Research article

Factors associated with diphtheria vaccination completion among children under five years old in Peru 2010–2019: A cross-sectional population-based study

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A B S T R A C T

The World Health Organization (WHO) recommends a minimum of 90% coverage of diphtheria three-dose complete vaccination scheme (DPT) as part of routine immunization programs in children. However, diphtheria coverage in Peru has not reached the minimum recommended during the last decades. Our study aimed to determine the complete three-dose DPT coverage and factors associated with compliance towards complete vaccination in Peru between 2010-2019. We conducted a secondary cross-sectional study using the "Encuesta Demográfica y de Salud Familiar (ENDES)"- Demographic and Family Health Survey, which is a survey that targets mothers between 15 and 49 years of age. DPT vaccination coverage was 72.4% and several factors were associated with the DPT scheme completion. Women in the age groups 18 to 24 (ORa = 2.31, 95%CI: 2.11–2.52), 25 to 34 (ORa = 3.37, 95% CI: 3.08–3.69), and 35 to 49 (ORa = 4.74, 95% CI: 4.29–5.22) were more likely to complete their children's DPT vaccination scheme compared to those between 15 to 17 years of age. Both Spanish (ORa = 1.39, 95% CI: 1.31–1.48) and Quechua (ORa = 1.34, 95% CI: 1.25–1.43) as first spoken language were associated with DPT completion compared to native language speaking mothers. Women who worked (ORa = 1.72, 95% CI: 1.57–1.88), studied (ORa = 1.47, 95% CI: 1.33–1.62), or were housewives (ORa = 1.41, 95% CI: 1.29–1.54) during the previous week were more likely to complete their children's DPT scheme compared to participants that did not work during the previous week. Women with the financial capability to access health care were less likely to complete the DPT scheme (ORa = 0.95, 95% CI: 0.92–0.97). Considering the accessibility to health care centers, women who knew the nearest location (ORa = 1.07, 95% CI: 1.03–1.11), had geographic accessibility (ORa = 1.09, 95% CI: 1.06–1.13) or a current transport (ORa = 1.06, 95% CI: 1.02–1.09) were more likely to complete their children 's DPT scheme. Our results highlight low diphtheria vaccine coverage levels in Peru, with values lower than what is recommended by the WHO. Results may serve as a baseline for future studies to improve vaccination programs, reduce barriers and increase DPT coverage in Peru.

1. Introduction

Diphtheria is a highly transmissible toxic-infectious disease whose three-dose vaccination completion is recognized as a marker of prevention effectiveness [1]. The diphtheria vaccine is included in the Peruvian national pentavalent scheme, including Diphtheria, Pertussis, Tetanus, Hepatitis B, and *Haemophilus influenzae* type b (DPT-HepB-Hib), which is applied during the first months of age [2, 3]. DPT vaccine (Diphtheria, Pertussis, and Tetanus) has two subsequent boosters scheduled at 18 and 48 months of age to increase the immune response, which completes the three-dose vaccination scheme [2].

Since 1974, the DPT three-dose vaccination program promoted by the World Health Organization (WHO) was established in Peru to reduce diphtheria incidence, emphasizing its use in children under five years of age, and a minimum coverage of 90% [3, 4, 5]. No diphtheria cases were reported in Peru since 1999, which is consistent with the introduction of the DPT vaccine in the Peruvian national vaccination scheme [6]. However, DPT vaccination between 2016–2019 achieved only 70–80% coverage nationwide [7]. Several factors are associated with vaccine program completion worldwide, including access to healthcare facilities, hesitancy, and the emergence of other health priorities, which overall decrease coverage rates [8, 9].

During epidemiological weeks 44 and 45 of 2020, 16 suspected and four confirmed cases were reported, along with a five-year-old girl who died due to associated myocarditis, representing the first diphtheria cases after more than 20 years of epidemiological silence [7]. Even though diphtheria is a preventable disease among children, little is known about the factors associated low diphtheria vaccine coverage in Peru, a country known for its geographic variability and inequitable healthcare services distribution [10]. This study aimed to determine the three-dose DPT coverage and factors associated with compliance toward vaccination in Peru between 2010–2019.

2. Materials and methods

2.1. Data collection

We performed a secondary cross-sectional study using data from the 2010–2019 editions of the "Encuesta Demográfica y de Salud Familiar (ENDES, Demographic and Family Health Survey)" including results on diphtheria immunization, demographic, and household characteristics (Supplementary material S1). ENDES is an annual, public survey carried out by the Instituto Nacional de Estadística e Informática (INEI, Peru's National Institute of Statistics and Information). Results are considered a representative estimate at a national and regional level [11]. For the study, data from 133,884 women aged 15–49 years with at least one live-born child and complete information regarding their diphtheria vaccination scheme were included. All participants with duplicated or missing data were dropped from the study (Figure 1). The specific sampling, processing, and data collection methods are detailed in the ENDES technical report [12].

2.2. Statistical analysis

The outcome variable, complete DPT vaccination, was defined as a child vaccinated with the three doses of the DPT vaccine and modelled as a binary variable [3]. The following covariates were included: age in years (15–17/18–24/25–34/35–49), first spoken language (Spanish/Quechua/others: Ashaninka, Awajun, Shipibo, Aimara, and others), highest educational level achieved (no education or elementary/secondary/higher), marital status (single/cohabiting or married/divorced or widowed), wealth index (low/middle/high), work related activities during the last week (don't have a job/have a job/study/housewife), household's head (child's mother/partner/grandfather or grandmother/other), region (Lima/rest of the coastline/highlands/jungle), trimester of pregnancy (not pregnant/first/second/third), last birth (in-hospital/out-of-hospital), number of siblings, health insurance status (no insurance/Integrated Health Insurance (SIS)/standard insurance), healthcare financial capability (yes/no), knowledge about the location of the nearest health center (yes/no), geographic accessibility to the health center (yes/no), and having a current private or public transport to the health center (yes/no).

Bivariate analysis was performed using Chi-square, Fisher Exact, and Mann-Whitney tests as appropriate. A logistic regression model was performed using the complete diphtheria vaccination scheme as the outcome. Crude and adjusted odds ratios (OR) with their respective 95% confidence intervals (CI) were calculated. The multiple regression model included variables with a p-value <0.20 in the crude analysis. The variance inflation factor (VIF) was generated to diagnose multicollinearity among the independent variables. A cut-off VIF equal to or greater than ten indicated significant multicollinearity and unstable regression coefficients. Data management and statistical analysis were performed with a 95% confidence level using STATA 16 (Stata Corp., College Station, TX). All survey data were collected and analyzed anonymously.

2.3. Ethics statement

The ENDES survey is freely and publicly available. Our study involves an analysis of secondary aggregated data in the public domain that does not allow the identification of the participants. All ENDES surveys are approved by the Ethics Committee (IRB) of the Demographic and Health Surveys (DHS) Program, which ensures that the survey complies with the U.S. Department of Health and Human Services regulations for the protection of human subjects (45 CFR 46) [13]. Additionally, this study was reviewed and approved by the Ethics Committee of the Universidad Peruana Unión (No. 1141–2021/UPEU–FCS–CF) in Lima, Peru.

3. Results

A total of 133,884 women with complete information regarding the diphtheria vaccination scheme of their children were included in the analysis (Figure 1). Most of them (46.0%) were adults between 25 and 34 years, and 78.2% identified Spanish as their mother tongue. The most frequent educational level achieved was up to secondary education with 59.6%. Overall, 84.6% were currently married or cohabiting with their partners. Most women (53.4%) were classified into the lowest wealth index, and 67.4% lived in rural areas. According to Peru's natural regions, 36.8% lived in the coast, not considering Lima, 31.3% in the highlands, and 20.9% in the jungle. Only 3.9% were pregnant, and the median number of siblings per family was 2.5 (IQR:1–3). A total of 89.9% of women gave birth at a hospital, and 80.5% had health insurance, including Peru's free healthcare system SIS (Integrated Health Insurance) and standard insurance. Regarding accessibility to health facilities, only 14.1% knew the location of the nearest health center, 59.9% had access problems, and 60.2% did not have an available private or public transport method to reach the health facility (Table 1).
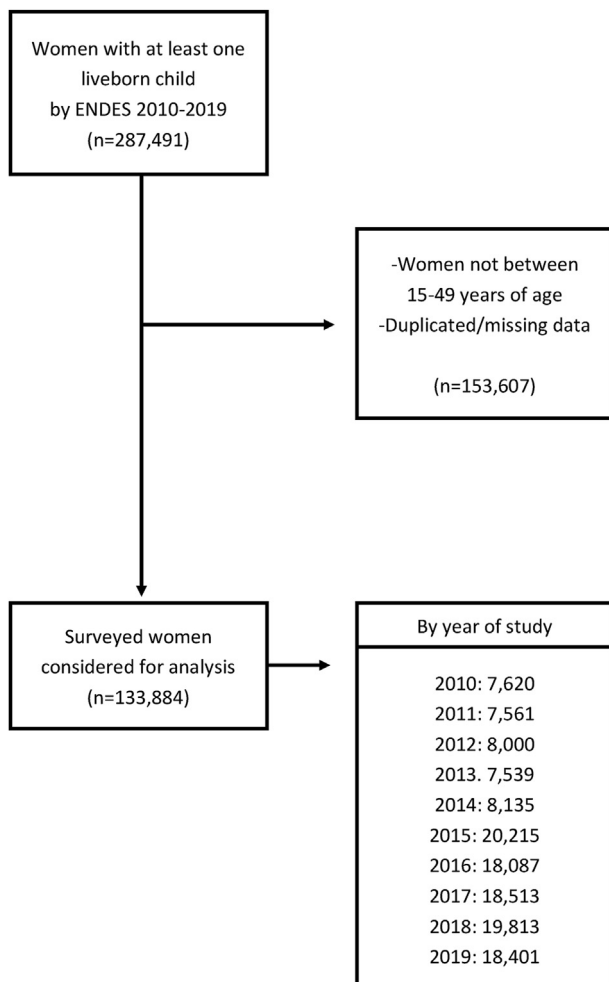
Figure 1. Flowchart of the selection of study participants, ENDES 2010–2019.

Women with at least one liveborn child by ENDES 2010-2019 (n=287,491)

-Women not between 15-49 years of age
-Duplicated/missing data
(n=153,607)

Surveyed women considered for analysis (n=133,884)

By year of study

2010: 7,620
2011: 7,561
2012: 8,000
2013: 7,539
2014: 8,135
2015: 20,215
2016: 18,087
2017: 18,513
2018: 19,813
2019: 18,401

Table 1. Description of participants included in the study. ENDES, Peru 2010–2019.

Characteristics	N	%
Age group (years)		
15–17	2,321	1.7
18–24	32,507	24.3
25–34	61,621	46.0
35–49	37,420	28.0
First language		
Others	5,798	4.3
Quechua	23,414	17.5
Spanish	104,672	78.2
Highest educational level		
No education/Elementary	34,204	25.6
Secondary	79,802	59.6
Higher	19,878	14.9
Marital status		
Single	7,513	5.6
Cohabiting/Married	113,231	84.6
Divorced/widowed	13,140	9.8
Wealth index		
Low	70,972	53.4
Middle	27,693	20.8
High	34,288	25.8
Place of residence		
Rural	89,279	67.4
Urban	43,108	32.6
Last week activity		
Don't have a job	69,857	54.5
Have a job	45,778	35.7
Study	10,207	8
Housewife	2,340	1.8
Household's head		
Child's mother	83,166	62.1
Partner	28,268	21.1
Grandfather/grandmother	14,997	11.2
Other	7,453	5.6
Region		
Lima	14,416	10.9
Rest of the coastline	48,464	36.8
Highlands	41,273	31.3
Jungle	27,593	20.9
Trimester of pregnancy		
Not pregnant	128,586	96.1
First	1,261	0.9
Second	2,182	1.6
Third	1,855	1.4
Last birth		
In-hospital	120,448	89.9
Out-of-hospital	13,418	10.1
Number of siblings[1]	2.5	[1–3][1]
Health insurance		
No insurance	26,049	19.5
SIS	79,133	59.1
Standard insurance	28,702	21.4
Healthcare financial capability		
No	57,200	42.7
Yes	76,683	57.3
Known location of health center		
No	115,080	85.9
Yes	18,804	14.1

Table 1 (*continued*)

Characteristics	N	%
Geographic accessibility to health center		
No	80,310	59.9
Yes	53,572	40.1
Transport to health center		
No	80,635	60.2
Yes	53,248	39.8
Complete three-dose DPT scheme		
Yes	96,065	72.4
No	36,666	27.6

1 Median (P25–P75).

Only 72.4% reported completing the three-dose diphtheria scheme (DPT). Participants between 25 and 34 years represented the highest frequency (46.9%) of mothers whose children received the complete DPT scheme. Women who reported Spanish as their mother tongue were more likely to complete their children's DPT scheme (78.5%) compared to women who reported Quechua (17.8%) or other languages (3.7%) as their mother tongue. According to their highest educational level, women with complete secondary education were more likely to complete their children's DPT scheme (59.5%). Moreover, women currently married or living with their partners represented the highest frequency (84.8%) of participants that completed their children's vaccination scheme, whereas only 5.5% were single mothers. Regarding the wealth index, the highest proportion of women whose children had the complete DPT scheme occurred in the lowest status (52.6%). Women without a current job were more likely to complete their children 's DPT vaccination scheme (56%) compared to participants who were housewives (1.6%), students (7.7%), or who were employed (34.7%). Moreover, women who self-reported as the household's head were more likely to complete their children's DPT vaccination scheme (63.6%) (Table 2).

Among participants, 68% of mothers who completed their children's vaccination lived in rural areas, compared to 32% in urban areas. Women that lived on the coastline (not considering Lima) and in the highlands were more likely to complete the DPT vaccination scheme, with a frequency of 36.8% and 3%, respectively. Women with geographic accessibility to health centers (57.5%) were more likely to complete their children's vaccination. However, only 13.5% and 38.9% of participants who knew the location of the nearest health centeror had an available transport method completed their children's DPT vaccination scheme, respectively.

We found that age was statistically associated with DPT vaccination scheme completion. Women in the age groups 18 to 24 (ORa = 2.31, 95% CI: 2.11–2.52), 25 to 34 (ORa = 3.37, 95% CI: 3.08–3.69), and 35 to 49 (ORa = 4.74, 95% CI: 4.29–5.22) were more likely to complete their children's DPT vaccination scheme, compared to those between 15 to 17 years of age. Women who identified Spanish (ORa = 1.39, 95% CI: 1.31–1.48) and Quechua (ORa = 1.34, 95% CI: 1.25–1.43) as their mother tongues were more likely to complete the DPT vaccination scheme compared to other languages. Regarding the highest educational level achieved, women with secondary school (ORa = 0.91, 95% CI: 0.88–0.94) or higher (ORa = 0.94, 95% CI: 0.89–0.99) levels were less likely to complete their children's DPT vaccination scheme, compared to women without education or elementary school only. According to their marital status, women who cohabited with their partners or were currently married (A ORa = 0.89, 95% CI: 0.85–0.95) had a lower probability of completing the scheme than single participants (Table 3).

Women who worked (ORa = 1.72, 95% CI: 1.57–1.88), studied (ORa = 1.47, 95% CI: 1.33–1.62), or were housewives (ORa = 1.41, 95% CI: 1.29–1.54), were more likely to complete their children's DPT scheme compared to mothers that were unemployed during the previous week. Mother's partner identified as the household's head was associated with

Table 2. Participant's background characteristics by three-dose DPT scheme completion. ENDES, Peru 2010–2019.

Characteristics	Complete DPT		p-value*
	Yes (96,065)	No (36,666)	
Age group (years)			<0.001
15–17	1,128 (1.2)	1,163 (3.2)	
18–24	22,110 (23.0)	10,086 (27.5)	
25–34	45,025 (46.9)	16,171 (44.1)	
35–49	27,796 (28.9)	9,237 (25.2)	
First language			<0.001
Others	3,540 (3.7)	2,156 (5.9)	
Quechua	17,071 (17.8)	6,106 (16.6)	
Spanish	75,454 (78.5)	28,404 (77.5)	
Highest educational level			<0.001
No education/Elementary	23,851 (24.8)	9,860 (26.9)	
Secondary	57,192 (59.5)	22,044 (60.1)	
Higher	15,022 (15.7)	4,762 (13.0)	
Marital status			0.002
Single	5,265 (5.5)	2,157 (5.8)	
Cohabiting/Married	81,474 (84.8)	30,281 (84.1)	
Divorced/widowed	9,326 (9.7)	3,688 (10.1)	
Wealth index			<0.001
Low	50,202 (52.6)	19,994 (54.9)	
Middle	20,047 (21.1)	7,440 (20.4)	
High	25,117 (26.3)	9,006 (24.7)	
Place of residence			<0.001
Rural	64,598 (68.0)	24,069 (66.3)	
Urban	30,355 (32.0)	12,219 (33.7)	
Last week activity			<0.001
Don't have a job	51,628 (56.0)	17,548 (50.2)	
Have a job	31,912 (34.7)	13,576 (38.8)	
Study	7,089 (7.7)	2,999 (8.6)	
Housewife	1,481 (1.6)	846 (2.4)	
Household's head			<0.001
Child's mother	61,074 (63.6)	21,385 (58.3)	
Partner	19,545 (20.4)	8,490 (23.2)	
Grandfather/grandmother	10,724 (11.2)	4,149 (11.3)	
Other	4,722 (4.8)	42,642 (7.2)	
Region			<0.001
Lima	10,438 (11.0)	3,901 (10.8)	
Rest of the coastline	34,738 (36.8)	13,417 (37.2)	
Highlands	30,671 (32.5)	10,190 (28.2)	
Jungle	18,678 (19.7)	8,578 (23.8)	
Trimester of pregnancy			
Not pregnant	92,149 (95.9)	35,421 (96.6)	<0.001
First	931 (1.0)	303 (0.8)	
Second	1,603 (1.7)	516 (1.4)	
Third	1,382 (1.4)	426 (1.2)	
Last birth			<0.001
In-hospital	87,679 (91.3)	31,874 (87.0)	
Out-of-hospital	8,378 (8.7)	4,782 (13.0)	
Number of siblings	2 (1–3)	2 (1–3)	<0.001[1]
Health insurance status			<0.001
No insurance	17,202 (17.9)	8,589 (23.4)	
SIS (Integrated Health Insurance)	57,407 (59.8)	20,978 (57.2)	
Standard insurance	21,456 (22.3)	7,099 (19.4)	
Healthcare financial capability			<0.001
No	41,636 (43.3)	15,192 (41.3)	
Yes	54,429 (56.7)	21,473 (58.7)	

Table 2 (*continued*)

Characteristics	Complete DPT		p-value*
	Yes (96,065)	No (36,666)	
Known location of health center			<0.001
No	83,086 (86.5)	31,062 (84.7)	
Yes	12,979 (13.5)	5,604 (15.3)	
Geographic accessibility to health center			
No	15,597 (42.5)	37,399 (38.9)	<0.001
Yes	21,068 (57.5)	58,665 (61.1)	
Transport to health center			<0.001
No	58,665 (61.1)	21,068 (57.5)	
Yes	37,399 (38.9)	15,597 (42.5)	

* Chi square test, 95% confidence level, [1] Mann-Whitney U test, 95% confidence level.

increased children's DPT completion (ORa = 1.22, 95% CI: 1.18–1.29), compared to families where mothers were in charge. In contrast, in families where the grandfather or grandmother (ORa = 0.91, 95% CI: 0.87–0.96) or other family members (ORa = 0.77, 95% CI: 0.72–0.88) were identified as the household head had a lower probability of completing the scheme, compared with families where mothers auto reported as the family head. Pregnant women who were at first (ORa = 1.22, 95% CI: 1.05–1.37), second (ORa = 1.24, 95% CI: 1.11–1.38), or third (ORa = 1.31, 95% CI: 1.17–1.47) trimester of pregnancy were more likely to complete the vaccination scheme, compared to women who were not pregnant during the interview. Moreover, having siblings reduced the probability of completing the DPT vaccination scheme (ORa = 0.82, 95% CI:0.81–0.83).

Mothers who did not give birth to their most recent child at a hospital (ORa = 0.77, 95% CI: 0.74–0.81) had a lower probability of completing their children's DPT scheme than women who did. According to health insurance status, women with SIS (ORa = 1.45, 95% CI: 1.40–1.49) or standard insurance (ORa = 1.25, 95% CI: 1.20–1.30) were more likely to complete the DPT vaccination scheme. Surprisingly, women with the financial capability to access health care were less likely to complete the DPT scheme (ORa = 0.95, 95% CI: 0.92–0.97). Considering the accessibility to health centers, women who knew the nearest location (ORa = 1.07, 95% CI: 1.03–1.11), had geographic accessibility (ORa = 1.09, 95% CI: 1.06–1.13) or a current transport (ORa = 1.06, 95% CI: 1.02–1.09) were more likely to complete their children's DPT scheme.

4. Discussion

Our study aimed to determine the coverage and factors associated with the DPT scheme completion in Peru. Between 2010-2019, a 72% coverage of complete DPT immunizations was achieved. However, it is still under the minimum 90% recommended by the WHO [14, 15]. Similar results have been found in Latin America and the Caribbean, where only 44% of countries have achieved the recommended coverage levels. Limited logistics for implementing vaccine programs, weak health systems, other health priorities, and inadequate distribution of limited resources are the main reasons for the vaccination gaps in the region [16]. We identified several factors associated with DPT three-dose scheme completion, including age, mother tongue, educational level, marital status, last-week activity, pregnancy trimester, family head of household, number of siblings, birthing location, health insurance, wealth index, health financial capability, and health center accessibility (known location, geographic access, transport).

An increase in maternal age was statistically associated with their children's DPT scheme completion. The oldest age group (35–49 years)

Table 3. Crude and adjusted odds ratios of factors associated with complete three-dose DPT scheme. ENDES, Peru 2010–2019.

Characteristics	OR$_c$	CI 95%	p-value	OR$_a$	CI 95%	p-value
Age group (years)						
15–17	Ref.			Ref.		
18–24	2.26	2.08–2.46	<0.001	2.31	2.11–2.52	<0.001
25–34	2.87	2.64–3.12	<0.001	3.37	3.08–3.69	<0.001
35–49	3.10	2.85–3.38	<0.001	4.74	4.29–5.22	<0.001
First language						
Others	Ref.			Ref.		
Quechua	1.70	1.60–1.81	<0.001	1.34	1.25–1.43	<0.001
Spanish	1.62	1.53–1.71	<0.001	1.39	1.31–1.48	<0.001
Highest educational level						
No education/ Elementary	Ref.			Ref.		
Secondary	1.07	1.04–1.10	<0.001	0.91	0.88–0.94	<0.001
Higher	1.30	1.25–1.36	<0.001	0.94	0.89–0.99	0.017
Marital status						
Single	Ref.			Ref.		
Cohabiting/Married	1.07	1.04–1.10	<0.001	0.89	0.85–0.95	0.001
Divorced/widowed	1.30	1.25–1.36	<0.001	0.99	0.92–1.06	0.685
Wealth index						
Low	Ref.					
Middle	1.07	1.04–1.11	<0.001	1.00	0.97–1.04	0.801
High	1.11	1.08–1.14	<0.001	0.99	0.96–1.04	0.967
Place of residence						
Rural	Ref.					
Urban	1.08	1.05–1.11	<0.001	0.96	0.94–1.01	0.041
Last week activity						
Don't have a job	Ref.					
Have a job	1.68	1.54–1.83	<0.001	1.72	1.57–1.88	<0.001
Study	1.35	1.23–1.48	<0.001	1.47	1.33–1.62	<0.001
Housewife	1.34	1.23–1.46	<0.001	1.41	1.29–1.54	<0.001
Household's head						
Child's mother	Ref.					
Partner	1.1	1.06–1.15	<0.001	1.22	1.18–1.29	<0.001
Grandfather/ grandmother	0.89	0.85–0.93	<0.001	0.91	0.87–0.96	<0.001
Other	0.69	0.65–0.73	<0.001	0.77	0.72–0.88	<0.001
Region						
Lima	Ref.					
Rest of the coastline	0.97	0.93–1.01	0.123	1.22	0.97–1.06	0.661
Highlands	1.12	1.08–1.17	<0.001	1.18	1.13–1.24	<0.001
Jungle	0.81	0.78–0.85	<0.001	0.97	0.92–1.02	0.198
Trimester of pregnancy						
Not pregnant	Ref.					
First	1.18	1.04–1.35	0.012	1.22	1.05–1.37	0.004
Second	1.19	1.08–1.32	0.001	1.24	1.11–1.38	<0.001
Third	1.25	1.12–1.39	<0.001	1.31	1.17–1.47	<0.001
Last birth						
In-hospital	Ref					
Out-of-hospital	0.64	0.61–0.66	<0.001	0.77	0.74–0.81	<0.001
Number of siblings	0.92	0.91–0.93	<0.001	0.82	0.81–0.83	<0.001
Health insurance status						
No insurance	Ref.					
SIS (Integrated Health Insurance)	1.37	1.33–1.41	<0.001	1.45	1.40–1.49	<0.001
Standard insurance	1.51	1.45–1.57	<0.001	1.25	1.20–1.30	<0.001
Healthcare financial capability						

Table 3 (*continued*)

Characteristics	OR$_c$	CI 95%	p-value	OR$_a$	CI 95%	p-value
No	Ref					
Yes	1.08	1.06–1.08	<0.001	0.95	0.92–0.97	<0.001
Known location of health center						
No	Ref					
Yes	1.15	1.12–1.19	<0.001	1.07	1.03–1.11	0.001
Geographic accessibility to health center						
No	Ref					
Yes	1.16	1.13–1.19	<0.001	1.09	1.06–1.13	<0.001
Transport to health center						
No	Ref.					
Yes	1.15	1.13–1.18	<0.001	1.06	1.02–1.09	0.001

OR$_c$: crude odds ratio; OR$_a$: adjusted odds ratio with all the variables present in the column.

was four times more likely to complete the scheme than the youngest group (15–17). The influence of age has been previously reported: older women are more likely to complete their children's vaccination schemes [17]. Quechua and Spanish were also associated with a higher proportion of DPT vaccination completion compared to other languages (Ashaninka, Awajun, Shipibo, Aimara, and others). Both are considered Peru's official languages, and their use is widespread across the country. The first spoken language identified as theirs mother tongue is a critical barrier to accessing health systems [18, 19], mainly among less-used ones. Thus, during the last decade, the Peruvian government has included multi-language programs and guidelines to promote health in different settings, including courses for healthcare professionals and promotional campaigns for the general population [20, 21, 22]. Our results highlight the need to plan interventions to increase DPT coverage focusing on younger groups and reinforcing multilanguage strategies.

Rurality has been commonly associated with less geographic access and transportation difficulties toward healthcare facilities, becoming a barrier to effective health system interventions such as vaccination programs [23, 24, 25]. Surprisingly, we found that participants living in Peru's highlands and rural areas were more likely to complete their children's DPT vaccination scheme. During the last five years, the Peruvian government has launched programs that strengthen multilanguage health programs and promote the construction of healthcare facilities in rural regions [20, 21, 22].

Women with higher levels of education can access information regarding the benefits and side effects of vaccination, which can directly impact a favorable decision to vaccinate their children [15, 26, 27, 28, 29]. However, we found that women with a higher level of education were less likely to complete their children's DPT scheme. Vaccine hesitancy has been recognized as a problem in high- and middle-income countries, where people with greater access to information and education reject vaccination [30, 31, 32]. Moreover, vaccination refusal has also been reported among academics and healthcare students, showing high levels of hesitancy and resistance to vaccination against other infectious diseases such as SARS-CoV-2 [33].

Previous studies have shown an increased risk of under-vaccination among children raised by single mothers [34]. One-parent families usually have economic distress, directly affecting their children's health [35]. However, our study found that cohabiting or married women were less likely to complete their children's vaccination scheme than single mothers. In recent years, single mothers have shown more economic independence and empowerment, allowing them to prioritize their children's health and welfare [36]. Moreover, in Peru, women's access to job opportunities has increased over the past years, giving them a more significant economic income [37].

The last week's economic activity of the mothers was associated with a greater probability of completing their children's DPT scheme, in which

women who work were more likely to complete the vaccination scheme. In addition, having healthcare financial capability and health insurance were also factors associated with completing the DPT scheme. Even though DPT vaccines are freely available in all health facilities nationwide by the Peruvian Ministry of Health, other expenses such as transport, medication for adverse reactions, and healthcare with a general practitioner are not covered [32, 33]. Employment gives women economic independence, empowerment, and prioritization of their children's welfare and health [36]. Moreover, having no insurance [15, 38, 39] or low income [30] has been reported to cause financial distress and vaccination hesitancy.

Pregnancy status, birth location, and the number of siblings were associated with DPT scheme completion. Pregnant participants at the survey were more likely to complete their children's DPT vaccination scheme. Moreover, an increase in pregnancy trimester was also associated with DPT completion. Pregnant women near their due date are more informed about healthcare programs such as child vaccination schemes and, as a result, have more confidence and acceptance of the national vaccination program [34]. Participants who gave birth out of a healthcare facility were less likely to complete their children's vaccination scheme. Hospital births allow mothers to connect early with healthcare, developing a pro-vaccination attitude toward their children [39]. A greater number of siblings was related to a lower probability of completing the DPT vaccination scheme. Having more kids stresses the family economy and negatively impacts children's healthcare resources, impacting the completion of vaccination schemes [15, 40].

Women who knew the location of the nearest health center were more likely to complete their children's DPT scheme. Moreover, vaccination completion was also associated with available transportation and geographical accessibility. Less geographic access and transportation availability increase difficulties in reaching healthcare facilities, especially considering Peru's diverse geographical characteristics and the wide dispersion of healthcare facilities across the country [34, 41, 42]. The Peruvian government has developed new health policies to improve health system decentralization [43]. However, our results highlight the need to establish strategies for constructing community healthcare facilities to strengthen rural health networks.

Our study had limitations. The cross-sectional design does not allow for establishing causality, given the absence of temporality. Moreover, this study involves the analysis of secondary data, and there is the possibility of record imprecision and memory bias from the respondents. Despite the limitations, the ENDES is a nationally representative survey and uses standardized instruments and DHS methodology [13] to study the health status of the Peruvian population.

Our results highlight low diphtheria vaccine coverage levels in Peru, with percentage values lower than recommended by the WHO. Diphtheria is a preventable infectious disease included in the Peruvian childhood vaccination schedule, and the application of the complete scheme is the only strategy to reduce the emergence of diphtheria cases. We found several factors associated with DPT three-dose scheme completion, including economic, geographic, and sociodemographic characteristics. Our results may serve as a baseline for future quantitative and qualitative studies to improve vaccination programs that could reduce vaccination barriers and increase vaccine coverage in Peru.

Declarations

Author contribution statement

Antony Gonzales: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Deysi Choque: Conceived and designed the experiments; Wrote the paper.

Pool Marcos-Carbajal: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Guillermo Salvatierra: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data associated with this study has been deposited at http://iinei.inei .gob.pe/microdatos/

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

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References

[1] S. Guillen, Nota informativa sobre la difteria, Soc. Española de Infectología Pediátrica, 2013, pp. 6–8.

[2] O. Oms, Plan de Acción Mundial sobre Vacunas Plan de Acción Mundial sobre Vacunas, Panor. Actual La Inmunizacion (2013) 14–27.

[3] B. Greenwood, The contribution of vaccination to global health: past, present and future, Philos Trans R Soc B Biol Sci 369 (1645) (2014). Print 2014.

[4] E.J. Anderson, M.A. Daugherty, L.K. Pickering, W.A. Orenstein, R. Yogev, Protecting the community through child vaccination, Clin. Infect. Dis. 67 (2018) 464–471.

[5] J. Lessler, C.J.E. Metcalf, F.T. Cutts, B.T. Grenfell, Impact on epidemic measles of vaccination campaigns triggered by disease outbreaks or serosurveys: a modeling study, PLoS Med. 13 (2016) 1–14.

[6] E. Mezones-Holguin, A. Al-kassab-Córdova, J.L. Maguiña, A.J. Rodriguez-Morales, Vaccination coverage and preventable diseases in Peru: reflections on the first diphtheria case in two decades during the midst of COVID-19 pandemic, Trav. Med. Infect. Dis. 40 (2021).

[7] CDC-MINSA, Riesgo de transmisión de Difteria ante la confirmación de un caso en el Perú 24, Alerta epidemiológica N, 2020.

[8] M. Clara, M.C. Restrepoméndez, J.D. Barros, L.M. Wong, H.L. Johnson, G. Pariyo, V.A. França, C. Fernando, Inequalities in full immunization coverage: trends in low- and middle-income countries, Bull. World Health Organ. 94 (2016) 794–805.

[9] J.J. Rainey, M. Watkins, T.K. Ryman, P. Sandhu, A. Bo, K. Banerjee, Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings from a systematic review of the published literature, 1999-2009, Vaccine 29 (2011) 8215–8221.

[10] E.R. Carrillo, Distribution of Health Care Facilities, in: Dieter K. Zschock (Ed.), Health Care in Peru: Resources and Policy, 2019, pp. 101–132.

[11] L.A. Encuesta, D.Y.D.E. Salud, F. Con, Sección Especial Manipulation , Analysis and Visualization of Data from thE 36, 2019, pp. 128–134.

[12] Instituto Nacional de Estadística e Informática - INEI, Encuesta Demografica de Salud Familiar 2017 - Ficha Técnica, Inei 15 (2017). https://proyectos.inei.gob.pe /endes/recursos/endes_2017_ficha_tecnica.pdf.

[13] S.O. Rutstein, G. Rojas, Guide to DHS Statistics: Demographic and Health Surveys Methodology, DHS Publ, 2006, pp. 1–168.

[14] Global Vaccine Action Plan, Vaccine 31, 2013, pp. B5–B31.

[15] B.A. Aquino, Factores asociados a la adherencia de la vacunación infantil de difteria, pertussis y tétanos en Perú, año 2019 [Thesis], Universidad Ricardo Palma, Lima, 2021. https://repositorio.urp.edu.pe/handle/URP/3752.

[16] A.F. Llau, M.L. Williams, C.E. Tejada, National vaccine coverage trends and funding in Latin America and the Caribbean, Vaccine 39 (2021) 317–323.

[17] D.A. Salmon, P.J. Smith, W.K.Y. Pan, A.M. Navar, B. Saad, N.A. Halsey, Disparities in preschool immunization coverage associated with maternal age 5, 2018, pp. 557–561.

[18] D. de Moissac, S. Bowen, Impact of language barriers on quality of care and patient safety for official language minority francophones in Canada, J. Patient Exp. 6 (2019) 24–32.

[19] R.F.I. Meuter, C. Gallois, N.S. Segalowitz, A.G. Ryder, J. Hocking, Overcoming language barriers in healthcare: a protocol for investigating safe and effective communication when patients or clinicians use a second language, BMC Health Serv. Res. 15 (2015) 1–5.

[20] M.A. Lagos Barzola, Traductor Móvil Para Mejorar La Comunicación En La Asistencia Médica a Pacientes Quechua Hablantes, Ayacucho 2016, Repos. URP (2017) 217.

[21] Aularia, Aprender en la propia lengua sin perder la identidad cultural, Plataformas Memorias Étnicas. 1 (2018) 117–122.

[22] Ministerio de Salud del Perú, Palabras clave para la atención en Salud: Quechua, Minsa, 2012, p. 136.

[23] C.A. Moyer, A. Mustafa, Drivers and deterrents of facility delivery in sub-Saharan Africa: a systematic review, Reprod. Health 10 (2013) 40.

[24] Y. Berhan, A. Berhan, A meta-analysis of sociodemographic factors predicting birth in health facility, Ethiop. J. Health Sci. 24 (2014) 81–92.

[25] C.M. Westgard, A. Rogers, G. Bello, N. Rivadeneyra, Health service utilization, perspectives, and health-seeking behavior for maternal and child health services in the Amazon of Peru, a mixed-methods study, Int. J. Equity Health 18 (1) (2019) 155.

[26] D. Mogere, Does the mother's level of education influence immunization coverage? Value Health 19 (2016) A179.

[27] F. Kibreab, S. Lewycka, A. Tewelde, Impact of mother's education on full immunization of children aged 12-23 months in Eritrea: population and health survey 2010 data analysis, BMC Publ. Health 20 (2020) 1–10.

[28] S.A. Balogun, H.A. Yusuff, K.Q. Yusuf, A.M. Al-Shenqiti, M.T. Balogun, P. Tettey, Maternal education and child immunization: the mediating roles of maternal literacy and socioeconomic status, Pan Afr. Med. J. 26 (2017) 1–8.

[29] A.M. Asif, M. Akbar, M.R. Tahir, I.A. Arshad, Role of maternal education and vaccination coverage: evidence from Pakistan demographic and health survey, asia-pacific, J. Public Heal 31 (2019) 679–688.

[30] S.A. Bono, E.F. de M. Villela, C.S. Siau, W.S. Chen, S. Pengpid, M.T. Hasan, P. Sessou, J.D. Ditekemena, B.O. Amodan, M.C. Hosseinipour, H. Dolo, J.N.S. Fodjo, W.Y. Low, R. Colebunders, Factors affecting COVID-19 vaccine acceptance: an international survey among low-and middle-income countries, Vaccines 9 (2021) 1–19.

[31] K. He, W.J. Mack, M. Neely, L. Lewis, V. Anand, Parental perspectives on immunizations: impact of the COVID-19 pandemic on childhood vaccine hesitancy, J. Community Health (2021).

[32] B. Akarsu, D. Canbay Özdemir, D. Ayhan Baser, H. Aksoy, İ. Fidancı, M. Cankurtaran, While studies on COVID-19 vaccine is ongoing, the public's thoughts and attitudes to the future COVID-19 vaccine, Int. J. Clin. Pract. 75 (2021) 1–10.

[33] V.C. Lucia, A. Kelekar, N.M. Afonso, COVID-19 vaccine hesitancy among medical students, J. Publ. Heal. 43 (3) (2021) 445–449.

[34] H. Kuroda, A. Goto, C. Kawakami, K. Yamamoto, S. Ito, et al., Association between a single mother family and childhood undervaccination, and mediating effect of household income: a nationwide, prospective birth cohort from the Japan Environment and Children's Study (JECS), BMC Publ. Health 22 (1) (2022) 1–10.

[35] V.K. Heintz-Martin, A.N. Langmeyer, Economic situation, financial strain and child wellbeing in stepfamilies and single-parent families in Germany, J Fam Econ Issues [Internet] 41 (2) (2020) 238–254. Available from:.

[36] H. Cornish, H. Walls, R. Ndirangu, N. Ogbureke, O.M. Bah, J.F. Tom-Kargbo, et al., Women's economic empowerment and health related decision-making in rural Sierra Leone, Cult. Health Sex. 23 (1) (2021) 19–36. Available from:.

[37] C. Aragao, A. Villanueva, How do mothers work? Kin coresidence and mothers' work in Latin America, Demogr. Res. 45 (2021) 917–956.

[38] P. Zambrano-Barragán, S. Ramírez Hernández, L.F. Freier, M. Luzes, R. Sobczyk, A. Rodríguez, et al., The impact of COVID-19 on Venezuelan migrants' access to health: a qualitative study in Colombian and Peruvian cities, J Migr Heal 3 (2021), 100029.

[39] A. Morrison, La participación laboral de las mujeres en el Perú: 10 mensajes clave y 6 recomendaciones de política, Banco Interam Desarro 18 (2021).

[40] K. Danis, T. Georgakopoulou, T. Stavrou, D. Laggas, T. Panagiotopoulos, Predictors of childhood vaccination uptake: a cross-sectional study in Greece, Proc. Vaccinol 2 (1) (2010) 86–91.

[41] J.F. Mosser, W. Gagne-Maynard, P.C. Rao, A. Osgood-Zimmerman, N. Fullman, N. Graetz, et al., Mapping diphtheria-pertussis-tetanus vaccine coverage in Africa, 2000–2016: a spatial and temporal modelling study, Lancet 393 (2019), 10183.

[42] O.J. Babalola, O. Ajumobi, I.O.O. Ajayi, Rural-urban disparities and factors associated with delayed care-seeking and testing for malaria before medication use by mothers of under-five children, Igabi LGA, Kaduna Nigeria, Malar. J. 19 (2020) 1–11.

[43] S.L. McNulty, G. Guerra Garcia, Politics and promises: exploring fifteen years of Peru's participatory decentralization reform, Publ. Organ. Rev. 19 (1) (2019) 45–64.