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Socioeconomic and geographic inequities in vaccination among children 12 to 59 months in Mexico, 2012 to 2021

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ABSTRACT

Objective. To document the evolution of socioeconomic and geographical inequalities in childhood vaccination in Mexico from 2012 to 2021.

Methods. Repeated cross-sectional analysis using three rounds of National Health and Nutrition Surveys (2012, 2018, and 2021). Dichotomous variables were created to identify the proportion of children who received no dose of each vaccine included in the national immunization schedule (BCG; diphtheria, pertussis, and tetanus-containing; rotavirus; pneumococcal conjugate; and measles, mumps, and rubella [MMR]), and the proportion completely unvaccinated. The distribution of unvaccinated children was analyzed by state, and by socioeconomic status using the concentration index.

Results. The prevalence of completely unvaccinated children in Mexico was low, with 0.3% children in 2012 and 0.8% children in 2021 receiving no vaccines ($p = 0.070$). Notwithstanding, for each vaccine, an important proportion of children missed receiving any dose. Notably, the prevalence of MMR unvaccinated children was 10.2% (95% CI 9.2–11.1) in 2012, 22.3% (95% CI 20.9–23.8) in 2018, and 29.1% (95% CI 26.3–31.8) in 2021 ($p < 0.001$ for the difference between 2012 and 2021). The concentration index indicated pro-rich inequalities in non-vaccination for 2 of 5 vaccines in 2012, 3 of 5 vaccines in 2018, and 4 of 5 vaccines in 2021. There were marked subnational variations. The percentage of MMR unvaccinated children ranged from 3.3% to 17.9% in 2012, 5.5% to 36.5% in 2018, and 13.1% to 72.5% in 2021 across the 32 states of Mexico.

Conclusions. Equitable access to basic childhood vaccines in Mexico has deteriorated over the past decade. Vigilant equity monitoring coupled with tailored strategies to reach those left out is urgently required.

Keywords Vaccination coverage; health inequities; Mexico.

With among the highest vaccine coverage levels in the world, the Region of the Americas is a global leader in the elimination and control of basic vaccine-preventable diseases. Introduced in 1991, Mexico's Universal Vaccination Program was created with the goal of delivering equitable access to vaccination; that is, to offer all children an optimal start in life, by increasing the breadth of vaccine coverage of the Mexican population and the depth of coverage in terms of the number of antigens included in the program (1).

The success of Mexico's vaccination program has been demonstrated by consistently high vaccine coverage rates, which by 2012 were exceeding regional averages for the Americas (2). As a result of the vaccination program, the country eliminated poliomyelitis, diphtheria, and measles, as well as reduced cases of other vaccine-preventable diseases (1). Combined with other public health interventions, immunizations in Mexico are believed to have contributed to a decrease in mortality from diarrheal diseases in children younger than 5 years and

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to the gains in life expectancy observed in Mexico from 1980 to 2000 (3, 4), as well as to decreases in the overall mortality of children under 5 from 1990 to 2010 (5).

Progress in achieving vaccine equity was also confirmed in analyses of Mexico's National Health and Nutrition Surveys (ENSANUT by the Spanish acronym), which demonstrated that the vaccination coverage gap observed between children from less and more advantaged households in 2000 was reversed by 2012, when for a complete scheme and by individual vaccines, there were only minor differences in coverage by socioeconomic quintile and by poverty status (6, 7). Nevertheless, the same analysis identified a drop in the overall percentage of children immunized between 2000 and 2012 (6), suggesting challenges to the immunization program and raising concerns related to unreliable estimation of the population denominators used to produce coverage estimates (8, 9), as administrative reported coverages remained high and unchanged (10).

By 2012, data from the ENSANUT 2012 indicate that among children age 15 to 23 months, coverages were 96.7%, 68%, 88%, and 80% for BCG, pentavalent, pneumococcal conjugate (PCV), and rotavirus (RV), respectively, and 87% for measles, mumps, and rubella (MMR), and 0.2% of this age group was never vaccinated (11). In 2018, from the ENSANUT 2018, for children 12 to 23 months a coverage of 97.4% was estimated for BCG, and 92.1% for one dose of pentavalent vaccine (12).

However, more recent analyses suggest a reversal of trend. An analysis of the ENSANUT from 2000 to 2018 identified a negative trend in vaccination coverage for children under 5 in Mexico and found that the probability of incomplete vaccination was related to socioeconomic and geographic factors (12). A similar analysis using only the 2012 and 2018-100k rounds of the ENSANUT found similar results, with decreasing coverage for specific vaccines and overall coverage of the complete scheme around 50% (13). By 2020, vaccination coverage in Mexico was below the regional average (14).

The World Health Organization (WHO) Global Vaccine Action Plan 2011–2020 defined a global goal that immunization benefits should be available for all individuals worldwide (15). In 2015, recognizing that continuous efforts are needed to sustain achievements and that high national vaccine coverage levels can often mask inequalities within a country, the Pan American Health Organization (PAHO) approved the 2016–2020 Plan of Action on Immunization for the Region of the Americas (16). To address within-country gaps in vaccination coverage, the plan recommended that each country should report vaccination coverage by income quintile or other subgroups that make it possible to monitor vaccination equity (Strategic Objective 2.2.1). However, in Mexico, attention to within-country immunization coverage gaps remains low.

Our aim in this article is to to document the evolution of socioeconomic and geographical inequalities in childhood vaccination in Mexico over the last decade, from 2012 to 2021. As children who receive no routine immunization doses are most vulnerable to morbidity and mortality from vaccine-preventable diseases, our analysis focuses on unvaccinated children (17).

MATERIALS AND METHODS

This is a repeated cross-sectional analysis using data from national multi-thematic health surveys in Mexico. We used publicly available data from Mexico's ENSANUT rounds 2012, 2018, and 2021. ENSANUT data are available from https://ensanut.insp.mx/. The ENSANUT is a national probabilistic multi-thematic household survey that includes a specific questionnaire for children from 0 to 9 years old addressed to the mother or the primary caregiver; further details of the surveys have been published elsewhere (18–20). In brief, the ENSANUT samples are designed to provide estimations for each state (full sample rounds) or regions (the current annual rounds), and within each state or region, for the urban and rural population. Within each stratum, census units are sampled as primary sampling units, and then urban blocks and rural segments of dwellings, and finally, dwellings. Within each dwelling, all households are surveyed, and within each household, one individual for each defined age group (0 to 9, 10 to 19, and 20 and older) is randomly selected.

We used the 2012 and 2018 rounds as the latest full sample rounds (i.e., data from about 50 000 households in the country) and 2021 as the latest available round, and restricted the sample to data from children 12 to 59 months old.

The ENSANUT gathers data on vaccination using the Mexican scheme (21, 22) and documents for each included vaccine whether a child received the vaccine and, if so, the date and place of vaccination. Data on vaccination were retrieved from the vaccination card or, if the card was not available at the time of the interview, reported by the caregiver. We considered five key vaccines included in the Mexican scheme (22): BCG vaccine; diphtheria, pertussis, and tetanus-containing vaccine (DPTc) (part of the current pentavalent vaccine in Mexico); rotavirus vaccine (RV); pneumococcal conjugate vaccine (PCV); and measles, mumps, and rubella (MMR) vaccine. For each of these five vaccines, we generated a dichotomous variable identifying children 12 to 59 months unvaccinated by vaccine (i.e., children who received no dose of a given vaccine) as well as those who were completely unvaccinated (i.e., children who received no dose of any of the five vaccines). These served as our outcome variables.

As a socioeconomic stratifier, we used a continuous indicator of household economic status generated using household structure and assets as well as dwelling characteristics. The procedure for constructing the indicator is published elsewhere (23). In brief, using the National Survey on Household Income and Expenditures we estimated a model to predict per-capita income based on household variables (structure, assets, dwelling characteristics) that are also available in the ENSANUT and then used the estimated coefficients from that model to impute in the ENSANUT. We also categorized this continuous variable created in each ENSANUT round in quintiles.

Analyses also considered a number of important correlates. In the ENSANUT, children's age and sex are reported by the caregiver; age was reported as years and months, and we converted this to months. Institutional birth was categorized as a dichotomous variable based on caregiver report concerning whether the birth occurred in a hospital or clinic, or elsewhere.

Health insurance status was categorized as none, public health insurance, social security (the system that covers employees in the formal economy), and private insurance. As some individuals may have both social security and private insurance, the first instance reported was used.

Data analysis

We reported the main characteristics of the population of children 12 to 59 months in Mexico for 2012, 2018, and 2021

using means for continuous variables and percentages for categorical ones. We compared the characteristics between those surveyed in 2012 and those surveyed in 2021 using t-tests or z-tests, as appropriate.

To study national trends, we estimated the prevalence of unvaccinated children by vaccine, and for completely unvaccinated children who received no vaccines, reporting 95% confidence intervals (95% CI) for each estimation. To study geographic inequalities, we repeated these analyses to estimate the prevalence of non-vaccination for all outcomes in each of Mexico's 32 states.

Then, we estimated the national magnitude of inequalities in vaccination coverage by socioeconomic status using the concentration index. The concentration index is a measure of inequality that indicates the distribution of a health indicator among the population rank ordered by the generated socioeconomic index. The concentration index is defined as twice the area between the concentration curve and the line of equality (the 45-degree line), and ranges from –1 to 1, where zero represents an absence of inequality. In this analysis, negative values indicate a pro-rich distribution of vaccination (24, 25). The concentration index (CI) is estimated by:

$$CI = \frac{2}{N^2 * \mu_n} * \sum_i^n h_i * r_i$$

where h_i is non-vaccination status children of children i, μ_h is the nationwide proportion of non-vaccinated children, and r_i is the fractional rank of children i for the socioeconomic index, with the n children as the highest index value. Because the vaccination indicators are bounded between 0 and 1, we used the normalization proposed by Wagstaff (25), dividing the concentration index by 1 minus the mean:

$$CI = \frac{\frac{2}{N^2 * \mu_n} * \sum_i^n h_i * r_i}{1 - \mu_n}$$

By using the Wagstaff adjustment, we are assuming that the relevant question regarding equity is related to a definition of the most unequal situation as one where only individuals in the top of the income distribution are vaccinated (healthy) (26). Data processing was conducted using Stata 15, with the command coindex for the concentration index, and adjusting for the complex survey design; i.e., weights, primary sampling units, and strata (27, 28).

Overall, we used data from 22 309 children aged 12 to 59 months, 11 169 of those from 2012 (50%), 8 343 from 2018 (37%), and 2 797 from 2021 (13%). These observations represented a population of 25.6 million: 8 841 893 in 2012, 7 893 045 in 2018, and 8 721 119 in 2021.

Ethical procedures

We used publicly available data from the ENSANUT that are de-identified. The institution responsible received permission to conduct the survey and followed informed consent procedures approved by their institutional review board (18–20).

RESULTS

Table 1 reports key characteristics of the study population and assesses differences across survey waves. From 2012 to 2021, several important changes suggest a deterioration in health system strength and social safety networks: notably, the proportion of institutional births decreased, the proportion of individuals with public health insurance decreased, the proportion without any health insurance increased, and the proportion of households with a vaccination card available at the time of the survey decreased ($p < 0.001$ for all comparisons).

Overall inequalities

In Table 2 we report the nationwide levels of unvaccinated children by vaccine and year (2012, 2018, and 2021), as well as for the top and bottom states (there are 32 states in Mexico). As reported, for all included vaccines there is a group of children in the country that is lacking immunization, and with distinct patterns for established and newly introduced vaccines. Among established vaccines, the proportion of unvaccinated children increased slightly for BCG (BCG unvaccinated children were 3.6% in 2012 [95% CI 2.8–4.5], 2.6% [95% CI 2.1–3.1] in 2018, and 3.8% [95% CI 2.8–4.8] in 2021 [$p = 0.032$]) and for DPTc (DPTc unvaccinated children were 1.2% [95% CI 0.9–1.5] in 2012, 3.0% [95% CI 2.5–3.6] in 2018, and also 3.0% in 2021 [95% CI 2.1–3.8] [$p < 0.001$ for the difference between 2012 and 2021]), and increased sharply for MMR (MMR unvaccinated children were 10.2% [95% CI 9.2–11.1] in 2012, 22.3% [95% CI 20.9–23.8] in 2018, and 29.1% [95% CI 26.3–31.8] in 2021 [$p < 0.001$ for the difference between 2012 and 2021]). For newly introduced vaccines, the proportion of unvaccinated children decreased but with a possible trend to increase back in 2021 (RV unvaccinated children were 12.1% [95% CI 10.7–13.6] in 2012, 3.9% [95% CI 3.3–4.5] in 2018, and 5.5% [95% CI 4.3–6.6] in 2021 [$p < 0.001$ for the difference between 2012 and 2021]), PCV unvaccinated children were 12.3% in 2012 [95% CI 11.1–13.6], 3.3% [95% CI 2.8–3.9] in 2018, and 4.8% [95% CI 3.7–6.0] in 2021 [$p < 0.001$ for the difference between 2012 and 2021]). Considering all vaccines together, in 2012 there were 0.3% [95% CI 0.2–0.4] children without any vaccine in Mexico, and in 2018 this percentage was 0.5% [95% CI 0.3–0.8], and then 0.8% [95% CI 0.3–1.3] in 2021 ($p = 0.070$), representing about 16 000 children in 2012, 42 000 children in 2018, and 72 000 children in 2021; that is, a 4.5 fold increase in a decade.

Geographic (subnational) inequalities

As shown in Table 2, there is a large variation at the subnational level. For BCG, the heterogeneity across states in the proportion of unvaccinated ranged from 0.6% to 19.4% in 2012, from 0.4% to 5.4% in 2018, and from 0.0% to 16.0% in 2021. For DPTc, the percentage unvaccinated varied from 0.0% to 3.8% in 2012, from 0.3% to 8.2% in 2018, and from 0.0% to 18.1% in 2021. Finally, for MMR, the variation in the percentage unvaccinated went from 3.3% to 17.9% in 2012, from 5.5% to 36.5% in 2018, and from 13.1% to 72.5% in 2021. For RV, these ranges were 4.0% to 22.7%, 0.8% to 8.7%, and 0.0% to 23.0% for 2012, 2018, and 2021, respectively. Regarding PCV, those unvaccinated ranged from 4.0% to 20.8% in 2012, 0.0% to 8.7% in 2018, and 0.0% to 18.8% in 2021. The percentage of children without any vaccine of the five

TABLE 1. Characteristics of children 12 to 59 months old (mean or proportion [95% CI]), Mexico, 2012, 2018, and 2021

Variable	2012	2018	2021	*p* 2012 vs. 2021*
Sex (% male)	50.8	51.2	51.2	0.764
	(49.4–52.2)	(49.6–52.7)	(48.6–53.8)	
Age	2.5	2.6	2.6	0.044
	(2.5–2.5)	(2.5–2.6)	(2.5–2.6)	
Institutional birth	90.2	95.7	84.3	0.000
	(88.8–91.5)	(95.0–96.4)	(82.0–86.6)	
Without health insurance	24.5	17.4	52.9	0.000
	(23.0–26.0)	(16.2–18.7)	(49.0–56.8)	
Public health insurance	45.2	47.5	9.9	0.000
	(43.4–46.9)	(45.9–49.2)	(7.9–12.0)	
Social security	29.9	33.7	37.0	0.001
	(28.2–31.6)	(32.2–35.2)	(33.2–40.8)	
Private insurance	0.4	1.4	0.2	0.210
	(0.2–0.7)	(0.8–1.9)	(0.0–0.4)	
Socioeconomic quintile				
Q1 (bottom)	28.2	40.4	41.7	0.000
	(26.3–30.1)	(38.9–42.0)	(38.1–45.2)	
Q2	22.7	25.9	24.1	0.378
	(21.4–24.1)	(24.6–27.3)	(21.4–26.8)	
Q3	20.2	17.7	17.6	0.060
	(19.0–21.5)	(16.6–18.8)	(15.2–20.1)	
Q4	16.6	6.6	11.2	0.000
	(15.4–17.9)	(5.9–7.3)	(9.0–13.5)	
Q5 (top)	12.2	9.4	5.4	0.000
	(11.0–13.3)	(8.5–10.2)	(3.8–7.0)	
Urban	73.9	71.6	74.6	0.758
	(71.8–76.0)	(70.2–72.9)	(70.2–79.0)	
Vaccination card available	61.6	48.2	46.4	0.000
	(59.9–63.2)	(46.6–49.7)	(43.0–49.7)	
N	11 169	8 343	2 797	

Note: *Test of differences of means or proportions between 2012 and 2021.
Source: Authors' estimations using data from ENSANUT 2012, 2018, and 2021.

included across states ranged from 0.0% to 1.8% in 2012 and 2018, and from 0.0% to 9.0% in 2021. It is important to notice that while in 2012 12 states had no completely unvaccinated children, this increased to 22 in 2021, meaning that completely unvaccinated children were concentrated in fewer states.

Socioeconomic inequalities

In terms of the estimated inequalities related to socioeconomic status, the concentration index reported in Table 3 suggests an increase in inequalities: while in 2012 there is evidence of pro-rich inequalities in two of the five vaccines, for 2018 the same is true for three of the five vaccines plus in terms of those without any vaccine, and for 2021 this is true for four of the five and also in terms of those without any vaccine.

In terms of the magnitude of the inequalities, an absolute value for the concentration index of 0.2 is conventionally used as the standard threshold for important inequalities. In 2012, no vaccine exceeded this threshold, and only PCV unvaccinated (–0.17) was close to the threshold. In 2018, no individual vaccine exceeded this threshold, although the concentration index for two of the five vaccines was close to the threshold (BCG unvaccinated –0.19, RV unvaccinated –0.18), and the concentration index for those without any vaccine was above the threshold (–0.23). In 2021, the concentration index for four of the five vaccines was above the threshold (BCG unvaccinated –0.24, DPTc unvaccinated –0.28, RV unvaccinated –0.29, and PCV unvaccinated –0.29), and the concentration index for those without any vaccine was also above the threshold (–0.56 for those without any vaccine).

DISCUSSION

To the best of our knowledge, this article is the first to analyze subnational inequities in vaccination in Mexico. We highlight four salient results.

First, our findings signal a clear and alarming deterioration in equitable access to basic childhood vaccines in Mexico. Results from analyses related to place of residence and to socioeconomic status demonstrate increases in immunization inequities from 2012 to 2018 and again from 2018 to 2021.

Second, while official WHO–UNICEF estimates indicate modest decreases in Mexico's national coverage for some key antigens (29), our analysis reveals much more extensive

TABLE 2. Percentage (95% CI) of unvaccinated children in Mexico, by vaccine and year (2012, 2018, and 2021), for the country and for the bottom and top states

Vaccine	Year	National		Bottom state		Top state	
		%	95% CI	%	95% CI	%	95% CI
No BCG	2012	3.6	(2.8–4.5)	0.6	(–0.2–1.4)	19.4	(12.1–26.8)
	2018	2.6	(2.1–3.1)	0.4	(–0.4–1.1)	5.4	(2.5–8.3)
	2021	3.8	(2.8–4.8)	0.0	(0.0–0.0)	16.0	(7.8–24.1)
No DPTc	2012	1.2	(0.9–1.5)	0.0	(0.0–0.0)	3.8	(1.3–6.3)
	2018	3.0	(2.5–3.6)	0.3	(–0.3–0.9)	8.2	(2.9–13.6)
	2021	3.0	(2.1–3.8)	0.0	(0.0–0.0)	18.1	(9.3–27.0)
No RV	2012	12.1	(10.7–13.6)	4.0	(0.9–7.1)	22.7	(16.9–28.5)
	2018	3.9	(3.3–4.5)	0.8	(–0.1–1.6)	8.7	(4.0–13.4)
	2021	5.5	(4.3–6.6)	0.0	(0.0–0.0)	23.0	(12.7–33.3)
No PCV	2012	12.3	(11.1–13.6)	4.0	(0.5–7.5)	20.8	(14.1–27.5)
	2018	3.3	(2.8–3.9)	0.0	(0.0–0.0)	8.7	(3.7–13.7)
	2021	4.8	(3.7–6.0)	0.0	(0.0–0.0)	18.8	(8.6–29.0)
No MMR	2012	10.2	(9.2–11.1)	3.3	(1.1–5.4)	17.9	(11.1–24.7)
	2018	22.3	(20.9–23.8)	5.5	(3.0–8.1)	36.5	(27.2–45.8)
	2021	29.1	(26.3–31.8)	13.1	(3.5–22.7)	72.5	(55.8–89.3)
Unvaccinated (no vaccines)	2012	0.3	(0.2–0.4)	0.0	(0.0–0.0)	1.8	(0.1–3.4)
	2018	0.5	(0.3–0.8)	0.0	(0.0–0.0)	1.8	(0.0–3.7)
	2021	0.8	(0.3–1.3)	0.0	(0.0–0.0)	9.0	(2.0–15.9)

Notes: No BCG, unvaccinated for BCG vaccine; No DPTc, unvaccinated for DPT containing vaccine; no RV, unvaccinated for rotavirus vaccine; no PCV, unvaccinated for pneumococcal conjugate vaccine; no MMR, unvaccinated for measles-containing vaccine, the measles, mumps, and rubella vaccine. Full data by state are available upon request to the authors.
Source: Authors' estimations using data from ENSANUT 2012, 2018, and 2021.

TABLE 3. Concentration indices of socioeconomic inequality in unvaccinated children 12 to 59 months, by vaccine and year (Mexico, ENSANUT 2012, 2018, and 2021)

12 to 59 months	No BCG			No DPTc			No RV		
	CI	SE	*p*	CI	SE	*p*	CI	SE	*p*
2012	0.09	0.06	0.111	–0.01	0.09	0.888	**–0.10**	**0.04**	**0.014**
2018	**–0.19**	**0.05**	**0.001**	**–0.11**	**0.05**	**0.038**	**–0.18**	**0.05**	**0.000**
2021	**–0.24**	**0.08**	**0.004**	**–0.28**	**0.09**	**0.002**	**–0.29**	**0.07**	**0.000**
			0.000			0.232			**0.042**

12 to 59 months	No PCV			No MMR			Unvaccinated		
	CI	SE	*p*	CI	SE	*p*	CI	SE	*p*
2012	**–0.17**	**0.03**	**0.000**	–0.04	0.03	0.180	–0.03	0.15	0.851
2018	–0.03	0.05	0.464	–0.05	0.02	0.064	**–0.23**	**0.11**	**0.033**
2021	**–0.29**	**0.07**	**0.000**	0.02	0.04	0.581	**–0.56**	**0.18**	**0.003**
			0.013			0.721			0.266

Notes: CI, concentration index; SE, standard error; *p*, *p*-value.
No BCG, unvaccinated for BCG vaccine; No DPTc, unvaccinated for DPT containing vaccine; no RV, unvaccinated for rotavirus vaccine; no PCV, unvaccinated for pneumococcal conjugate vaccine; no MMR, unvaccinated for measles-containing vaccine, the measles, mumps, and rubella vaccine.
Source: Authors' estimations using data from ENSANUT 2012, 2018, and 2021.

subnational inequalities, with coverage levels among states sometimes differing by an order of magnitude.

Third, results varied by antigen. Declining coverages for older vaccines often co-occurred with improvements in coverage for PCV and RV vaccines, suggesting that programmatic focus makes an important difference.

Fourth, results for measles vaccination coverage are particularly alarming. After 22 years of intensive action, the Region of the Americas was the first in the world to have eliminated measles and was declared measles free in 2016. This achievement is now at risk. Our analysis demonstrates that substantial pockets of MMR unvaccinated children persist in Mexico, leaving the country vulnerable to outbreaks. Empirical evidence substantiates this concern. Mexico, which was declared free of measles after reaching high levels of vaccination at the end of the 20th century (30), reported a measles outbreak in early 2020 (before the COVID-19 pandemic). This outbreak was linked to under-vaccination, as only 14% of the reported cases were in vaccinated individuals. Notably, further analysis indicated that lack of stock figured among the key causes of measles under-vaccination (31).

These results have diverse, interrelated causes. An important transnational factor relates to Mexico's dependency on global vaccine markets. Mexico was once a vaccine producer but chose to disinvest in local capacity, as it was assumed that external supply would meet demand at a lower price. However, fluctuations in global vaccine markets, with increasing demand and supply growing at a comparatively slower pace, jeopardized opportune access to vaccines and left Mexico vulnerable to global supply shortages (10). The impact of this dependency is borne out in program monitoring data. According to regular monitoring of the country's Universal Vaccination Program, three key factors contribute to coverage decreases: failure to secure biological procurements, distribution challenges, and the growth of areas disputed by criminal groups that have thus become unsafe for health personnel (32, 33). In terms of biological procurements, while in the period 2012–2018 the reported challenge was in terms of national procedures to access imported vaccines—i.e., lengthy paperwork—for the period 2018 to date the challenge is reported as shortages in the global supply of vaccines (32, 33). In Mexico, biologicals are concentrated centrally in Mexico City and subsequently distributed across the country. The importance of distributional challenges is seen in the fact that states with high percentages of unvaccinated children are observed across the development spectrum, but that lower coverage often seems to correlate with distance from the capital. For example, some highly developed states that share a border with the United States of America have a high proportion of unvaccinated children. Evaluations of the vaccination program suggest difficulties related to storage capacity at the subnational level (34). Reports from program officials indicate stockouts as the main challenge related to vaccination inequalities, a situation that was further aggravated by service disruptions during the initial phase of the COVID-19 pandemic. The impact of stockouts and service disruptions may be aggravated by a lack of health facilities in the most marginalized areas served by mobile brigades. In addition, some of the states with low coverage levels, including several near the northern border with the United States and others closer to Mexico City, are among the least secure (35). Security concerns may impede health workers' ability to perform their functions and limit the general public in accessing services. Finally, increasing inequities in child vaccination reflect changes in the broader policy landscape leading to increased social inequalities in Mexico, visible in related areas of health and social security, such as decreases in institutional delivery and insurance coverage.

Our study has at least three important limitations. First, children who are unvaccinated may be systematically underrepresented in household surveys (36). This would lead to an underestimation of the prevalence of unvaccinated children and might affect distributional estimates in unknown ways. However, there are at present no viable alternative data sources to compensate for these gaps. Second, the ENSANUT surveys rely both on vaccination data from health cards and child caregiver reports, the latter being in general higher than the former. Although this may pose a difficulty for estimation of coverage levels, nevertheless, as we focus on distribution, these potential biases may be of less concern. Third, the COVID-19 pandemic has disrupted routine immunization services worldwide, leading to an increase in unvaccinated (no DPT1) and under-vaccinated (no DPT3) children. According to the most recent WHO–UNICEF estimates, the Region of the Americas went from 2.4 million to 2.7 million under-vaccinated and unvaccinated children from 2019 to 2020 (29, 37). Mexico is part of this trend. Despite its high coverage levels, Mexico figures among the 10 countries that account for 62% of unprotected children, and the situation has deteriorated: Mexico had 391 000 under-vaccinated children in 2019 and 563 000 under-vaccinated children in 2020. Due to the time periods covered by available data sources, these pandemic-related changes are not fully captured in our results.

Conclusion

Vigilant equity monitoring is essential even in contexts of high coverage such as Mexico's. To close emerging equity gaps, Mexico must address key supply constraints, take action to mitigate security concerns, and strengthen the storage and distribution capacity of vaccines by establishing subnational hubs that avoid the concentration of biologicals in Mexico City. In addition, a specific focus on equity is required, which traces unvaccinated children and tailors procedures for those hard to reach. As nominal, individual-level data are required to effectively reach these unvaccinated children, investments in data systems may be required.

Author contributions. JPG conceived the original idea and analyzed the data. JPG and MJ interpreted the results and wrote the paper. Both authors reviewed and approved the final version.

Conflict of interest. None declared.

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Inequidades socioeconómicas y geográficas en la vacunación infantil entre los 12 y 59 meses de edad, México, 2012-2021

RESUMEN

Objetivo. Documentar la evolución de las inequidades socioeconómicas y geográficas en la vacunación infantil en México del 2012 al 2021.

Métodos. Se llevó a cabo un análisis transversal repetido con tres rondas (2012, 2018 y 2021) de la Encuesta Nacional de Salud y Nutrición (ENSANUT). Se crearon variables dicotómicas para determinar la proporción de la población infantil que no había recibido cada una de las vacunas incluidas en el calendario nacional de vacunación (BCG; difteria, tos ferina y tétanos; rotavirus; conjugado neumocócico; y sarampión, parotiditis y rubéola [triple viral]) y la proporción de la población infantil completamente sin vacunar. La distribución de la población infantil sin vacunar se analizó por estado y nivel socioeconómico mediante el índice de concentración.

Resultados. La prevalencia de la población infantil completamente sin vacunar en México fue baja, con 0,3% en el 2012 y 0,8% en el 2021 de la población infantil que no recibió ninguna vacuna ($p = 0,070$). No obstante, en relación con cada vacuna, una gran proporción de población infantil no recibió ninguna dosis. En particular, la prevalencia de la población infantil sin vacunarse con la triple viral fue de 10,2% (IC del 95% 9,2–11,1) en el 2012, 22,3% (IC del 95% 20,9–23,8) en el 2018 y 29,1% (IC del 95 % 26,3–31,8) en el 2021 ($p < 0,001$ para la diferencia entre el 2012 y el 2021). El índice de concentración reveló desigualdades que favorecen a los estratos más ricos en la probabilidad de no estar vacunado para 2 de las 5 vacunas en 2012, en 3 de las 5 vacunas en 2018, y en 4 de las 5 vacunas en el 2021. Asimismo, hubo marcadas variaciones subnacionales: el porcentaje de la población infantil que no recibió la vacuna triple viral osciló entre 3,3% y 17,9% en el 2012, entre 5,5% y 36,5% en el 2018 y entre 13,1% y 72,5% en el 2021 en los 32 estados de México.

Conclusiones. El acceso equitativo a las vacunas infantiles básicas en México se ha deteriorado en el último decenio. Es urgentemente necesario un monitoreo vigilante de la equidad, así como estrategias adaptadas, para poder vacunar a la población al margen.

Palabras clave Cobertura de vacunación; inequidades en salud; México.

Iniquidades socioeconômicas e geográficas na vacinação de crianças entre 12 e 59 meses no México, 2012 a 2021

RESUMO

Objetivo. Documentar a evolução das desigualdades socioeconômicas e geográficas na vacinação infantil no México, no período entre 2012 e 2021.

Métodos. Foi realizada a análise repetida de dados transversais obtidos em três ciclos da Pesquisa Nacional de Saúde e Nutrição do México (2012, 2018 e 2021). Variáveis dicotômicas foram elaboradas para estimar o percentual de crianças que não receberam nenhuma dose de cada uma das vacinas do calendário nacional de vacinação (a saber: vacina BCG, vacina contra difteria, coqueluche e tétano, vacina contra rotavírus, vacina pneumocócica conjugada e vacina contra sarampo, caxumba e rubéola [SCR]) e a proporção de crianças totalmente não vacinadas. O índice de concentração foi usado para analisar a distribuição das crianças não vacinadas por estado e condição socioeconômica.

Resultados. A prevalência de crianças totalmente não vacinadas foi baixa no país (0,3% em 2012 e 0,8% em 2021, $p = 0,070$). Porém, um percentual significativo deixou de receber alguma dose de vacina. A prevalência de crianças não vacinadas com a vacina SCR foi 10,2% (IC 95% 9,2-11,1) em 2012, 22,3% (IC 95% 20,9-23,8) em 2018 e 29,1% (IC 95% 26,3-31,8) em 2021 ($p < 0,001$ para a diferença entre 2012 e 2021). O índice de concentração indicou desigualdade de renda entre vacinados e não vacinados com relação a 2 das 5 vacinas em 2012, 3 das 5 vacinas em 2018 e 4 das 5 vacinas em 2021. Houve uma grande variação geográfica na vacinação infantil. Em particular, o percentual de não vacinados com a vacina SCR nos 32 estados do país variou de 3,3% a 17,9% em 2012, 5,5% a 36,5% em 2018 e 13,1% a 72,5% em 2021.

Conclusões. Ocorreu uma piora no acesso equitativo à vacinação básica infantil na última década no México. É imprescindível monitorar atentamente a equidade e implementar estratégias específicas para garantir a cobertura vacinal de todos.

Palavras-chave Cobertura vacinal; iniquidades em saúde; México.