths about the safety of vaccines? Did the population show distrust in health personnel? Did the population prefer the use of traditional or alternative medicine in the face of the pandemic rather than getting vaccinated? Was there difficulty in moving to the vaccination site during the pandemic, which prevented users from going on the day of the appointment? Did they not go to get vaccinated due to lack of economic

resources to buy supplies such as masks, gel, or antiseptic alcohol? The following inquiries must be addressed: first, did vaccination personnel dedicate themselves to the search for cases of the novel virus; second, did personnel infected with the virus enter quarantine; third, did the population become negatively influenced by misinformation disseminated on social networks or fake news about vaccines during the aforementioned pandemic; fourth, did the fear of possible side effects or unknown factors discourage the population from receiving the vaccine; fifth, was the Vaccination Day of the Americas developed; sixth, was the Vaccination Day against influenza developed? The following research questions must be addressed: first, did the population encounter vaccination personnel dedicated to the search for cases of the virus? Second, did the population encounter infected personnel and, if so, were they isolated? Third, did misinformation on social networks or fake news about vaccines negatively influence the population during the pandemic? Fourth, did the fear of possible side effects or unknowns discourage the population from getting vaccinated? Fifth, was the vaccination day of the Americas developed? Sixth, was the vaccination day against influenza developed? Seventh, was there any campaign to recover regular schedule vaccination coverage? Eighth, was there community promotion on the importance of vaccination in local media or educational campaigns? Ninth, did local authorities (government, community leaders) provide institutional support to promote and facilitate vaccination days? Tenth, were door-to-door vaccination strategies implemented in hard-to-reach communities? Eleventh, were training activities developed for staff to achieve vaccination coverage goals during the emergency health crisis?

Results

Age Groups Gender		**Ye rs**			
		2018	**2019**	**2020**	**2021**
Children under 1 year old	Men	176,10%	175,40%	160,90%	134,90%
	Women	160,50%	158,20%	147,80%	121,10%
Over 1 year old	Men	91,30%	93,80%	83,20%	72,50%
	Women	91,30%	92,60%	82,80%	71,20%

Table 1. Coverage of the Regular Vaccination Schedule in Children Under 2 Years of Age by Age and Sex, Years 2018-2019 (Pre-Pandemic) And 2020 And 2021 (Intra-Pandemic), Ibarra-Ecuador

During the period under consideration, a downward trend was observed in vaccination coverage among both men and women. Specifically, among children under one year of age, coverage decreased from 176.1% in 2018 to 134.9% in 2021, while among those over one year of age, it declined from 91.3% in 2018 to 71.2% in 2021. A similar pattern was evident in girls under one year of age, whose coverage decreased from 160.5% in 2018 to 121.1% in 2021. In the group of people over one year of age, the reduction was from 91.3% in 2018 to 71.2% in 2021.

Overall, vaccination coverage in children under one year of age was consistently higher compared to that of children aged 12 to 24 months throughout the period analyzed. However, the general trend indicates a progressive decline in coverage over time, which underscores the need for strategies to mitigate this reduction and strengthen immunization in the child population.

Years		N	Dif. Average	Statistical	Asymptotic significance
2018	2019	20	2,2%	170	0,4152
2018	2020	20	22,5%	19	0,0000
2018	2021	20	7,9%	60	0,0001
2019	2020	20	20,3%	21,5	0,0000
2019	2021	20	5,7%	117	0,0246
2020	2021	20	-14,6%	34,5	0,0000

Table 2. Mean Differences in Regular Vaccination Coverage in Children Under 2 Years of Age, Pre-Pandemic and Intra-Pandemic Period, Ibarra-Ecuador

To determine if there were significant differences in vaccination coverage in the Ibarra Canton during the period 2018-2021, a bivariate statistical analysis was carried out. First, the normality of the data was assessed using the Kolmogorov-Smirnov test, the results of which indicated that the data did not follow a normal distribution ($p < 0.001$). Because of this, a non-parametric test was chosen, selecting the Kruskal-Wallis test to compare vaccination coverage between the years analyzed ($p < 0.001$). The results confirmed that vaccination coverage varied significantly throughout the period studied.

Subsequently, a comparative analysis was carried out between the different years, with the aim of identifying specific statistical differences and determining the magnitude of variations in vaccination coverage. The results showed that:

- Between 2018 and 2020, a highly significant decrease in vaccination coverage ($p = 0.0000$) was observed, suggesting a considerable impact of the pandemic on childhood immunization.
- When comparing 2018 with 2021, a significant difference was also evidenced ($p = 0.0001$), although the decrease was smaller compared to 2020.
- The comparison between 2019 and 2020 reflected a highly significant reduction ($p = 0.0000$), while the difference between 2019 and 2021 was equally significant but with less impact ($p = 0.0246$).
- Between 2020 and 2021, although coverage continued to decline, the difference was not as marked as in previous comparisons ($p = 0.0000$).

The findings indicate that vaccination coverage in Ibarra experienced a precipitous decline between 2018 and 2020, largely attributable to the repercussions of the pandemic. Although the downward trend persisted in 2021, the magnitude of the reduction was less pronounced.

A subsequent analysis, employing the Kruskal-Wallis test, revealed statistically significant disparities in vaccination coverage between children under one year of age and those between 12 and 24 months of age ($p = 0.019$). This finding underscores the necessity for customized immunization strategies, tailored to address the varying levels of vaccination across distinct age groups.

VACCINE	2018 - 2019		2020 - 2021	
	RURAL	URBAN	RURAL	URBAN
BCG 24 hours	2%	117%	0%	96%
BCG 364 days	2%	37%	0%	31%
Hepatitis B (HB)	3%	121%	1%	102%
Rotavirus 1st dose	78%	74%	74%	61%
Rotavirus 2nd dose	83%	79%	72%	61%
fIPV 1st dose	53%	85%	62%	69%
fIPV 2da dosis	57%	87%	63%	69%
Oral bivalent polio vaccine (bOPV)	82%	78%	71%	57%
Pneumococcal conjugate 1 dose	77%	73%	76%	62%
Pneumococcal conjugate 2 doses	82%	77%	78%	64%
Pneumococcal conjugate 3 doses	80%	75%	78%	64%
Pentavalent 1st dose	78%	75%	76%	62%
Pentavalent 2da dosis	83%	79%	76%	62%
Pentavalent 3rd dose	82%	77%	77%	64%
Measles, Rubella and Mumps (MMR) 1 dose	88%	88%	80%	59%
Measles, Rubella and Mumps (MMR) 2 doses	92%	85%	69%	54%
Yellow fever	88%	87%	86%	69%
Chickenpox	88%	84%	84%	68%
Bivalent oral polio vaccine (bOPV) 4	91%	79%	77%	62%
Diphtheria, Tetanus, Pertussis (DPT) 4	91%	79%	82%	65%

Table 3. Coverage of the Regular Vaccination Schedule in Children Under 2 Years of Age by Geographical Area, Years 2018-2019 (Pre-Pandemic) And 2020-2021 (Intra-Pandemic), Ibarra-Ecuador

Analysis of the data reveals a widespread decline in vaccination coverage in both urban and rural areas; however, the reduction is particularly pronounced in urban areas. Vaccines that require additional doses or boosters, such as pneumococcal, pentavalent, MMR, and polio, experienced a more marked drop in coverage, indicating that full immunization schedules were particularly

affected. This could have long-term implications for protecting children from preventable diseases.

Importantly, the reduction in coverage varied by vaccine type and geographic location. For example:

- bOPV vaccine: Decreased from 82% to 78% in rural areas and from 78% to 57% in urban areas.
- MMR vaccine: Reduced coverage from 88% to 80% in rural areas and from 88% to 59% in urban areas.
- Pentavalent (third dose): It fell from 82% to 77% in rural areas and from 77% to 64% in urban areas.

In contrast, vaccines administered at birth, such as BCG and Hepatitis B, exhibited minor variations in their coverage. This phenomenon could be attributed to the fact that their administration occurs in a hospital setting, which ensures a more consistent implementation, or because they are biologics that are better recognized and accepted by the population.

Conversely, certain vaccines, including the initial administration of rotavirus and fIPV, exhibited a comparable decline in coverage across both geographical regions. However, notable disparities emerged among specific vaccines. For instance, the second dose of fIPV exhibited a modest increase in coverage in urban areas, while other vaccines continued to demonstrate a downward trend.

To assess differences in vaccination coverage by geographic area, the nonparametric Kruskal-Wallis test was applied, with a 95% confidence level. The findings revealed statistically significant disparities between urban and rural regions during the study periods ($p = 0.048$). However, when analyzing the data from 2018 and 2019, insufficient evidence was found to affirm that there were significant differences in vaccination coverage between the two geographical areas.

VACCINES	Q1	Q2	Q3	Q4	Q5
BCG 24 hours	0,0%	0,0%	0,0%	0,0%	83,6%
BCG 364 days	0,0%	0,0%	1,4%	0,0%	27,1%
Hepatitis B (HB)	0,0%	0,0%	2,7%	0,0%	88,9%
Rotavirus 1st dose	49,3%	50,8%	94,0%	48,3%	63,0%
Rotavirus 2nd dose	47,3%	46,8%	83,6%	49,2%	62,7%
fIPV 1st dose	12,0%	4,0%	98,8%	9,1%	69,0%
fIPV 2da dosis	15,3%	2,4%	95,3%	11,6%	69,4%
Oral bivalent polio vaccine (bOPV)	54,0%	61,1%	84,2%	54,5%	58,8%
Pneumococcal conjugate 1 dose	51,3%	47,6%	95,1%	49,6%	64,1%

Pneumococcal conjugate 2 doses	52,7%	52,4%	90,6%	53,3%	65,9%
Pneumococcal conjugate 3 doses	58,7%	65,9%	90,8%	64,9%	65,9%
Pentavalent 1st dose	48,7%	54,8%	96,7%	50,8%	63,5%
Pentavalent 2da dosis	49,3%	50,0%	89,5%	52,1%	64,3%
Pentavalent 3rd dose	54,7%	62,7%	86,9%	59,9%	65,6%
Measles, Rubella and Mumps (MMR) 1 dose	71,8%	69,6%	98,3%	70,4%	61,1%
Measles, Rubella and Mumps (MMR) 2 doses	74,5%	78,4%	80,5%	61,3%	55,0%
Yellow fever	71,1%	79,2%	100,6%	67,5%	71,6%
Chickenpox	68,5%	71,2%	100,2%	61,3%	71,0%
Bivalent oral polio vaccine (bOPV) 4	71,1%	71,2%	85,9%	65,4%	63,7%
Diphtheria, Tetanus, Pertussis (DPT) 4	72,5%	85,6%	89,4%	70,4%	67,6%

Table 4. Coverage of the Regular Vaccination Schedule in Children Under 2 Years of Age According To Socioeconomic Level (Sociodemographic Quintiles) Period 2020-2021, Ibarra-Ecuador

In the second period examined, a more pronounced decrease in vaccination coverage was observed among the lowest socioeconomic quintiles, particularly in the first quintile. This phenomenon may be attributed to the repercussions of the ongoing pandemic, which has had a disproportionate impact on the most vulnerable segments of the population, thereby impeding their access to healthcare services and immunization programs.

Notwithstanding the variability in the data, the general trend observed in 2018-2019 persists: namely, inequalities in vaccination coverage between different socioeconomic quintiles. The correlation between socioeconomic status and vaccination coverage is evident, with lower socioeconomic levels correlating with reduced vaccination coverage. This underscores the necessity for the implementation of strategies targeting the most disadvantaged sectors to mitigate these disparities.

The vaccines exhibiting the most pronounced disparities between quintiles are those requiring multiple doses, such as pneumococcal and pentavalent vaccines. This phenomenon suggests that vaccination programs for these vaccines may be less effective in the lowest quintiles, possibly due to barriers in accessing health services, inadequate follow-up, or economic and geographic difficulties. Conversely, vaccines administered at birth, including BCG and Hepatitis B, exhibited higher coverage in the highest quintiles. This suggests that disparities in access to vaccination may be associated with the frequency and conditions under which each biologic is administered.

Data from 2020 and 2021 reveal a further intensification of inequalities in vaccination coverage, with a significantly higher concentration observed in the highest quintiles. A comparison of these findings with the data presented in Table 5 substantiates the exacerbation of this disparity in recent years.

To facilitate a more nuanced understanding of the dynamics underlying these disparities, a figure is presented below. This figure illustrates the average coverage achieved by each socioeconomic quintile, categorized by the period of analysis.

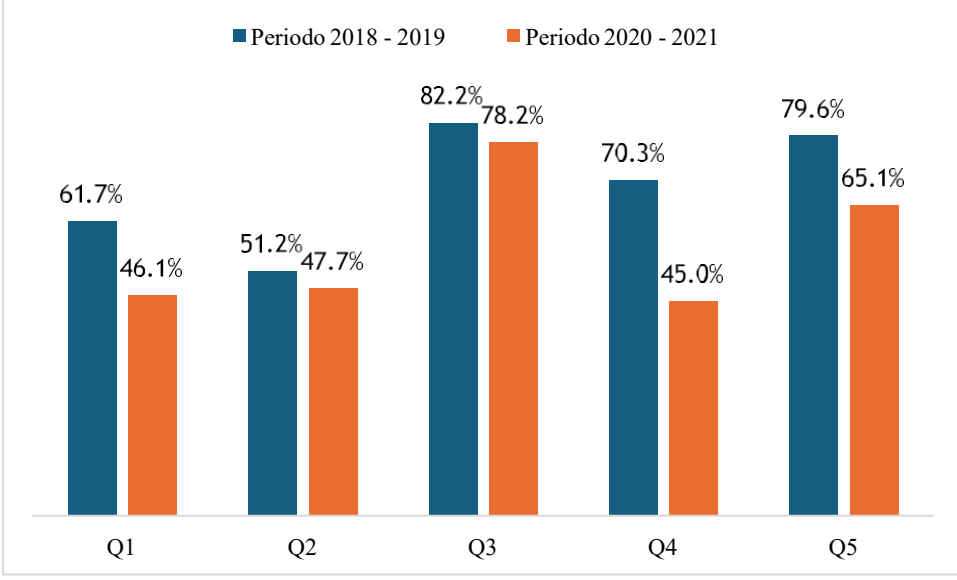

Figure 1. Average Coverage of the Regular Vaccination Schedule in Children Under 2 Years of Age According to Socioeconomic Level (Sociodemographic Quintiles) And Periods of Analysis, Ibarra-Ecuador

In the initial period examined (2018-2019), quintile 2 exhibited the lowest vaccination coverage, with an average of 51.2%, while the other quintiles surpassed 61%. Conversely, during the subsequent period (2020-2021), a more pronounced decline was observed, with three quintiles (1, 2, and 4) registering coverage rates below 50%, signifying a substantial impact on the equity of access to vaccination.

Furthermore, the increasing trend in coverage as the socioeconomic level rises was more evident during the period 2018-2019 than in 2020-2021. This finding suggests that, while inequalities in vaccine coverage have always existed, they were further accentuated during the pandemic, particularly affecting the most vulnerable sectors.

Characteristics	**Categories**	**N**	**%**
Lack of vaccine distribution	Never	3	33,3%
	Rare	4	44,4%
	Regular	2	22,2%
	Never	7	77,8%
	Rare	1	11,1%

Was there a closure of health facilities?	Regular	1	11,1%
Was there a closure of educational institutions?	Very common	4	44,4%
	Never	2	22,2%
	Rare	2	22,2%
	Regular	1	11,1%
Restricted hours of operation in health facilities?	Never	7	77,8%
	Rare	1	11,1%
	Regular	1	11,1%
Was there a lack of equipment for vaccine storage (cold chain)?	Never	8	88,9%
	Regular	1	11,1%
Was there a deficit of human talent to vaccinate?	Very common	3	33,3%
	Never	4	44,4%
	Regular	2	22,2%
Vaccination staff dedicated to finding COVID-19 cases?	Very common	4	44,4%
	Never	1	11,1%
	Rare	4	44,4%
Vaccination personnel infected by COVID-19 and in isolation?	Very common	4	44,4%
	Never	2	22,2%
	Rare	3	33,3%

Table 5. Barriers To Access from The Direct Services of Health Facilities and Their Personnel That Prevent the Fulfillment of Goals of The Regular Vaccination Schedule in Children Under 2 Years of Age in The Intra-Pandemic Period, Ibarra-Ecuador

According to the individuals responsible for the implementation of vaccination programs in health facilities within the city of Ibarra, it was reported that 60% of health centers were unable to achieve the vaccination goals that had been established for the years 2020 and 2021.

An analysis of these facilities revealed that 66.6% of them reported challenges in the distribution of vaccines, suggesting potential irregularities or insufficiencies in the supply chain. This may have resulted in limited availability of biologics during crucial periods.

With respect to the infrastructure and operational capacity of health services, while most facilities (77.7%) did not encounter prolonged closures, 22.2% did face time restrictions and temporary closures, which may have constrained timely access to vaccination.

The ongoing pandemic has precipitated substantial changes across multiple sectors, including immunization programs. The primary factors influencing vaccination coverage are as follows:

- Closure of educational institutions (77.7%), which made it difficult to recruit children of vaccination age.
- Reassignment of health personnel to the care of patients with COVID-19 (88.8%), which reduced the operational capacity of vaccination services.

- Contagion of health personnel (77.7%), causing absences and reducing the availability of trained professionals to administer vaccines.

A further impediment identified was the absence of dedicated personnel for vaccination in health facilities, a phenomenon reported in 55.5% of cases. This limitation became particularly pronounced in the context of the additional demand triggered by the pandemic.

While most facilities reported no significant challenges with the cold chain, the identification of isolated incidents of storage failures underscores the need for enhanced cold chain management to ensure the stability and quality of biologicals.

In addition to the analysis of the supply of vaccination services, factors associated with the demand for vaccination were also evaluated, that is, the perception and actions of the population regarding immunization during the period 2020-2021. To this end, the heads of the Expanded Program of Immunization (PAI) in each health facility were consulted, obtaining the following results:

Characteristics	**Categories**	**N**	**%**
Did usersnot attend the health facility when they were scheduled to be vaccinated?	Very common	4	44,4%
	Rare	4	44,4%
	Regular	1	11,1%
Did usersreject health personnel for home vaccination for fear of getting infected?	Very common	2	22,2%
	Never	1	11,1%
	Rare	3	33,3%
	Regular	3	33,3%
Was there a lack of communication or effective promotion about the vaccination days in the community?	Very common	1	11,1%
	Never	5	55,6%
	Rare	1	11,1%
	Regular	2	22,2%
Was there a rejection of vaccination due to beliefs or myths about the safety of vaccines?	Very common	1	11,1%
	Never	1	11,1%
	Rare	4	44,4%
	Regular	3	33,3%
Did the population show distrust in health personnel?	Very common	3	33,3%
	Never	3	33,3%
	Rare	1	11,1%
	Regular	2	22,2%
Did the population prefer the use of Traditional or Alternative Medicine in the face of the pandemic situation rather than getting vaccinated?	Very common	3	33,3%
	Rare	3	33,3%
	Regular	3	33,3%
	Very common	4	44,4%
	Rare	2	22,2%

Was there difficulty in getting to the vaccination site during the pandemic, which prevented users from going on the day of the appointment?	Regular	3	33,3%
Did theynot go to get vaccinated due to lack of economic resources to buy supplies such as masks, gel or antiseptic alcohol?	Very common	1	11,1%
	Never	1	11,1%
	Rare	6	66,7%
	Regular	1	11,1%
Was the population negatively influenced by misinformation on social media or fake news about vaccines during the pandemic?	Very common	2	22,2%
	Rare	3	33,3%
	Regular	4	44,4%
Did fear of possible side effects or unknown discourage the population from getting vaccinated during the pandemic?	Very common	3	33,3%
	Rare	3	33,3%
	Regular	3	33,3%

Table 6. Barriers To Access from the Population That Prevent the Fulfillment of Goals of the Regular Vaccination Schedule in Children Under 2 Years of Age In The Intra-Pandemic Period Declared By Health Personnel, Ibarra-Ecuador

It has been determined that the noncompliance with scheduled vaccinations is a pervasive issue, with 44% of surveyed establishments reporting that users did not attend vaccination appointments. This finding suggests a widespread challenge in adhering to vaccination schedules.

Additionally, it was observed that 55.5% of the establishments reported instances of individuals rejecting home vaccination due to concerns regarding contagion and mistrust in health personnel (44.4%), a phenomenon that can be attributed to the uncertainty and fear instilled by the ongoing pandemic.

The dissemination of misinformation regarding vaccines on social networks and other media platforms contributed to the propagation of doubts and fears within the population, as indicated by 44.4% of the establishments surveyed. Furthermore, 66.6% of these establishments noted that the population was influenced by social networks.

The scarcity of financial resources to procure biosecurity supplies (77%) and the challenges in mobility (77%) during the pandemic emerged as significant barriers identified by health personnel.

The preference for traditional or alternative medicine (66.6%) emerged as an additional barrier, reflecting the heterogeneity of beliefs and health practices within the population.

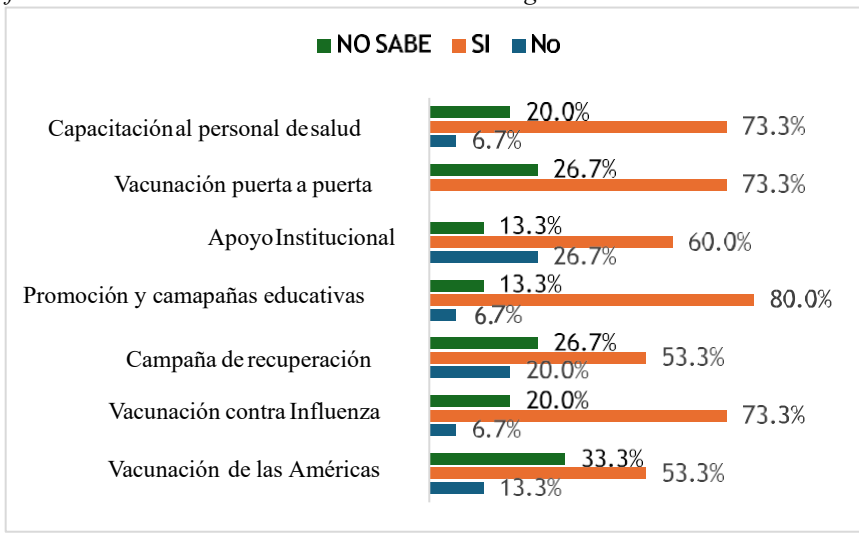

Figure 2. Access Barriers From the Permanent Recruitment Actions of Health Establishments, Regular Vaccination Schedule in Children Under 2 Years of Age, Ibarra-Ecuador

As illustrated in Figure 2, the results provide a comprehensive overview of the strategies employed by health facilities to ensure access to vaccination, particularly during the health emergency caused by the COVD-19 pandemic. These data facilitate the identification of both strengths and weaknesses in the planning and implementation of immunization activities. Concerning the adopted strategies, the majority of the facilities reported having implemented:

- Specific vaccination days, such as Vaccination Week in the Americas (53.3%) and the campaign against influenza (73.3%).
- Coverage recovery campaigns (53.3%).
- Promotion and training activities aimed at health personnel (80%).

However, a considerable percentage of the establishments answered "don't know" to some questions, which could indicate failures in internal communication or deficiencies in data collection and systematization.

Moreover, while the majority of the establishments reported receiving support from local authorities, 26.7% indicated that they did not receive such support. This lack of support could have hindered the effective implementation of vaccination strategies and affected the coverage achieved.

While the findings indicate a notable endeavor by health facilities to fortify vaccination efforts and personnel training, the repercussions of the aforementioned barriers—impeding both the provision of services and the population's response—precluded the attainment of stipulated objectives. This stands in contrast to previous years, wherein these impediments did not hold such a pronounced significance.

Discussion

A comparison of vaccination coverage before and during the pandemic revealed that in several vaccines and age groups, including children under 1 year of age and over 1 year, levels above 90% were not attained. These levels are considered epidemiologically acceptable according to

the recommendations of the World Health Organization (WHO, 2012). The findings of this study indicate a substantial decline in the vaccination of children under two years of age during the years 2020 and 2021 compared to the years preceding the pandemic. In the canton of Ibarra, this decline corresponds with the adverse effects of the pandemic on immunization programs worldwide, particularly in Latin America. This phenomenon is analogous to the findings reported by the Pan American Health Organization (PAHO, 2020), which documented an average reduction of 14% in vaccination coverage across the Americas during the period of the health crisis.

A parallel situation was documented in Peru by Falconí (2021), who reported a decrease in rotavirus vaccine coverage from 93.25% in 2018 to 49.75% in 2020. A comparable trend was observed in Ibarra, Ecuador, where coverage of the same vaccine decreased from 77.2% in 2018 to 55.1% in 2020. These figures underscore the deleterious consequences of the interruption of regular health services during the pandemic.

A similar phenomenon was observed in Colombia, where the country's routine immunization programs experienced a substantial decline in vaccination coverage due to the global impact of the pandemic. According to Moreno-Montoya et al. (2022), Colombia experienced an average decrease of 14.4% in vaccination coverage in 2020, from 76.0% in 2019 to 61.6% in 2020. This decline was particularly pronounced among children under 12 months of age. Geographically, rural areas exhibited a more pronounced decline in coverage compared to urban areas.

These patterns are consistent with those observed in other national-level studies, such as that conducted by Suarez et al. (2022), who reported a decrease of 137,000 doses administered in Ecuador during 2020 compared to the years prior to the pandemic. The global pandemic of the novel Coronavirus (SARS-CoV-2) led to the redirection of health resources towards emergency management, thereby decreasing the operational capacity of childhood vaccination programs. This phenomenon was also reported in low- and middle-income countries, including Colombia, Peru, and Ecuador.

A detailed analysis of vaccination coverage by age reveals that in urban areas, coverage for children under 1 year of age can exceed 100%. This is primarily due to the administration of vaccines such as BCG and Hepatitis B in health facilities where children are born, leading to an aggregation of records in these areas, even for newborns from rural areas. This phenomenon aligns with a World Health Organization (WHO) study (2021) on monitoring immunization inequalities, which emphasizes that urban areas tend to exhibit higher coverage rates due to the concentration of more accessible and well-equipped health services, thereby facilitating the registration and administration of vaccines at birth. However, the study also cautions that this centralization can introduce distortions in the data, potentially obscuring the true origin of the vaccinated population. This, in turn, can perpetuate disparities in access to healthcare, particularly in rural areas. The findings underscore the imperative for strategies that enhance rural healthcare services, such as the deployment of mobile vaccination units and the establishment of precise records, to ensure equitable access to immunizations and mitigate disparities between urban and rural regions (PAHO, 2020).

In Ibarra, geographical disparities were also evident. Children under one year of age in urban areas exhibited significantly higher coverage, surpassing their rural counterparts by up to 80 percentage points. However, this disparity was notably diminished in the 12 to 24-month age group, where rural areas exhibited slightly higher vaccination coverage compared to urban areas. This finding

suggests that, while initial disparities in access to vaccination services are evident, rural communities may tend to compensate for these differences in the later stages of the vaccination schedule.

This phenomenon aligns with the observations reported by Vásquez-Uriarte et al. (2020) in Peru, where initial vaccination coverage was found to be significantly higher in urban areas for children under 12 months of age. However, in the 12-to-59-month age groups, rural areas exhibited a substantial recovery in coverage, which was attributed to specific interventions and campaigns targeting these communities. Both contexts exhibit a comparable trend, underscoring the efficacy of compensatory measures in rural areas to bridge the gap in vaccination coverage among older age groups.

A statistically significant disparity ($p = 0.019$) was identified in vaccination coverage between children under one year of age and those between 12 and 24 months. This finding corroborates studies such as that of Amoroso et al. (2023), who reported that interruptions affected booster doses to a greater extent than initial doses, especially in pediatric populations.

Studies such as those by Martínez-Marcos et al. (2021) in Catalonia underscore that, although coverage decreased during the lockdown, a partial recovery was observed in the subsequent period. A similar trend was observed in Ibarra, where although coverage in 2021 exhibited a modest recovery, it persisted at significantly lower levels compared to pre-pandemic times.

Conclusions

The findings of this study demonstrate the deleterious impact of the ongoing pandemic on the vaccination coverage of children in the Ibarra canton, Ecuador. A substantial decline was observed between 2020 and 2021. This decline was most pronounced in rural areas and in the lowest socioeconomic quintiles, reflecting persistent inequalities in access to immunization.

The analysis identified several key barriers that contributed to this decline, including disruptions in vaccine distribution, reassignment of health personnel, mobility restrictions, and a decrease in demand for vaccination due to fear of contagion. Furthermore, it was observed that vaccines requiring multiple doses, such as pentavalent and pneumococcal vaccines, were particularly impacted.

Despite a modest recovery in some coverage in 2021, these metrics remain below pre-pandemic levels, underscoring the necessity for the implementation of effective strategies to enhance vaccination rates. Among the proposed strategies to address this issue are the strengthening of epidemiological surveillance, the improvement of biological distribution logistics, and the reinforcement of awareness campaigns targeting the population.

Finally, the study underscores the imperative for adopting tailored approaches to address the unique challenges faced by rural and low-income populations, thereby promoting equitable access to vaccination and ensuring the sustainability of immunization programs in the face of future health crises.

Recommendations

Based on the findings of this study, the following recommendations are proposed to improve vaccination coverage and ensure equitable access to immunization programs, especially in contexts of health crises:

1. **Strengthening the vaccine supply and distribution chain:** It is essential to ensure efficient logistics that allow the timely delivery of biologics to all regions, prioritizing rural and hard-to-reach areas (WHO, 2021).

2. **Differentiated vaccination strategies:** It is recommended to implement specific vaccination campaigns for vulnerable populations, including mobile days in rural communities and active search strategies for unvaccinated children (PAHO, 2020).

3. **Reassignment and training of health personnel:** It is necessary to reinforce the training of health personnel in immunization strategies and guarantee the availability of exclusive human resources for vaccination, avoiding the excessive reassignment of these professionals in health emergency situations (Moreno-Montoya et al., 2022).

4. **Strengthening epidemiological surveillance:** Monitoring of vaccination coverage should be improved through integrated and reliable information systems, allowing the early identification of gaps in immunization and the implementation of timely corrective measures (Suarez et al., 2022).

5. **Awareness and education in the community:** It is crucial to develop awareness campaigns on the importance of vaccination, combating misinformation and promoting confidence in biologicals. This can be done through the media, social networks, and community leaders (Falconí, 2021).

6. **Incentives and institutional support:** It is recommended that health authorities provide incentives to families to attend vaccination days, as well as establish alliances with the education sector to facilitate immunization in schools (Vásquez-Uriarte et al., 2020).

7. **Reduction of barriers to access:** It is suggested to make the hours of operation in health centers more flexible, guarantee free vaccines, and facilitate access to the population in conditions of socioeconomic vulnerability (Martínez-Marcos et al., 2021).

Implementing these recommendations will contribute to the recovery of vaccination coverage and strengthen the resilience of health systems in the face of future health crises, ensuring equitable and sustained protection for the child population.

Author Contributions

The author designed the study, collected data, curated and analyzed the dataset, and wrote the first and the final version of the manuscript.

Competing Interest

No conflict of interest to declare.

Ethical Consent

The participants provided their written informed consent to participate in this study.

Data Availability

The data supporting the findings of this study are available from the corresponding author, upon reasonable request.

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