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Vaccination against COVID-19 and socioeconomic inequalities: A cross-sectional study in Ecuador

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ABSTRACT

Background: Equity in vaccination against COVID-19 is a public health concern. The objective of this study was to analyze socioeconomic inequalities related to vaccination for the first and second doses from primary series against COVID-19 in Ecuador.
Methods: Secondary database study in 12,743,507 respondents from 15 years and over. The COVID-19 section of the National Survey of Employment, Unemployment and Underemployment (ENEMDU) was analyzed. Socioeconomic characteristics and vaccination against COVID-19 were associated with the at least one dose and second dose. Poisson regressions for complex samples were obtained.
Results: As of the date of the survey, 87.3% of the sample (95% CI 86.7%-87.8%) had received at least one vaccine against COVID-19. A lower probability of having received at least one vaccine against COVID-19 was found in rural areas (PR 0.82, 95% CI 0.74–0.91), indigenous population (PR 0.43, 95% CI 0.29–0.64), no level of education (PR 0.25, 95% CI 0.14–0.43), and the lowest economic income (PR 0.42, 95% CI 0.35–0.52). A significantly lower probability of vaccination with two or more doses was found in rural vs urban area (PR 0.88, 95% CI 0.80–0.96), women vs men (PR 0.85, 95% CI 0.77–0.91), indigenous population vs white (PR 0.44, 95% CI 0.33–0.59) and individuals in the lowest income quartile vs highest income quartile (PR 0.48, 95% CI 0.42–0.55). Underemployment, population economically inactive (PR 0.77, 95% CI 0.67–0.88 and PR 0.71, 95% CI 0.61–0.83) and individuals with no level of education (PR 0.39, 95% CI 0.27–0.58) also were less likely to complete the primary phase of vaccination compared with individuals in the highest income quartile, employment and postgraduate level of education.
Conclusions: There were socioeconomic inequalities with the primary series of vaccine against COVID-19, with a greater disadvantage for rural residents, women, indigenous populations, lower economic income and lower levels of education.

1. Introduction

The COVID-19 pandemic led to a deep health and political-economic crisis around the world [1]. In low- to middle-income countries, with overstretched health systems and difficulties in maintaining the financial support required by the pandemic, its effects would have a greater impact, with long-term consequences [2]. Previous estimates mention that the excess mortality observed in several Latin American countries could reduce life expectancy by between 2 and 10 years in these countries, with a greater impact on the poorest socioeconomic populations [3]. In the case of Ecuador, the pandemic exposed the weaknesses of the health system, with limited response capacity and lack of contingency plans [4], becoming one of the Latin American countries with the worst fatality indicators from COVID-19 [5,6]. At the same time, the massive loss of employment and the worsening of the economic situation mean an increase in poverty and social inequality with devastating consequences in the long term [5]. Until December 31, 2021, the cut-off period considered for this study, 549,418 confirmed cases were reported in Ecuador, with 512,352 recovered and 33,681 deaths [7]. According to the most recent information, as of August 2, 2023, 1,069,114 confirmed cases and 36,042 deaths have been reported [8].

One of the global strategies to mitigate the impact of the pandemic

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has been vaccination against COVID-19. Vaccination against COVID-19 has been associated with a lower risk of complications, hospitalization, and mortality from the disease [9]. However, there are also inequalities in access, administration, and acceptance of vaccination that affect the most vulnerable populations [10]. Lack of equitable distribution of vaccines contributes to widespread outbreaks and the emergence of new virus mutations, while equitable access substantially slows the spread of new strains, thereby reducing the further spread of the disease and its complications [11,12]. On the other hand, reducing the transmission of the disease and keeping it at low levels require high vaccination rates in the entire population, regardless of age, sex and ethnicity, which demands reducing the gaps inherent in vaccination [11,13].

Although the initiative of the World Health Organization advocated equity in the distribution of vaccines [14], there was an imbalance in the supply of vaccines worldwide, with a greater impact on low- and middle-income countries [10].

Bayati, et al [15] recognize inequalities in vaccination against COVID-19 on at least two levels: a macro level related to the stability and country's economic status and the infrastructure and health system, which includes functional cold chains in vaccine transport, transport infrastructure, medical and non-medical facilities, etc., legal and politics facilities to administration and access to vaccination, as well as epidemiologic and demographic factors, and a micro/individual level, including economic and demographic and social characteristics, such as economic income, employment, ethnicity, cultural conditions, among others.

In Ecuador, vaccination against COVID-19 began in January 2021. Given the limited number of doses available, a phased vaccination process was carried out. Phase 1, from March to May 2021 with vaccination of vulnerable groups and higher exposure to the virus. Phase 2, from June to August 2021, with mass vaccination in high-incidence provinces; phase 3, from September to December, in provinces with low long-term incidence [16]. The first doses arrived in Ecuador on January 21/2021, there were 8,000 doses of the vaccine BNT162b2 (Pfizer-BioNTech), which were destined for frontline personnel in a few hospitals [17]. Days later 78,000 more doses were distributed in 95 health units of the country, these were also intended for older adults in private gerontological centers and their caregivers [17]. Subsequently, to complete phases 1, 2 and 3 of the vaccination plan, the country acquired 379,080 doses of the BNT162b2 (Pfizer-BioNTech), 1,976,400 of PiCoVacc (Sinovac Biotech) and 857,760 doses of AZD1222 (Oxford-Astrazeneca) vaccine, under a total budget of 453 million of dollars [16]. Vaccination at the national level reached greater strength in July and August 2021, given the greater availability of the vaccine and better access to vaccination sites distributed throughout the country [18]. Vaccination at the national level was fully subsidized by the Ecuadorian State.

Three years after the beginning of the pandemic, it is necessary to look back and make visible problems that, if better addressed, would have reduced fatalities, economic and social costs from COVID-19. This study analyzes the socioeconomic inequalities related to vaccination coverage against COVID-19 at the end of 2021 in Ecuador, with the purpose of evidencing gaps in vaccination coverage and identifying susceptible populations that may require prioritized and focused attention to improve vaccination coverage and prevent subsequent outbreaks of the disease.

2. Methods

2.1. Study design and population

A secondary base analysis of the National Survey of Employment, Unemployment and Underemployment (ENEMDU) was carried out [19,20]. This survey is carried out periodically by the National Institute of Statistics and Censuses of Ecuador (INEC) to provide information on economic activity and sources of income of the population. For 2021, this survey included a section for vaccination against COVID-19 [19]. The sample size was 27,048 homes, with 91,169 people surveyed. Using the expansion factor proposed by ENEMDU, the sample size for this study was 17,917,508 data from respondents, representative of the national, urban and rural levels [20]. This study included data from people over 15 years of age, people who have answered the questions about vaccination against COVID-19 and socioeconomic information.

2.2. Data collection

The ENEMDU survey with its section for vaccination against COVID-19 was applied in Quito, Guayaquil, Cuenca, Machala, Ambato, and urban and rural areas throughout the country, from September to December 2021 [20]. The objective of the implementation of the survey was to measure the population infected by COVID-19 and characterize the sociodemographic conditions of the vaccinated and unvaccinated population. The sampling technique was two-stage and stratified. The information-gathering period was from October to December 2021. The information collection method was carried out through face-to-face interviews by trained interviewers. The number of people vaccinated and not vaccinated was estimated from a self-report question by the informant. The estimate of people vaccinated against COVID-19 obtained in the survey is consistent with official data [20]. The information collected in this survey is available at: https://www.ecuadorencifras.gob.ec/vacunacion-covid-19/ [19].

2.3. Study variables

The following variables were considered:

•Demographic and socioeconomic characteristics: Area of residence (urban/rural), sex (women/men), age, education (none, literacy, school, high school, college, post graduate), ethnicity (indigenous, afro-descendant, montuvio, mestizo, white), employment status (employment, underemployment unemployment, retired and other economically inactive like housewife, student, etc.,) income per capita (per capita monthly income, divided into quartiles), and economic support received from the State (Human Development Bond or Disability Bond).

•Variables related to the vaccine against COVID-19: received or not the vaccine against COVID-19 and the number of doses.

2.4. Data analysis

Initially, a descriptive analysis was carried out, the characteristics of the sample were determined, and the percentages of vaccination against COVID-19 for one dose and two or more doses were calculated for the different demographic socioeconomic variables. The expansion factor suggested by the ENEMDU survey was used for the analysis of complex samples [19].

To determine inequalities in vaccination against COVID-19, first the relationship between socioeconomic variables and having received at least the first dose of vaccine was analyzed, compared with those who had not received any dose of vaccine. Subsequently, the relationship between socioeconomic variables with having received two or more doses of the vaccine, compared with those who received a single dose or no doses was analyzed. Prevalence ratios and confidence intervals at 95% were calculated using bivariate Poisson regressions for complex samples. Variables significantly associated with vaccination with a p-value less than 0.20 were maintained in the multivariate model. Variables with a p-value less than 0.05 were considered significant. SPSS version 26 software was used for data analysis.

3. Results

The sociodemographic characteristics of the sample are shown in Table 1. The 69.7% of the respondents resided in the urban area (95% CI

Table 1
Demographic and socioeconomic characteristics, individuals ≥ 15 years of age older included in the study. ENEMDU-Ecuador survey, 2020 (n expanded = 12,743,507).

Categories	Frequency (n°)	Relative Frequency (%)	95% Confidence Interval (CI)
Area			
Urban	8,877,881	69.7%	69.2% – 70.1%
Rural	3,865,626	30.3%	29.9% – 30.8%
Age (years)			
15–18	1,375,328	10.8%	10.3% – 11.3%
19–30	3,290,469	25.8%	25.2% – 26.4%
31–60	5,943,518	46.6%	45.9% – 47.3%
>60	2,134,192	16.8%	16.3% – 17.2%
Sex			
Men	6,227,612	48.9%	48.2% – 49.6%
Women	6,515,895	51.1%	50.4% – 51.8%
Ethnic self-identification			
Indigenous	1,235,659	9.7%	9.3% – 10.1%
Afrodescendant[a]	549,092	4.3%	4.1% – 4.6%
Montuvio[b]	625,389	4.9%	4.6% – 5.3%
Mestizo[c]	10,126,529	79.5%	78.9% – 80.0%
White	206,838	1.6%	1.5% – 1.8%
Education			
None	454,319	3.6%	3.3% – 3.8%
Literacy	37,509	0.3%	0.2% – 0.4%
School	4,229,551	33.2%	32.5% – 33.9%
High school	5,450,479	42.8%	42.1% – 43.5%
College	2,364,765	18.5%	18.1% – 19.0%
Post graduate	206,884	1.6%	1.5% – 1.8%
Employment status			
Employment	2,779,389	21.8%	21.2% – 22.4%
Underemployment	5,023,889	39.5%	38.7% – 40.1%
Unemployment	386,417	3.0%	2.8% – 3.2%
Retired	830,986	6.5%	6.2% – 6.8%
Other (housewife, student, etc.)	3,722,826	29.2%	28.6% – 29.9%
Income per capita (quartile)[d]			
Q1 (lowest)	4,235,146	33.5%	32.9% – 34.2%
Q2	3,385,503	26.8%	26.2% – 27.4%
Q3	2,787,943	22.1%	21.6% – 22.6%
Q 4 (highest)	2,220,762	17.6%	17.2% – 18.0%
Human Development Bonus			
No	11,255,486	88.3%	87.8% – 88.8%
Yes	1,488,021	11.7%	11.2% – 12.2%
Disability Bonus			
No	12,701,879	99.7%	99.6% – 99.8%
Yes	41,628	0.3%	0.2% – 0.4%

[a] Afrodescendant = includes those who considered themselves Afro-Ecuadorians, mulattoes and black.
[b] Montuvio = peasant of the coast.
[c] Mestizo = ethnic group born from the cross between Europeans, indigenous and Africans during the colonial era. It is a hegemonic category that includes other socio-racial identities, including indigenous people themselves and black people with all their derivations.
[d] Missing data = 114153.

69.2% – 70.1%) and 30.3% in the rural area (95% CI 29.9% – 30.8%), 51.1% were women (95% CI 50.4% – 51.8%) and 48.9% were men (95% CI 48.2% – 49.6%). The age group from 31 to 60 years represented 46.6% of the sample (95% CI 45.9% – 47.3%). Most of the respondents were of 'mestizo' ethnicity (72.1%, 95% CI 71.5%-72.7%), while the 47.9% (95% CI 74.3%-48.5%) had school education. The highest percentage of the sample belonged to the lowest economic income quartile (38.7%, 95% CI 38.1%-39.3%). Other characteristics of the sample are mentioned in Table 1.

As of the date of the survey, of the 12,743,507 respondents 15 years of age or older, 11,122,431 (87.3%) had received at least one dose. Of these, 9,972,283 individuals (78.3%) had received two or more doses, while 1,150,148 (9%) had stayed on only one dose. On the other hand, 1,621,076 individuals (12.7%) had not received any dose up to the time of the survey (Table 2). The main reason for not having been vaccinated yet was "others", as it was collected in the survey, and which includes reasons such as fear of the vaccine, religious beliefs, among others. Inconveniences related to the administration of the vaccine, such as not knowing where to receive the vaccine, inconvenient hours, long waiting

Table 2
Characteristics of vaccination against COVID-19, individuals ≥ 15 years of age older included in the study. ENEMDU-Ecuador survey, 2021 (n expanded = 12,743,507).

Categories	Frequency (n°)	Relative Frequency (%)	95% Confidence Interval (CI)
Received a vaccine against COVID-19			
No	1,621,076	12.7%	12.2% – 13.4%
Yes (at least one dose)[a]	11,122,431	87.3%	86.7% – 87.8%
Number of Doses			
0 dose	1,621,076	12.7%	12.2% – 13.3%
Only one dose	1,150,148	9%	8.4—9.6%
Two or more doses[b]	9,972,283	78.3%	77.6% – 78.9%
Reasons for not having been vaccinated (for 0 dose)			
Fear of getting vaccinated	1,162,723	71.7%	62.6% – 65.4%
Can not get vaccinated for medical reasons	194,292	12.0%	10.5% – 13.1%
Don't know where to get the vaccine	88,353	5.5%	4.4% – 6.7%
No appointment for the vaccine	63,558	3.9%	3.2% – 4.9%
Can not go to the vaccination center	47,958	2.9%	2.0% – 4.4%
Inconvenient schedules with waiting times prolonged	64,192	4.0%	3.1% – 5.1%
Interest in getting vaccinated against COVID-19 (for 0 dose)			
Yes	734,219	45.3%	42.8% – 47.8%
No	886,857	54.7%	52.2% – 57.2%
Reasons for not to be interest			
Side effects	506,631	57.1%	54.0% – 60.2%
Doṅt believe in vaccines	135,662	15.3%	13.3% – 17.5%
COVID-19 is not dangerous	41,751	4.7%	3.5% – 6.3%
Vaccine is not sufficient effective	98,268	11.1%	9.7% – 12.6%
Previous infection and recovered	6288	0.7%	0.5% – 0.1%
Other (ex. Medical reasons)	98,257	11.1%	8.7% – 14.0%

[a]Includes everyone who has received at least one dose of vaccine (1, 2 or 3 doses of the vaccine).
[b]Includes those who have received 2 or 3 doses of the vaccine.

times, not having an appointment or not being able to go to the vaccination center, account for 16.4% of the reasons for not having received at least one dose of vaccine. The prevalence of rejection to vaccination (not interest in receive the vaccine) was 6.9% concerning the total number of respondents. The main reason for rejection was the "fear of adverse effects of the vaccine" (Table 2).

Table 3 show the association between socioeconomic characteristics with having received at least one dose of the COVID-19 vaccine, respectively. Rural area residents were 60% less likely to receive one dose of the vaccine than urban area residents (PR 0.40, 95% CI 0.36–0.44). Those who self-identified as indigenous were 78% less likely to have received their first vaccination than those who self-identified as white (PR 0.22, 95% CI 0.15–0.32). Those with no level of education were 91% less likely to receive a dose of the vaccine (PR 0.09, 95% CI 0.05–0.32). The underemployed and those considered economically inactive (domestic workers, students, etc.) were less likely to have

Table 3
Demographic and socioeconomic characteristics associated with at least one dose of vaccine against COVID-19 compared with cero doses. ENEMDU Ecuador, 2021. (n expanded = 12,743,507).

Categories	N	Vaccinated with at least one doseFrequency (%)	Without vaccine[a]Frequency (%)	PR (95% CI)	PR adjusted (95% CI)
Sample	12,743,507	11,122,431 (87.3%)	1,621,076 (12.7%)		
Area					
Urban	8,877,881	8,048,023 (90.7%)	829,858 (9.3%)	Reference	Reference
Rural	3,865,626	3,074,408 (79.5%)	791,218 (20.5%)	0.40 (0.36–0.44)**	0.82 (0.74–0.91)**
Age (years)					
15–18	1,375,328	1,084,059 (78.8%)	291,269 (21.2%)	0.35 (0.29–0.42)**	0.42 (0.34—0.51)**
19–30	3,290,469	2,849,296 (86.6%)	441,173 (13.4%)	0.61 (0.52–0.72)**	0.48 (0.40—0.58)**
31–60	5,943,518	5,239,817 (88.2%)	703,701 (11.8%)	0.71 (0.61–0.82)**	0.63 (0.53—0.74)**
>60	2,134,192	1,949,259 (91.3%)	184,933 (8.7%)	Reference	Reference
Sex					
Men	6,227,612	5,421,349 (87.1%)	806,263 (12.9%)	0.96 (0.87–1.06)	–
Women	6,515,895	5,701,082 (87.5%)	814,813 (12.5%)	Reference	–
Ethnic self-identification					
Indigenous	1,235,659	788,206 (63.8%)	447,453 (36.2%)	0.22 (0.15–0.32)**	0.43 (0.29 – 0.64)**
Afrodescendant	549,091	458,444 (83.5%)	90,647 (16.5%)	0.62 (0.43–0.92)**	0.96 (0.65 – 1.42)
Montuvio	625,390	501,381 (80.2%)	124,009 (19.8%)	0.49 (0.32–0.75)**	0.88 (0.58 – 1.36)
Mestizo	10,126,530	9,190,216 (90.8%)	936,314 (9.2%)	1.21 (0.84–1.73)	1.60 (1.11 – 2.31)*
White	206,837	184,184 (89.0%)	22,653 (11.0%)	Reference	Reference
Education					
None	454,320	373,492 (82.2%)	80,828 (17.8%)	0.09 (0.05–0.15)**	0.25 (0.14 – 0.43)**
Literacy	37,508	32,189 (85.8%)	5319 (14.2%)	0.11 (0.04–0.32)**	0.60 (0.22 – 1.70)**
School	4,229,551	3,524,224 (83.3%)	705,327 (16.7%)	0.09 (0.06–0.15)**	0.27 (0.16 – 0.45)**
High school	5,450,479	4,747,911 (87.1%)	702,568 (12.9%)	0.13 (0.08–0.20)**	0.35 (0.21 – 0.58)**
College	2,364,765	2,241,527 (94.8%)	123,238 (5.2%)	0.34 (0.21–0.56)**	0.60 (0.36 – 1.00)
Post graduate	206,884	203,088 (98.2%)	3796 (1.8%)	Reference	Reference
Employment status					
Employment	2,779,389	2,595,145 (93.4%)	184,244 (6.6%)	Reference	Reference
Underemployment	5,023,889	4,197,276 (83.5%)	826,613 (16.5%)	0.36 (0.31 – 0.42)**	0.78 (0.66 – 0.94)**
Unemployment	386,417	355,493 (92.0%)	30,924 (8.0%)	0.82 (0.63–1.06)	1.25 (0.94 – 1.65)
Retired	830,986	784,427 (94.4%)	46,559 (5.6%)	1.19 (0.880–1.62)	0.96 (0.71 – 1.31)
Other (housewife, student, etc.)	3,722,826	3,190,090 (85.7%)	532,736 (14.3%)	0.43 (0.36 – 0.50)**	0.73 (0.60 – 0.88)**
Income per capita (quartile)[b]					
Q1 (lowest)	4,235,146	3,362,706 (79.4%)	872,440 (20.6%)	0.18 (0.15–0.21)**	0.42 (0.35–0.52)**
Q2	3,385,503	2,979,243 (88.0%)	406,260 (12.0%)	0.37 (0.28–0.40)**	0.59 (0.48–0.72)**
Q3	2,787,943	2,545,392 (91.3%)	242,551 (8.7%)	0.48 (0.39–0.59)*	0.70 (0.57–0.85)**
Q 4 (highest)	2,220,762	2,123,048 (95.6%)	97,714 (4.4%)	Reference	Reference
Human Development Bonus					
No	11,255,486	9,913,831 (88.1%)	1,341,655 (11.9%)	Reference	Reference
Yes	1,488,021	1,208,600 (81.2%)	279,421 (18.8%)	0.59 (0.51 – 0.68)**	0.98 (0.83 – 1.16)
Disability Bonus					
No	12,701,879	11,084,667 (87.3%)	1,617,212 (12.7%)	Reference	–
Yes	41,628	37,764 (90.7%)	3864 (9.3%)	1.43 (0.73 – 2.79)	–

*significant p-value < 0.05.
**significant p-value < 0.01.
[a] Includes those who have not received any dose of vaccine.
[b] Missing data = 114153.

received at least one dose of the vaccine compared to those who are fully employed (PR 0.36, 95% CI 0.31–0.42; PR 0.43, 95% CI 0.36–0.50). People with the lowest income were less likely to be vaccinated with at least dose than those whom belonged to in the highest economic quartile (PR 0.18, 95% CI 0.15–0.21). People who receive a Human Development Bonus were also less likely to receive at least one dose of the vaccine than those who do not received it (PR 0.59, 95% CI 0.51–0.68). In the multivariate analysis, the characteristics that remained significantly associated with less probability of vaccination against COVID-19 were being a resident of a rural area (PR 0.82, 95% CI 0.74–0.91), being indigenous (PR 0.43, 95% CI 0.29–0.64), no education (PR 0.25, 95% CI 0.14–0.43). Likewise, being underemployed or being a housewife/student/other was significantly associated with a lower probability of receiving the vaccine than being an employee (PR 0.78, 95% CI 0.66–0.94; PR 0.73, 95% CI 0.60–0.88). Belonging to the quartiles with the lowest economic income also remained significantly associated with a lower probability of having received at least one dose of the vaccine against COVID-19 (PR 0.42, 95% CI 0.35–0.52; PR 0.59, 95% CI 0.48–0.72; PR 0.70, 95% CI 0.57–0.85 for quartile 1, 2 and 3 respectively). No significant differences were found by sex, Human Development Bonus or Disability Bonus. Individuals aged 60 years and over were the ones who presented the highest prevalence in terms of having received at least one dose of the vaccine (Table 3).

Regarding those who received two or more doses of the vaccine against COVID-19 (Table 4), rural area residents were 54% less likely to receive two or more doses than urban area residents (PR 0.46, 95% CI 0.42–0.49). This association was maintained after adjusting for other variables (PR 0.88, 95% CI 0.80–0.96). People 60 years of age and younger were less likely to have received the second or more doses than those older than 60 years (PR 0.19, 95% CI 0.17–0.24; PR 0.44, 95% CI 0.38–0.50; PR 0.72, 95 % CI 0.62–0.84, for 15–18 years, 19–30 years and 31–60 years, respectively), remaining significant after adjustment. Women were 8% less likely to have two or more doses of the vaccine than men (PR 0.92, 95% CI 0.83–0.98), significant after adjustment (PR 0.84; 95% CI 0.77–0.91). Those self-identified as indigenous were 78% less likely to receive two or more doses than those self-identified as white (PR 0.22, 95% CI 0.17–0.29). This data remained significant after adjusting for other demographic and socioeconomic variables (PR 0.44, 95% CI 0.33–0.59).

A lower educational level was associated with a lower prevalence of vaccination with two or more doses (PR 0.05, 95% CI 0.03–0.08; PR 0.09, 95% CI 0.03–0.25; PR 0.03, 95% CI 0.02–0.05, PR 0.12, 95% CI 0.08–0.20, PR 0.35, 95% CI 0.21–0.57 for none education, literacy, school and high school level respectively, compared with postgraduate level). This association remained significant after adjustment (Table 4).

The lowest income quartile was 79% less likely to receive two or more doses, compared with those in the highest income quartile (PR 0.21, 95% CI 0.19–0.23). Likewise, income quartiles 2 and 3 presented a 61% and 46% lower probability of receiving the second dose, respectively (PR 0.39, 95% CI 0.35–0.45; PR 0.54, 95% CI 0.47–0.60). After adjustment, this association remained significant (PR 0.48, 95% CI 0.42–0.55; PR 0.68, 95% CI 0.60–0.79; PR 0.76, 95% CI 0.67–0.87, for quartile 1, 2 and 3, respectively).

The underemployed and other population considered economically inactive (housewife, student, etc.) had 61% and 59% respectively lower prevalence of vaccination than those who were employed (PR 0.39, 95% CI 0.35–0.45 for underemployed and PR 0.71, 95% CI 0.61–0.83). This result remained significant after adjustment (PR 0.77, 95% CI 0.67–0.88 and PR 0.71, 95% CI 0.61–0.83, respectively) (Table 4).

Those who received economic support from the government, such as the Human Development Bonus, presented lower percentages of vaccination with a second dose against COVID-19 than those who did not receive this benefit. This association was also significant in the multivariate analysis (PR 1.20, 95 % CI 1.05–1.39 for those who do not receive a bonus versus those who do receive it) (Table 4).

4. Discussion

This study shows the socioeconomic gaps in vaccination against COVID-19 in Ecuador with the first and two or more doses from the primary vaccine series. There was a lower probability of having received at least one dose of the vaccine against COVID-19 in rural residents, indigenous people, lower education level and those with lower income, compared with urban residents, people self-identified as white, postgraduate level and the highest income quartile. A lower probability of being vaccinated with two or more doses was also found in rural residents, women, indigenous people, with a lower educational level, underemployed or economically inactive, and those with the lowest level of economic income, compared to urban residents, men, postgraduate educational level, fully employed and the highest income quartile.

Previous studies have shown that the most socially vulnerable groups were those who presented the highest risk of illness and death during the pandemic. Especially rural indigenous populations have presented a high reproduction rate of the virus and high rates of infection by COVID-19 [21,22]. In this study, the indigenous population was 56% less likely to receive two or more doses of vaccine against COVID-19 than the white population, regardless of the sector of residence, age, economic income, and other variables included in the adjustment. This lower probability of receiving the vaccine in indigenous ethnic groups or minority populations has been found in other studies [23,24]. This shows the social, health, economic, and political vulnerability of indigenous, ethnic or minority populations during the pandemic, and the need to focus government actions on policies aimed at reducing such vulnerability [25,26]. At the same time, it has been observed that ethnic groups also present greater hesitancy to be vaccinated [27], so health education and communication strategies are also necessary to reduce the inequalities observed.

Coverage of the primary vaccine series against COVID-19 at the time of the study, with first and second doses, was higher in urban areas compared to rural areas, probably due to better access to vaccination sites and a broader distribution of the vaccine in the central cities of the country. The rural area was 12% less likely to have two doses or more of the vaccine compared to the urban area (PR 0.88, 95% CI 0.80–0.96). A study conducted in Kenya also estimated higher vaccination coverage in urban areas, 27.8% higher than in rural areas [28], due in part to the distance and travel time required to access vaccination sites. This suggests vaccine-related geographic inequities, which could be addressed through increased vaccination sites and better geographic access to them. Another study conducted in the United States similarly reported higher rates of vaccination coverage with the first series in urban versus rural populations [29]. This finding denotes a lack of infrastructure and access to health in rural populations, but it could also be explained by a greater hesitancy to receive the vaccine in this sector [29].

In this study, women were less likely than men to complete the primary vaccination series against COVID-19. This finding differs from others studies, where a lower probability of completing the scheme was found in men [30,31], who presented higher rates of hesitancy to the vaccine than women [31]. The difference could probably be due to a later administration of the primary series in women, given their employment status. In our study, we found that “economically inactive” people, such as housewives who are preferably women, had lower coverage in the primary series of the vaccine, while employees who are preferably men had higher percentages of two or more vaccine dose. In fact, the initial phases of vaccination in Ecuador were directed, in addition to older adults and vulnerable people, to health workers and essential employees, which are spaces generally occupied by men.

This study did find an association between educational level and vaccination against COVID-19. Those with none or a lower level of education were less likely to have received the vaccine against COVID-19, compared to those with the highest level of education, regardless of the area of residence, age, economic income and other variables considered in the adjustment. The study carried out by Bergen, et al. [10] confirms

Table 4
Demographic and socioeconomic characteristics associated with COVID-19 primary vaccination. ENEMDU Ecuador, 2021. (n expanded = 12,743,507).

Categories	n	Vaccinated second dose or moreFrequency (%)	Vaccinated with one or cero dose[a]Frequency (%)	PR (95% CI)	PR adjusted (95% CI)
Sample	12,743,507	9,972,283 (78.3%)	2,771,224 (21.7%)		
Area					
Urban	8,877,881	7,326,666 (82.5%)	1,551,215 (17.5%)	Reference	Reference
Rural	3,865,626	2,645,617 (68.4%)	1,220,009 (31.6%)	0.46 (0.42–0.49)**	0.88 (0.80–0.96)**
Age (years)					
15–18	1,375,328	796,477 (57.9%)	578,851 (42.1%)	0.19 (0.17–0.22)**	0.19 (0.17–0.24)**
19–30	3,290,469	2,498,688 (75.9%)	791,781 (24.1%)	0.44 (0.38–0.50)**	0.32 (0.27–0.37)**
31–60	5,943,518	4,803,363 (80.8%)	1,140,155 (19.2%)	0.72 (0.62–0.84)**	0.49 (0.43–0.56)**
>60	2,134,192	1,873,755 (87.8%)	260,437 (12.2%)	Reference	Reference
Sex					
Men	6,227,612	4,817,484 (77.4%)	1,410,128 (22.6%)	0.92 (0.83–0.98)*	0.84 (0.77 – 0.91)*
Women	6,515,895	5,154,799 (79.1%)	1,361,096 (20.9%)	Reference	Reference
Ethnic self-identification					
Indigenous	1,235,659	609,179 (49.3%)	626,480 (50.7%)	0.22 (0.17–0.29)**	0.44 (0.33–0.59)**
Afrodescendant	549,091	397,073 (72.3%)	152,018 (27.7%)	0.59 (0.44–0.79)*	0.96 (0.71–1.29)
Montuvio	625,390	442,470 (70.8%)	182,920 (29.2%)	0.54 (0.39–0.75)*	0.96 (0.69–1.33)
Mestizo	10,126,530	8,354,590 (82.5%)	1,771,940 (17.5%)	1.07 (0.81–1.39)	1.13 (0.96–1.92)
White	206,837	168,779 (81.6%)	38,058 (18.4%)	Reference	Reference
Education					
None	454,320	339,188 (74.7%)	115,132 (25.3%)	0.18 (0.13–0.25)**	0.39 (0.27–0.58)**
Literacy	37,508	23,370 (62.3%)	14,138 (37.7%)	0.09 (0.05–0.19)**	0.38 (0.19–0.73)**
School	4,229,551	3,086,608 (73.0%)	1,142,943 (27.0%)	0.16 (0.12–0.22)**	0.43 (0.31–0.59)**
High school	5,450,479	4,214,698 (77.3%)	1,235,781 (22.7%)	0.20 (0.15–0.27)**	0.58 (0.43–0.79)**
College	2,364,765	2,113,220 (89.4%)	251,545 (10.6%)	0.50 (0.37–0.68)**	0.90 (0.66–1.24)
Post graduate	206,884	195,199 (94.4%)	11,685 (5.6%)	Reference	Reference
Employment status					
Employment	2,779,389	2,433,502 (87.6%)	345,887 (12.4%)	Reference	Reference
Underemployment	5,023,889	3,694,743 (26.5%)	1,329,146 (73.5%)	0.39 (0.35–0.45)**	0.77 (0.67 – 0.88)**
Unemployment	386,417	313,201 (81.1%)	73,216 (18.9%)	0.61 (0.49–0.76)*	0.91 (0.72–1.14)
Retired	830,986	761,096 (91.6%)	69,889 (8.4%)	1.55 (1.23–1.94)*	0.99 (0.79–1.25)
Other (housewife, student, etc.)	3,722,827	2,769,741 (25.6%)	953,086 (74.4%)	0.41 (0.37–0.47)**	0.71 (0.61 – 0.83)**
Income per capita (quartile)[b]					
Q1 (lowest)	4,235,146	2,829,071 (66.8%)	1,406,075 (33.2%)	0.21 (0.19–0.23)**	0.48 (0.42–0.55)**
Q2	3,385,503	2,688,582 (79.4%)	696,921 (20.6%)	0.39 (0.35–0.45)**	0.68 (0.60–0.79)**
Q3	2,787,943	2,337,857 (83.9%)	450,086 (16.1%)	0.54 (0.47–0.60)**	0.76 (0.67–0.87)**
Q 4 (highest)	2,220,762	2,013,453 (90.7%)	207,309 (9.3%)	Reference	Reference
Human Development Bonus					
No	11,255,486	8,922,046 (88.1%)	2,333,440 (11.9%)	1.59 (1.41–1.79)*	1.20 (1.05–1.39)*
Yes	1,488,021	1,050,237 (70.6%)	437,784 (29.4%)	Reference	Reference
Disability Bonus					
No	12,701,879	9,940,299 (87.3%)	2,761,580 (12.7%)	1.09 (0.53–2.53)	
Yes	41,628	31,984 (90.7%)	9644 (9.3%)	Reference	

* significant p-value < 0.05.
**significant p-value < 0.01.

[a] Includes those who did not receive any vaccine or only one dose.
[b] Missing data = 114153.

that, worldwide, there were inequalities related to the level of education, with a lower reception of the vaccine among the less educated compared to the more educated. The level of education was also related to the acceptance and reluctance to the vaccine, observing structural barriers in low- and middle-income countries.

The present study shows that the people in the lowest income quartile would be less likely to have received one dose or two or more doses of vaccine against COVID-19, compared to people belonging to the highest income quartile. Previous studies also show the most economically disadvantaged sectors are less likely to be vaccinated against COVID-19 [32,33]. At the same time, those populations with greater economic disadvantages also presented greater hesitancy to vaccination [10,27].

The inequalities in vaccination with one or two doses for COVID-19 in Ecuador would be reflecting problems at the macro and micro levels [15]. When vaccination began, the limited number of doses and the organization of the health system led to problems in the availability and distribution of the vaccine. In this study, one of the main reasons for not being vaccinated was not having an appointment for the vaccine or not knowing where they should be vaccinated, which suggests problems with organizational access to vaccination, as well as difficulties in information.

Subsequently, with the increase in the availability of the vaccine and the political decision of the government to guarantee vaccination, a coordinated process was implemented, with an increase in vaccination sites and the logistical support of various governmental, non-governmental and educational entities. Despite this, and the government's effort to guarantee free and universal vaccination against COVID-19, there were inequalities in vaccination coverage that affected the most socially and economically vulnerable populations.

This study suggests the inequities evidenced at the beginning of vaccination have not been fully remedied, because of the lower probability of having completed the primary vaccination series in less favored ethnic and economic groups. The study carried out by DiRago et al. [34] also shows that despite the vaccination rollouts against COVID-19, cumulative inequality persisted in socioeconomically disadvantaged populations. Hence the need for governments to guarantee equitable access to the strategies implemented to prevent or control this or other pandemics from the beginning of their planning and execution, with special emphasis on the most vulnerable populations.

Following what has been mentioned by other authors, guaranteeing equity in vaccination requires a joint effort between countries and within each country, regarding the availability, administration and acceptability of the vaccine. Among the strategies to guarantee equity, it is suggested a constant monitoring of inequalities in vaccination to identify neglected groups, direct resources and evaluate the impact of the strategies implemented, expanding the vaccination offer beyond health establishments, to extramural areas, in places where vaccine recipients commonly gather, and generate alliances between different sectors and civil society, to expand information and communication, which allows reducing misinformation regarding vaccination [35].

This study has several limitations. The database contains information collected over a period, which does not allow for a follow-up analysis of inequality in vaccination against COVID-19 over time. On the other hand, the data collected may contain information biases and there are missing data for some variables. It was not possible to carry out an analysis of inequality disaggregated by territories, nor was it possible to analyze vaccination in children under 15 years of age. However, the information is representative of the national level, in the population aged 15 and over and for rural/urban areas. The study makes it possible to address ethnic, geographic, and socioeconomic inequalities and to observe persistent gaps in the primary vaccination series, including one and two doses of the vaccine.

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

The data that supports the findings of this study are openly available in Instituto Nacional de Estadísticas y Censos (INEC). (2021) at https://www.ecuadorencifras.gob.ec/vacunacion-covid-19/

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