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The impact COVID-19 pandemic on coverage and inequalities in childhood immunization in Peru

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Abstract

Background We examined the impact of COVID-19 on childhood immunization coverage and inequalities in Peru, focusing on pentavalent, rotavirus, and pneumococcal (PCV) vaccines. Since the 1990s, Peru has worked to improve childhood vaccine coverage, but the COVID-19 pandemic posed significant challenges to the health system.

Methods We analysed data from nationally representative health surveys conducted annually between 2015 and 2023. The surveys measured vaccine coverage among children aged 18–29 months, namely three doses for pentavalent and PCV and two doses for the rotavirus vaccine, based on data from home-based records. We studied inequalities at the individual child level using the slope index of inequality (SII) based on household wealth quintiles.

Results In 2019, the home-based record coverage levels for pentavalent, PCV and rotavirus vaccines were 78.0%, 74.5%, and 75.9%, respectively. In 2020, these rates dropped significantly due to pandemic disruptions: PCV and pentavalent coverage fell by 14% points, and rotavirus by 12 points. By 2021, coverage levels improved, returning to pre-pandemic rates by 2022 and 2023. Individual-level analyses showed that pro-rich inequalities were present during the full study period, but these increased sharply during the pandemic in 2020, with poorer children experiencing more significant drops in coverage than wealthier children. This trend reversed by 2021 and 2022 when inequality measures returned to pre-pandemic levels. Due to reasons that are still unclear, inequality increased again in 2023. Nevertheless, the confidence intervals for the summary inequality measures are wide and must be interpreted cautiously.

Conclusions The COVID-19 pandemic temporarily disrupted Peru's childhood immunization efforts, particularly affecting poorer populations, but coverage rebounded to pre-pandemic levels by 2022. These findings contribute to the scant literature on the pandemic's impact on vaccine equity.

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Background

The COVID-19 pandemic had a profound impact globally, with Peru experiencing one of the highest per capita death rates in the world [1]. Consequently, the country faced significant challenges in its healthcare infrastructure, which was stressed due to the high number of severe cases requiring ambulatory care and hospitalization [2]. The pandemic disrupted routine immunization programs in many low and middle-income countries (LMICs), exacerbating existing public health challenges and threatening years of progress in disease prevention [3–6]. As healthcare systems became overwhelmed, resources and personnel were often diverted from regular vaccination efforts to COVID-19 response activities, leading to declining immunization rates. Lockdowns and restrictions on movement further hindered access to healthcare facilities, while economic hardships reduced families' ability to access health services. Additionally, supply chain disruptions affected the availability of vaccines, and misinformation about vaccines fuelled public hesitancy.

According to the World Health Organization (WHO) and UNICEF, 20.5 million children missed one or more routine vaccines in 2022, compared to 24.4 million children in 2021 [7]. Despite this improvement, the number remains higher than the 18.4 million children who missed out in 2019 before pandemic-related disruptions [8]. To address this challenge, international organizations and partners launched 'The Big Catch-Up' in 2023, calling on governments to catch up with the children who missed vaccinations during the pandemic and restore immunization services to pre-pandemic levels [9].

Compared with the large literature on the impact of the pandemic on national immunization coverage levels, there is limited evidence of its impact on vaccine equity within countries [10]. The availability of annual household health surveys in Peru provides a unique opportunity to assess the impact of the COVID-19 pandemic on immunization coverage rates, with a focus on socioeconomic inequalities that are present in virtually all LMICs [11]. We focused on pentavalent, rotavirus and pneumococcal vaccines. The present analyses complement an earlier study of the targeted rollout of new vaccines in Peru [12], including vaccines against *Haemophilus influenzae* type b (Hib, introduced as a standalone vaccine in 1998 and incorporated in pentavalent vaccine in 2007), rotavirus and pneumococci (introduced in 2008 and 2009, respectively).

Methods

The study's analyses were initially conducted at the individual child level. The Peruvian National Institute of Statistics and Computing (INEI) regularly conducts national household demographic and health surveys, known as Encuesta Demográfica y de Salud Familiar (ENDES) [13]. Since 2004, these annual surveys have collected data on various demographic and health indicators, including child vaccine coverage, and they are highly comparable to the Demographic and Health Surveys (DHS) [14] carried out in numerous low- and middle-income countries (LMICs). The survey samples are designed to be representative at the regional and national levels within Peru.

While vaccine coverage is usually estimated for children aged 12–23 months, for the purposes of this study, we focused on children aged 18–29 months. This age range aligns with traditional reporting practices in Peru since the measles vaccine was previously scheduled at 15 months. We restricted the analyses to surveys carried out from 2015 onwards in order to cover the period around the pandemic.

Our primary outcome variables were the coverage rates for three doses of the pentavalent and pneumococcal conjugate vaccine (PCV), administered at 2, 4, and 12 months of age, and two doses of the rotavirus vaccine, given at 2 and 4 months, as per the schedule of the Peruvian Ministry of Health. We refer to pentavalent vaccine coverage as both the standalone and the pentavalent formulations [15]. The analyses were restricted to vaccine doses documented in home-based records, because respondents were only inquired about undocumented doses of pentavalent vaccine. For this vaccine, coverage (2015–2023) was 8.2% points higher when recalled doses were also computed, with small variability by wealth quintile (range 7.4 to 9.4% points).

The analyses evaluated inequalities based on the household wealth, assessed through a composite wealth index, which acts as a proxy for socioeconomic position of the family. The index was derived in each survey via principal component analysis (PCA) of indicators like ownership of durable goods (e.g., televisions, bicycles, cars), housing characteristics (e.g., type of flooring and roofing), access to utilities (e.g., electricity and clean water), and land ownership. Households were categorized into wealth quintiles, with the first quintile signalling the poorest 20% of all households in the national sample, and the fifth quintile the wealthiest 20% of households [16]. For the individual-level analyses, the slope index of inequality (SII) was calculated to measure the absolute difference in vaccine coverage between children from the richest and poorest ends of the wealth distribution [17]. The SII was derived using logistic regression of coverage rates against household wealth, utilizing the entire wealth distribution rather than just the extreme quintiles. The SII for prevalence outcomes varies between −100 and 100% points, with the value of zero indicating complete equality. The index yields positive values for pro-rich coverage patterns (that is, coverage increasing with wealth quintiles) and negative values for pro-poor patterns (when coverage

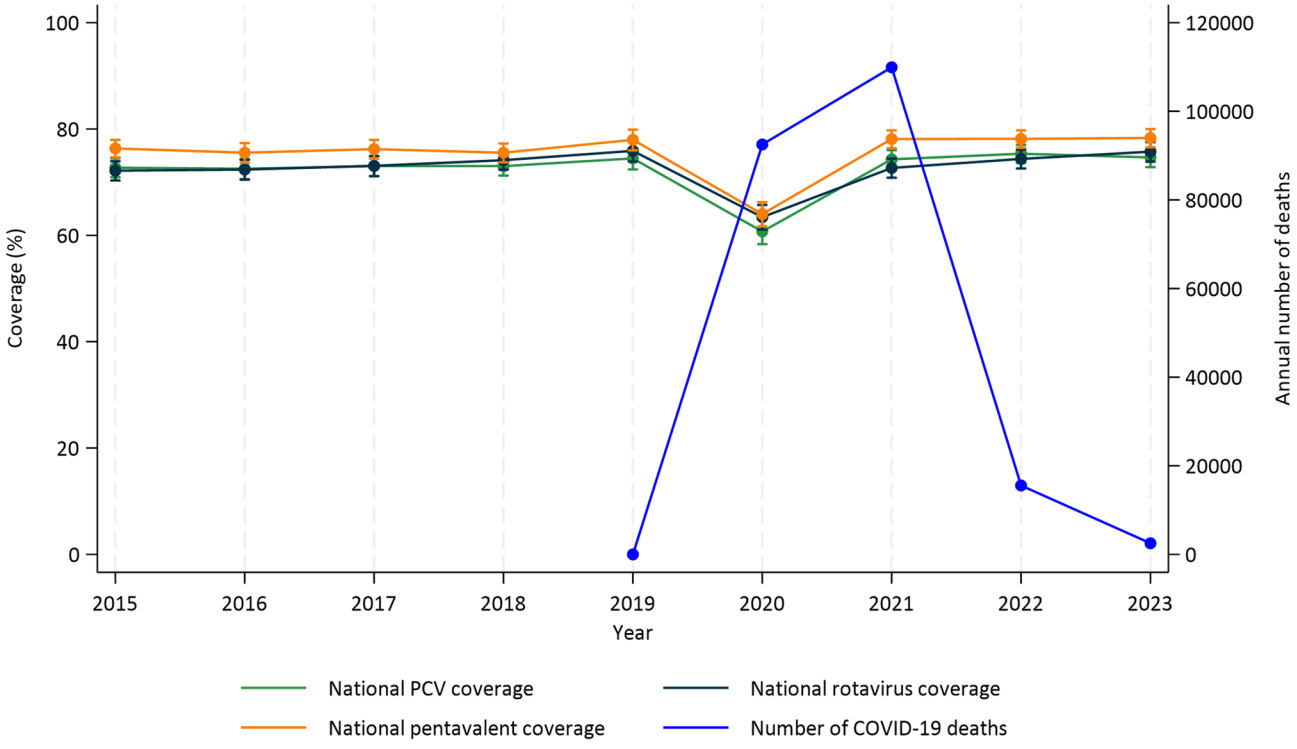

Fig. 1 Annual coverage with pentavalent, PCV and rotavirus vaccines in Peru, 2015–2023, restricted to doses registered in home-based records

Table 1 Slope indices of inequality (SII) for pentavalent, PCV, and rotavirus vaccines. Individual-level analyses

Year	SII (95%CI) *		
	Pentavalent	**PCV**	**Rotavirus**
2015	7.0 (-0.06;14.1)	10.7 (4.0;17.4)	12.4 (5.3;19.6)
2016	7.4 (0.3;14.6)	7.8 (-0.2;15.9)	11.7 (3.9;19.5)
2017	5.1 (-0.9;11.1)	6.1 (0.3;12.1)	7.3 (1.8;12.7)
2018	3.6 (-3.7;11.0)	1.3 (-5.9;8.4)	6.8 (-0.2;13.9)
2019	5.6 (-0.8;12.0)	5.4 (-1.0;11.9)	5.4 (-0.9;11.6)
2020	17.5 (8.6;26.4)	15.2 (6.1;24.2)	14.5 (5.0;24.1)
2021	6.7 (-0.1;13.6)	9.4 (2.4;16.4)	13.5 (6.5;20.3)
2022	0.5 (-9.0;10.0)	7.1 (-1.7;15.9)	3.8 (-4.7;12.3)
2023	9.7 (0.5;19.0)	11.6 (3.1;20.3)	13.5 (5.0;22.0)

*Adjusted for region of the country

declines with greater wealth). All analyses included fixed effects for country regions.

Data analysis was performed using Stata version 18, considering the multi-stage survey design and sampling weights. Initial analyses were conducted for each survey year (2015–2023), utilizing publicly available anonymized databases. INEI secured ethical approval.

Results

A total of 38,496 children were included in the analyses, with a median annual sample of 4,277 (Supplementary Table 1).

There were two peaks in deaths due to COVID-19 in Peru, from May to August 2020 and from February to May 2021 [2]. Figure 1 shows that vaccine coverage levels entered in home-based records were reasonably stable from 2015 to 2019, reaching 78.0% for pentavalent, 74.5% for PCV, and 75.9% for the rotavirus vaccine by 2019. With the arrival of the pandemic in 2020, the vaccine coverage fell by 14 pp for pentavalent, 13.8 pp for PCV, and 12.5 pp for rotavirus. These drops were followed in 2021 by increases of 14.1, 13.6, and 9.3 pp, respectively. By 2022, coverage for all vaccines had returned to pre-pandemic levels and continued to increase in 2023. Supplementary Table 1 shows the numerical results illustrated in Fig. 1.

The impact of the pandemic on equity was evident in the individual-level analyses. Although confidence intervals were wide, all point estimates of annual SII levels (Table 1) were positive, suggesting the presence of

pro-rich inequality. To improve precision, results from 2015 to 2019 were pooled, resulting in SII levels of 5.7 (95% CI 2.4;8.9) for pentavalent vaccine, 6.3 (3.0;9.5) for PCV and 8.4 (5.1;11.6) for rotavirus vaccine; for the three pooled SIIs, the lower confidence limit was above zero, confirming the pro-rich patterns. As the pandemic arrived in 2020, SIIs increased sharply by about 10% points for the three vaccines (Table 1), with lower confidence limits well above zero, thus accentuating the pre-existing pro-rich advantage. Inequality returned to pre-pandemic levels by 2022, but in 2023 the SIIs for the three vaccines increased again. These results are adjusted for country region, but unadjusted analyses showed very similar patterns (data not shown).

Figure 2 shows annual coverage by wealth quintile for each vaccine. The darker circles show coverage levels in the poorer quintiles of households, while the yellow circles show coverage in the wealthier households. Throughout the study period, coverage tended to be directly associated with wealth. Possibly as a function of sampling variation, smooth monotonic gradients are not observed in most periods, although the positive values of the SII, which are calculated using the same data, support the presence of positive associations between coverage and wealth (Table 1). The most remarkable aspect of the figure is how coverage fell particularly fast in the poorest quintile in 2020 during the pandemic's peak.

Discussion

Peru experienced major health system disruptions during the COVID-19 pandemic, and the availability of annual surveys allowed us to measure the impact on coverage and inequalities regarding pentavalent, PCV, and rotavirus vaccines. By 2019, coverage levels with the three vaccines were close to 80%. The onset of the pandemic led to coverage reductions of 12 to 14 pp in 2020. By 2021, coverage was already picking up, and by 2022 and 2023, coverage had already returned to pre-pandemic levels. Paradoxically, recovery was slower for the rotavirus vaccine – which requires two doses - than for the PCV or pentavalent vaccine, both of which require three doses. Similar patterns of coverage declines, reductions in vaccine doses administered, and timeliness of vaccination were reported for several countries from 2019 to 2021 [3–6, 18]. In contrast, the literature describing the impact of the pandemic on vaccine equity is limited [10].

Our results must be interpreted considering the strategy for rolling out new vaccines in Peru from 1998 to 2009, when health authorities initially prioritized the country's poorest, highest mortality regions. These policies indeed resulted in higher coverage in the poorest regions than in the rest of the country in the early years of vaccine rollout, as documented in our earlier publication on temporal-geographic analyses of the 25 districts from 2004 to 2022 [12]. However, we also showed that vaccine coverage remained directly correlated with family wealth, even within the most vulnerable country regions that had been targeted.

Our present findings confirm that children from affluent families were more likely to be vaccinated than children from poor households [12]. This finding is consistent with the ample literature showing that, in nearly all LMICs, vaccine coverage among children is directly related to their families' socioeconomic position due to greater economic and geographic access to health services and to higher parental educational levels, among other factors [11]. In Peru, the pro-rich pattern was evident before the pandemic, but inequalities were sharply accentuated during the peak year of 2020, when coverage among poor children was reduced to a greater extent than for better-off children – a finding that, to our knowledge, has not been reported for other countries.

Our analyses have potential limitations. Asset indices index may underestimate the wealth of rural households. Still, the indices were initially calculated separately for urban and rural areas and later combined into a single score using a scaling procedure to improve comparability [16]. Annual SII values had wide confidence intervals, often including the value of zero (which is consistent with the absence of inequality) but when we pooled values for several years this was no longer the case. Vaccine coverage levels were derived from home-based records, as information on doses reported by respondents was available for pentavalent but not for PCV and rotavirus vaccines. Based on the pentavalent (pentavalent) vaccine, levels reported were approximately 7 pp lower than coverage levels that also included reported doses [12]. Nevertheless, our results on trends and associations should not be affected. Lastly, due to the restriction of the sample to children aged 18–29 months, a potential effect of the 2023 "Big Catch-up" could not be detected in the time series [9].

The increase in the three vaccine SIIs in 2023 relative to 2021 and 2022 was unexpected. Two of our team's statisticians analysed the recently released data from the 2023 ENDES, and the wealth index and SIIs calculations were confirmed. Political instability at the national level has affected the leadership of the Ministry of Health, with 11 different Ministers in the past four years [19]. Yet, our four Peruvian co-authors, who have been leading and evaluating immunization programs in the country for at least three decades, state that such frequent changes have been going on for decades and that there is no clear explanation for increased inequality in 2023. Given the wide confidence intervals for the SIIs in 2023, sampling variability cannot be ruled out.

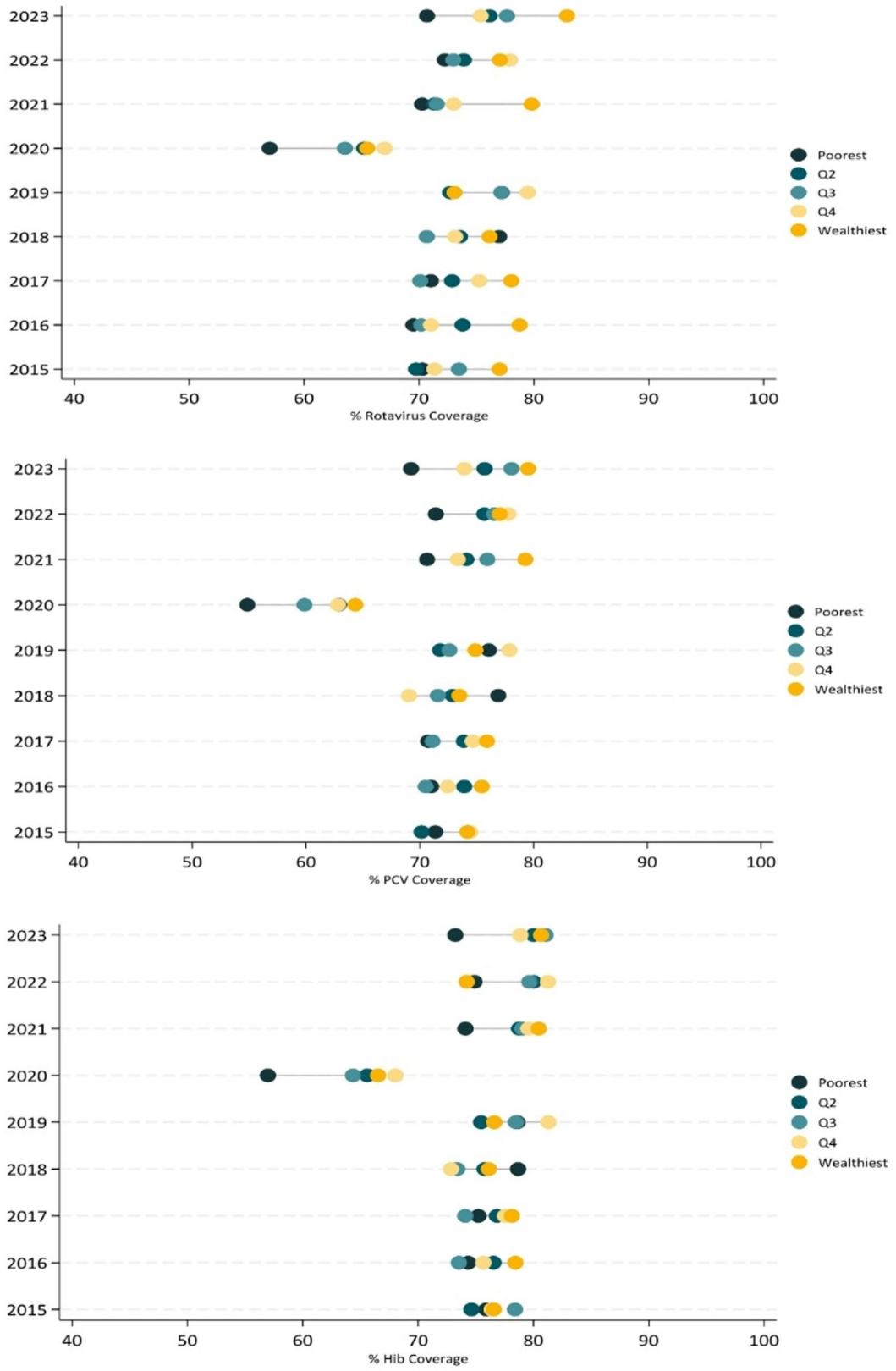

Fig. 2 Equiplots for vaccine coverage by wealth quintiles, 2015 to 2023

Conclusions

Peru has faced frequent changes at the top managerial level of its Ministry of Health due to political instability lasting decades. Nevertheless, the country's health systems have been notably resilient and contributed to improved child health, lowered mortality and undernutrition, and high and remarkably equitable maternal and child health services coverage [20]. Peru has innovated while scaling up the coverage of new vaccines, starting with their deployment in the country's poorest regions where vaccines were most needed due to high child mortality rates [12]. Our analyses showed that the impact of COVID-19 on immunization coverage was limited in time despite the major intensity of the pandemic in the country. Yet, we also found an impact on inequality that lasted longer as the pandemic disproportionately affected immunization rates for children from the poorest households in the county. Peruvian policymakers should again consider targeting the country's poorest regions to offset the pandemic's consequences, as done in the earlier phases of rolling out new vaccines.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12939-025-02505-3.

Supplementary Material 1

Author contributions

CGV and LH conceptualized the manuscript. CGV, AJDB, LANS, FSC, and BOCP conducted statistical analyses and prepared figures, tables, and supplementary materials. CV drafted the manuscript. LH, CFL, MAMA, and TJO provided information on vaccine implementation in Peru and critically reviewed the manuscript. TM and DH contributed information on the impact of the pandemic on coverage in different countries and provided inputs into subsequent versions of the manuscript. All authors had full access to all the data in the study, and the final version was reviewed and approved by all co-authors.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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