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Tracking the impact of the COVID-19 pandemic on routine infant vaccinations in the Dominican Republic

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ABSTRACT

As the COVID-19 pandemic progresses, millions of infants are unprotected against immune-preventable diseases due to interruptions in vaccination services. The direct effects of the pandemic, as well as the non-pharmacological interventions for its containment, mitigation and suppression adopted by many countries, have affected their vaccination programs. We conducted an ecological study analyzing the performance of the vaccination program in the Dominican Republic before (2019) and during the COVID-19 pandemic (2020). We compared annual public coverage data, analyzed trends and changes in coverage, dropout rate, and number of partially and unvaccinated infants by geographic area and COVID-19 incidence rate. Compared to baseline, coverage for all vaccines decreased by 10.4 (SD, 3.6) percent; among these, coverage for the third dose of the pentavalent vaccine decreased from 90.1% in 2019 to 81.1% in 2020. The number of partially vaccinated (n = 34,185) and unvaccinated (n = 5,593) infants increased 66% and 376%, respectively. The slight increase in the annual dropout rate (1.1%) was directly proportional to the number of COVID-19 cases per month. We found a significant association between the annual absolute change of Penta3 and the subnational Human Development Index. The pandemic significantly weakened the performance of the routine vaccination program. Interventions are needed to recover and maintain lost vaccination coverage, reducing the risk of outbreaks of preventable diseases, especially in those provinces with less human development.

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Introduction

In March 2020, the World Health Organization (WHO) officially declared the COVID-19 pandemic.[1] Since the first case was reported in December 2019 in Wuhan, China, the disease has caused more than 150 million cases and 3.1 million deaths worldwide.[2] The impact of the pandemic has weakened most health systems and services around the world, causing the biggest global health crisis of this generation.[3]

Health crises and emergencies caused by epidemics can dramatically increase mortality, either directly from the outbreak or indirectly from failures in the health system to meet the demand for preventable and treatable conditions.[4] The WHO and the United Nations Children's Fund have warned that public health interventions to deal with the pandemic can affect coverage and access to routine vaccines.[5] Recent studies have revealed that approximately 80 million infants are vulnerable to immune-preventable diseases in 68 countries that have reported interruptions in vaccination services due to COVID-19.[6,7] The situation is alarming, since the pandemic could increase the risk of outbreaks of immunopreventable diseases and their complications, especially in infants.[8]

Since the confirmation of the first cases in March 2020, the Dominican Republic decreed a state of national emergency in response to the pandemic. The measures adopted included: sanitary and epidemiological controls, restriction of mobility and social activities, closure of borders and ports, suspension of classes and limitation of productive activities and public transport, among others.[9] As of April 30, 2021, the country has confirmed 266,214 cases, including 3,471 deaths.[2]

Although considerable efforts have been made to describe the magnitude of the problem on a global level, many important questions remain unresolved; the consequences of COVID-19 on vaccination programs are unknown in many countries.[7,8] This study could provide evidence for the design of public health strategies and policies that allow, in a precise way, to expand the scope and benefits of vaccination programs, especially during situations of public health crisis. To our knowledge, this is the first study that has examined the effects of the COVID-19 pandemic on the vaccination programs in the Dominican Republic. Similar studies are being reported for other countries.[10,11] For the above reasons, the aim of our study was to assess the impact of the COVID-19 pandemic on routine infant vaccination in the Dominican Republic.

Methods

Study design

We conducted a retrospective observational study to analyze the vaccination program before (2019, baseline) and during (2020) the COVID-19 pandemic. The Dominican Republic is

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an upper-middle-income country (Per-capita gross national income: USD $ 18,300).[12] It has a territorial extension of 48,671 km^2, equivalent to 64% of the island of Hispaniola that it shares with Haiti.[13] It is divided into 31 provinces and a National District (which occupies the capital). The estimated population is 10.5 million inhabitants (population density ~ 220 inhabitants/km^2), where 9% are under five years of age.[14] 81.8% live in urban areas and 21% live in poverty; life expectancy is 73.8 years.[12] The Expanded Program of Immunization provides routine vaccinations free of charge in public and private health facilities.[15] The recommended vaccines during the first year of life include: Bacillus Calmette-Guérin, Hepatitis B, Pentavalent (prevents against diphtheria, tetanus, pertussis, hepatitis B and invasive diseases caused by *Haemophilus influenzae* type B.), rotavirus, polio, the pneumococcal conjugate vaccine and the measles-mumps-rubella (MMR) vaccine (Table 1).[16] In 2020, the program's annual target population was 189,843 infants.[14] The application of the combined diphtheria-tetanus-pertussis (DTP) vaccine before the first year of life has been used to monitor the vaccination program.[17] We described the coverage by type of vaccine and analyzed the whole program through the pentavalent vaccine.

Data source

Coverage estimates of infant vaccination for 2019 and 2020 were obtained from the Ministry of Public Health (MSP) through the Single Access to Information Request Portal.[18] Coverage was calculated by the number of infants who received a vaccine, divided by the estimated population of children under one year of age from the National Statistical Office.[14] The sub-national data for the Human Development Index (HDI) were obtained from the Global Data Lab[19] and those of COVID-19 from the public information platform of the MSP[20,21] and WHO.[2]

Data analysis

We summarized the vaccination coverage data using frequencies and percentages for categorical data and by mean and standard deviation (SD) for continuous data. We analyzed the performance of the program in terms of access and coverage through the first (Penta1) and third (Penta3) doses of the pentavalent vaccine.[17] We calculated the dropout rate [(Penta1-Penta3)*100/Penta1] in each geographic area, as well as the number of partially immunized infants [(100-Penta3)/population <1 year)] and not immunized [(100-Penta1)/population <1 year)]. Coverage and absolute change were adjusted for data above 100% in order to more accurately estimate the dropout rate and the regression model. Finally, we calculated the percentage of absolute annual change for each indicator by subtracting the most recent value from that of the previous year.

To follow the progress in coverage and access to vaccination services, we reported the trends of Penta3 and the dropout rate by month and year and compared them with the number of reported COVID-19 cases. We applied a linear logistic regression model to analyze the association between the dropout rate and the monthly number of COVID-19 cases. We used the HDI to analyze the scope of coverage during the pandemic according to the socioeconomic level of the provinces. The index is a geometric average of three-dimensional indicators: health (child survival, population affiliated with social security, doctors, and beds per 10,000 inhabitants), education (completion of studies, literacy and schooling) and income level (income per-capita); the closer to one, the greater human development. The details of the HDI methodology are described in this UNDP technical note.[22]

We explored differences between annual averages using the Student's t test; analysis of the slope of the line and a simple regression model were used to test the association between Penta3 coverage, dropout rate and number of COVID-19 cases per month and between changes in Penta3 coverage and HDI. Variables with a p value <.05 were considered statistically significant. The analyses were carried out using SPSS version 25 and Microsoft Excel.

Table 1. National vaccination schedule for infants in the Dominican Republic.

Age	Antigen	Dose
Birth	Bacillus Calmette–Guérin (BCG)	Single
	Hepatitis B	
2 months	Rotavirus	1st
	Polio	
	Pneumococcal	
	Pentavalent	
4 months	Rotavirus	2nd
	Polio	
	Pneumococcal	
	Pentavalent	
6 months	Polio	3rd
	Pentavalent	
12 months	Measles-mumps-rubella (MMR) Pneumococcal	1st Booster

Source: National vaccination schedule[14]

Results

Overview of the vaccination program coverage

There was a general downward trend in vaccination coverage and performance indicators during the COVID-19 epidemic in the Dominican Republic. Table 2 shows vaccination program performance and coverage by vaccine at the national level in 2019–2020. Compared to 2019, vaccination coverage for all vaccines decreased during 2020, showing a mean drop of −10.4 (SD,3.6) percentage points. Of all the studied vaccines, the BCG had the highest coverage (99.2%) and the second-highest negative change, surpassed only by MMR (−14%); whereas the hepatitis B had the lowest coverage (71.4%) and the rotavirus vaccine showed the lowest negative change (−3%). The comparison of means showed much more significant differences in annual coverage (p < .05) for the BCG, hepatitis B, polio, pneumococcal, MMR, Penta1 and Penta3 vaccines. This indicates that during the pandemic the changes in coverage were significant. The vaccination targets of the Immunization Action Plan for the Region of the Americas 2015–2020 (goal = 95%) were not achieved for most vaccines, except for the BCG and Penta1.[23] Penta3 coverage, used as a proxy for vaccination performance,[17] decreased nine percentage points (2019: 90.1% – 2020: 81.1%) leaving more than

Table 2. Mean vaccine coverage and performance of the immunization program at the national level, Dominican Republic 2019–2020.

	2019	2020	Change 2020–2019	p-value
Bacillus Calmette–Guérin (%)	113 [51.6]	99.2 [67.7]	−13.8	0.016
Hepatitis B (%)	80.6 [39.7]	71.4 [44.7]	−9.2	0.017
Rotavirus (%)	80.2 [16.7]	76.9 [18.6]	−3.3	0.330
Polio (%)	91.5 [15.5]	79.9 [18.0]	−11.6	0.000
Pneumococcus (%)	93.2 [18.1]	81.3 [20.7]	−11.9	0.000
Measles-mumps-rubella (%)	96.2 [18.5]	82.2 [16.8]	−14	0.013
Penta1 (%)	107.3 [12.1]	94.1 [17.1]	−13	0.006
Penta3 (%)	90.1 [8.9]	81.1 [12.3]	−9.0	0.000
Dropout rate (Penta1-Penta3)	9.0 [7.7]	10.1 [6.0]	+1.1	0.745
Number of areas Penta3 ≥ 80%	29.0	25.0	−4	0.063
Number of areas with dropout ≤10%	24.0	21.0	−3	0.348
Number of partially immunized children	20591 [1630]	34185 [2393]	+13594	0.007
Number of unimmunized children	1487 [360]	7079 [468]	+5593	0.724
Number of surviving infants	190745 [9089]	189843 [3441]	−902	0.008

[SD] = Standard deviation.
p = significant value for t-student.

34,000 children vulnerable to immune-preventable diseases, of which 20.7% (7,079) never received the first dose of pentavalent. In 2020, the national dropout rate increased 1.1%. On the other hand, the number of geographic areas that had achieved coverage ≥80% (p = .063) and a dropout rate ≤10% (p = .745) were reduced by 14% and 12% respectively, compared to the baseline.

Infant vaccination trends and COVID-19

Figure 1 shows the Penta3 coverage trends, dropout rate, and number of COVID-19 cases per month during the study period. After the report of the first case of COVID-19, the declaration of a state of emergency and the implementation of confinement as part of the measures to mitigate the pandemic, our analysis revealed a significant drop in vaccination coverage of at least 30 percentage points (approximately 56,952 infants) and an increase in the dropout rate as of March 2020 compared to the same month of 2019.[9] As of May 2020, there was an increase in Penta3's coverage rates (percentage difference: 66%) and a decrease in the dropout rate (percentage difference: 57.1%) that coincides with the gradual reopening of the economy and the flexibilization of mobility measures, despite the monthly increase in the number of COVID-19 cases.[9]

We used a simple linear regression to predict the Penta3 coverage and the dropout rate based on the number of COVID-19 cases per month. A significant regression equation

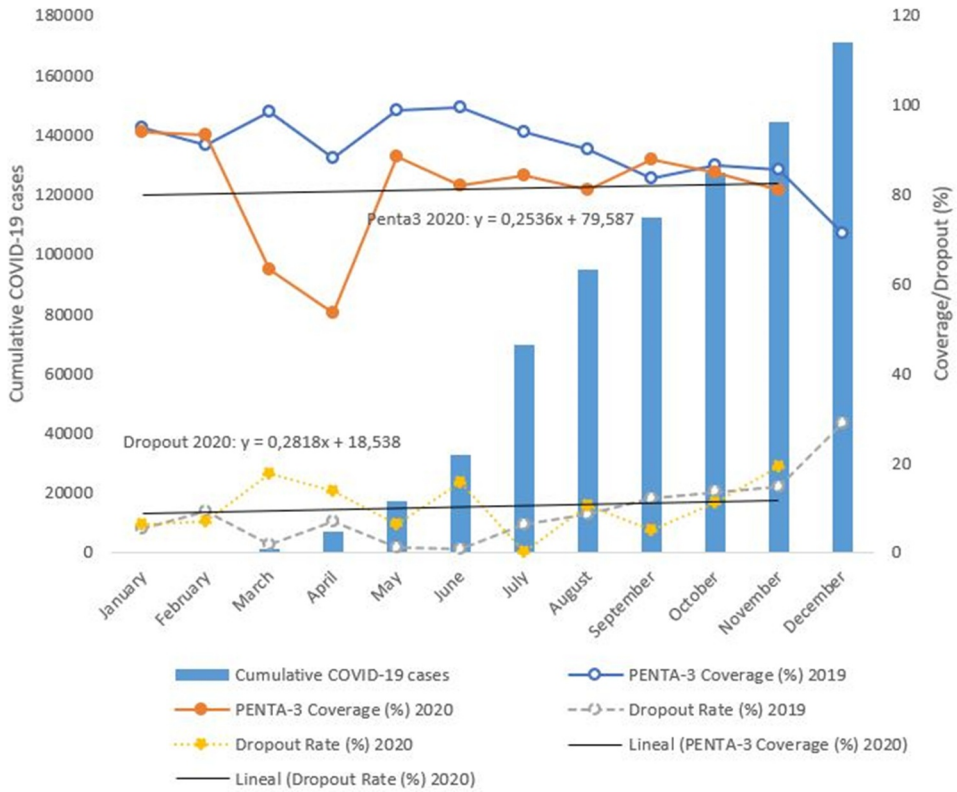

Figure 1. Trends in immunization coverage,dropout rate and cumulative COVID-19 cases by month,2019–2020.
Penta3 2020 = third dose of the pentavalent vaccine coverage in 2020.

was found for Penta3 (β = 79,587; p = .000; R2 = 0.16) and dropout rate (β = 18,538; p = .000; R2 = 0.474); therefore, the Penta3 coverage and the dropout rate increased on average by 79% and 18%, respectively, for each unit of COVID-19 monthly cases.

Subnational vaccine coverage by incidence of COVID-19

Vaccination indicators were compared at the subnational level according to HDI and mean annual incidence rate of COVID-19 in Supplementary Table 1. During 2020, Penta1 coverage rates differed substantially at the subnational level (range: 81% [El Seibo] to 146.6% [Santo Domingo]), showing negative changes in 27 out of 32 areas. Likewise, Penta3 coverage levels also showed variations between provinces (range: 61.6% [Elías Piña] to 120.4% [Pedernales]). When comparing with the previous year, six provinces (Elías Piña [61.6%], Santo Domingo [72.6%], Monte Cristi [73.2%], Azua [77%], Valverde [77.4] and Santiago [79.4]) showed negative changes in vaccinations and coverage below the reference standard (≥80%). Compared to the previous period, the number of infants who did not complete the series (13,594) and who did not receive any dose (5,593) of the pentavalent vaccine increased 66% and 376%, respectively. About 23,000 partially immunized infants (68%) resided in four provinces: Santo Domingo (56.5%), Distrito Nacional (18.3%), Santiago (15.4%) and San Cristóbal (9.9%). Santiago, San Cristóbal, Puerto Plata, Azua and La Vega, with an estimated 8,415 partially immunized infants, represented 64% of the total unvaccinated infants in the country. The provinces with a cumulative incidence of COVID-19 above the national average (1,265.5 cases per 100,000 inhabitants) showed the lowest Penta3 coverage levels and concentrated 54% of partially immunized and 87% of unvaccinated infants.

Figure 2 shows in a scatter chart the relationship between Penta3 coverage changes and HDI. We found a moderate to strong negative correlation, which means that in the provinces with higher HDI, greater changes in coverage occurred. We then calculated a simple linear regression to predict the percentage change in Penta3 coverage based on the provincial HDI. A significant regression equation was found [β = 64,428; p = .045]. The coefficient indicates that for each point of HDI increase, a 64% increase in Penta3 coverage can be expected.

Discussion

Our study revealed that, during the COVID-19 pandemic, a significant deterioration in the performance of the vaccination program of the Dominican Republic occurred and is still underway. Before the pandemic, Penta3 coverage was 90%, still below the goal of the Pan American Health Organization's Plan of Action on Immunization of 95% or more.[23] Current coverage gaps leave more than 34,000 infants vulnerable to preventable diseases and threaten the country's progress in reducing infant mortality.[24] The findings of this study could be explained in part by several factors, including the implementation of public health policies and measures to limit the transmission of the virus, the decrease in the demand for services due to the perception of the risk of contagion in the population, the limitations of economic, human, and logistics resources, among others, to combat the pandemic.[8] On the other hand, regardless of the epidemiological situation, the dimensions of social inequalities (sex of the child, place of residence, maternal education, socioeconomic level, and others) limit the probability of overcoming the gaps in order to obtain a better health outcomes.[25]

Combined, the national coverage of the third dose of the pentavalent vaccine below 90%, the reduction in the number of areas with coverage of Penta3 ≥ 80% and the dropout rate> 10% widen the limitations of the Dominican Republic to achieve a functional and equitable vaccination program. They also diminish the possibilities of achieving the strategic objectives of the WHO Global Vaccine Action Plan 2011–2020, including achieving universal health coverage.[26] The analysis of the indicators at the subnational level suggests that the most vulnerable infants reside in the places most affected by COVID-19 and with the least human development.

Furthermore, there is a correlation between changes in vaccination program performance at the subnational level and the HDI. This indicated that there are inequities in relation

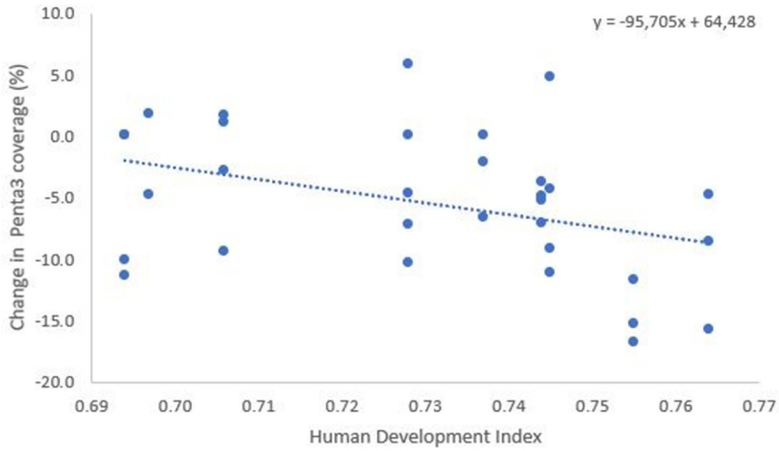

Figure 2. Correlation of change in Penta3 coverage with the Human Development Index, by province,2019–2020.
Dropout 2020 = dropout rate for 2020.

to access to vaccination. Previous studies have identified negative changes in comprehensive vaccination coverage over time among infants from disadvantaged households.[27] Taking into account the decrease in subnational coverage of Penta3 below the threshold recommended by the WHO, the increase in the number of partially and unvaccinated infants and the appearance of sporadic cases of diphtheria, tetanus and pertussis, there is a significant risk of outbreaks of immunopreventable diseases in these provinces that could be exacerbated by the current pandemic.[8,28]

Compared to 2019 and until March 2021, the incidence rate of diphtheria (0.38), tetanus (0.34) and pertussis (0.19) per 100,000 inhabitants increased 383%, 45% and 21%, respectively. In April of 2021, the MSP issued an epidemiological alert due to the report of 10 cases of diphtheria (four confirmed and six probable, including eight deaths; all with incomplete vaccination schedules). The cases were reported in Monte Plata (4), Santo Domingo (2), San Cristóbal (2), Peravia (1) and Bahoruco (1);[29] provinces identified with low or medium-low HDI, with the first three being among those with the highest number of partially vaccinated infants.[30] This situation underscores the need to guarantee timely and homogeneous coverage.[23]

To our knowledge, this is the first study that provides evidence of the impact of COVID-19 on the vaccination program in the Dominican Republic. Vaccination coverage was seriously affected during the pandemic, suggesting a similar behavior for the rest of routine vaccinations. This deterioration coincides with that reported in previous studies by other countries affected by the pandemic.[31–33] Our findings reflect the impact of the COVID-19 pandemic on the vaccination services of an upper-middle-income country. However, they are critically relevant for other countries in the region when it comes to systematizing experiences for the reestablishment of services. We hope that these results can contribute to the strengthening of policies for the provision of vaccination services during pandemics. Policies should be geared toward: (1) maintaining the routine vaccination platform with a focus on infection prevention and control; (2) adapting vaccination strategies and campaigns to the specific health situation at any particular time; (3) involving groups of experts and immunization advisory technicians; (4) strengthening the surveillance of preventable diseases and performing risk assessment and (5) ensuring the provision of supplies, equipment and logistics for vaccinations.[34,35]

The findings of this study are subject to certain limitations. Being a retrospective observational study, we cannot establish a causal association.[36] Data of coverage estimates may be biased due to underestimation or overestimation of applied doses, population migration or inaccurate population estimates, among others.[37] Penta1 and Penta3 coverage for the month of December of 2020 was not available at the time of analysis. Despite its limitations, this study provides an essential contribution to improving our understanding of the impact of COVID-19 on vaccination services.

Conclusions

Our findings demonstrate a decline in vaccination coverage during the COVID-19 pandemic in the Dominican Republic. The vaccination program could be considered relatively poor, even before the pandemic.[17] The health crisis and its aftermath exposed the limitations of the system in the country. Successful reinstatement of vaccination depends on making the necessary modifications to safely deliver services.[34] Vaccination is one of the most successful and cost-effective public health strategies to reduce morbidity and mortality from preventable diseases, and has been recognized by the WHO as a central element of the right to health.[26] Ensuring that all children have access to vaccines is a challenge, which involves identifying and dealing with vaccination gaps in terms of accessibility and individual determinants, especially during health crises.[38,39] Additional efforts are needed to ensure continuity of infant vaccination services and to ensure that unvaccinated infants are brought up to date as soon as possible. Future research should include an analysis of infant vaccination coverage with data from demographic surveys at the level of the different subgroups of the population, evaluating inequalities according to the sex of the child, place of residence, level of education of the mother and socioeconomic level of the household, among others.[40]

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Author contributions

MC conceived and designed the study, carried out the statistical analysis, and drafted the paper; JD and AG analyzed the data, interpreted the results, and contributed drafting the manuscript. All authors read and approved the final manuscript.

Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

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