COVERAGE AND FACTORS ASSOCIATED WITH MEASLES VACCINATION IN CHILDREN AGED 12-59 MONTHS IN PERU: ESTIMATE BASED ON THE 2017 DEMOGRAPHIC AND FAMILY HEALTH SURVEY

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RESUMEN

Objectives. To estimate coverage and determine factors associated with measles vaccination in Peru. ***Materials and Methods.*** We conducted a secondary source study using the 2017 Demographic and Family Health Survey (ENDES). The reporting unit was a woman of childbearing age, 15 to 49 years; the unit of analysis was a child, 12 to 59 months (for the first dose), or a child, 18 to 59 months (for the booster dose) who had vaccination information. Coverage data were obtained from the vaccination card. ***Results.*** According to the vaccination card, coverage for the first dose was 70.2% (95% CI: 68.8-71.6); for the booster dose, 52% (95% CI: 50.5-53.6). Children aged 24-35 months were more likely to be vaccinated for the first dose (OR 1.59, 95% CI: 1.28-1.97) and booster dose (OR 2.04, 95% CI: 1.62-2.56), compared with children aged 12-23 months and 18-23 months respectively. Children with growth and development check-ups performed in the private sector were less likely to be vaccinated for the first dose (OR 0.30, 95% CI: 0.21-0.43) and booster dose (OR 0.26, 95% CI: 0.17-0.40), compared to those being monitored in the public sector. ***Conclusions.*** According to ENDES 2017, Peru and none of its regions achieved 95.0% coverage for the first and booster doses. Growth and development monitoring in public sector facilities is associated with measles vaccination in terms of first and booster doses.

Palabras clave: Measles, Vaccination; Vaccination Coverage; Peru (source: MeSH NLM).

INTRODUCTION

The measles vaccine is key in preventing this viral infection [1-3]. Administering the vaccine at the age of 12 months or more develops immunity in 95.0% of children; if a second dose is added, this proportion reaches 99.0% [4,5]. To interrupt endemic transmission and eliminate measles, an immunity level of 93.0% to 95.0% must be achieved throughout the population [5-7]. The World Health Organization recommends that the first dose is given at the age of 12 months (nine months in countries with high rates of measles transmission) and the booster dose at 15-18 months. In Peru, the first dose is applied at 12 months and the booster dose at 18 months [8].

Since 2000, Peru does not have autochthonous measles cases [9], and it was not until 2016 that the Americas were declared free of measles. However, in 2018, 667 suspected cases of measles were reported nationwide, of which 38 were confirmed, 16 of them being from the Callao region [10]. Two circumstances would have facilitated the reappearance of autochthonous cases of measles in Peru: increased international migration—especially from Venezuela, which had an epidemic outbreak of measles in 2017—and vaccination coverage [9].

With regards to measles vaccination coverage in one-year-old children, Peru's Ministry of Health reported coverage of 83% by 2017, with marked variations between regions

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This study is part of the thesis: Vásquez-Uriarte K. Vaccination against measles and coverage predictors in children under five old according to the demographic and health survey, 1996-2017. [Thesis for the professional diploma in nursing]. Cajamarca: Facultad de Ciencias de la Salud, Universidad Nacional de Cajamarca; 2019.
Received: 11/04/2019 Approved: 02/10/2019 Online: 06/11/2019

Citation: Vásquez-Uriarte K, Ninatanta Ortiz JA, Romani F, Roque-Henriquez JC. Coverage and factors associated with measles vaccination in children aged 12-59 months in peru: estimate based on the 2017 demographic and family health survey. Rev Peru Med Exp Salud Publica. 2019;36(4):610-9. doi: 10.17843/rpmesp.2019.360.4456.

ranging from 65% in Arequipa to 99% in Tumbes [9]. This information comes from routine vaccination reports from health facilities. This estimate may be susceptible to errors in the compilation of monthly reports (especially if electronic records are not used), delays, or duplications. Also, it does not report information from the private sector and may overestimate coverage as the report may be subject to incentives [11]. Another method for estimating vaccination coverage is through population surveys, such as the Demographic and Family Health Survey (Encuesta Demográfica y de Salud Familiar, ENDES), which uses probability sampling and has quality assessment controls, which would result in more accurate estimates compared to routine reporting coverage [12].

Based on a population survey, this study estimates vaccination coverage for the first and booster dose against measles in children aged 12 to 59 months in Peru. The results of the study will provide a reliable estimate of the coverage of this vaccine in the context of reappearance of autochthonous cases during 2018.

KEY MESSAGES

Research motivation. Vaccination against measles is essential for the prevention of this infection, so it is important to have reliable coverage estimates.

Main findings. According to the 2017 Demographic and Family Health Survey, national coverage for the first dose was 70.2% and for the booster dose 52.0%. Children with growth and development control in the private sector were less likely to be vaccinated compared to those in the public sector.

Implications. Coverage varied amongst regions; however, it was less than 95%. This is a call to implement strategies to increase vaccination in the health system.

MATERIALS AND METHODS

STUDY DESIGN

We conducted a secondary source study based on the ENDES 2017, a population survey with a complex two-stage, probabilistic, balanced, stratified and independent sampling for the departmental level and for urban/rural areas. The ENDES is carried out by the National Institute of Statistics and Data Processing and the database is freely available (http://iinei.inei.gob. pe/microdatos/). The sample design allows inferences for the national and regional level, the rural and urban areas, and the three natural regions (coast, highlands and jungle). ENDES 2017 was conducted between March and December on a sample of 35,910 homes in Peru.

SOURCE OF INFORMATION

We used the individual questionnaire for women between 15 and 49 years old, which includes questions on demographic and social characteristics, prenatal care, childbirth assistance, pregnancy and breastfeeding, and immunization of children.

The units of analysis were the children of the women surveyed. If a woman had more than one child under the age of five, the analysis included each of them. The inclusion criteria for the units of analysis were: child between the ages of 12 and 59 months (module 70 variable Q478: first dose), child between 18 and 59 months (module 70 variable Q478: booster dose), measles vaccination data provided (module 70 variable H9 or variable S45SP2).

ENDES was the source for the measles immunization information; in our analysis, the data was considered valid whether the date of vaccination was recorded on the vaccination card or not. This methodology has previously been used to assess hepatitis B vaccine coverage in newborns [13]. The use of the vaccination data from the card resulted in better estimates of vaccination coverage (concordance of 81.0%, sensitivity of 77.0%, specificity of 84.0% and positive predictive value of 92.0%) [12]. We also present the estimate of coverage based on information obtained from the card or the mother's report.

CHILD VARIABLES

The dependent variables were: first dose measles vaccine (variable H9) and its booster dose (variable S45SP). For both, response categories were: vaccinated with date on card, vaccinated without date on card, not vaccinated, vaccinated reported by mother and does not know. It should be noted that the option "vaccinated as reported by the mother" can be the case of a child without a vaccination card or with a vaccination card where the vaccination is not recorded, including those received in vaccination and/or health campaigns.

The independent variables were: age in months of the child under the age of five (variable Q478), place of birth (variable M15 of module 69: home address, public sector, private sector, non-governmental organizations, other), growth and development control (variable S466 of module 70: no, yes, don't know), location of growth and development control (variable S466B of module 70: public sector, private sector, non-governmental organizations, other) and has vaccination card (variable H1 of module 70: no card; yes, seen; yes, not seen; no longer has card).

VARIABLES RELATED TO THE MOTHER

The independent variables were: age of the mother (variable V102 and V103 of module 66), highest educational level of the mother (variable V106 of module 66: no education, elementary, secondary, tertiary), number of prenatal controls (variable M14 of module 69), wealth index (variable V190 of module 66): wealthier, wealthy, middle, poor, poorer), Health insurance: (variables V481, V481D, V481E, V481F, V481G and V481X), natural region (variable SREGION of module 66: other coastal region, Metropolitan Lima, highlands, jungle), type of residence area (variable V025 of module 66: urban, rural), de facto place of residence (variable V026 of module V481, V481D, V481E, V481F, V481G and V481X), natural region (variable SREGION of module 66: other coastal region, Metropolitan Lima, highlands, jungle), type of residence area (variable V025 of module 66: urban, rural), de facto place of residence (variable V026 of module 66: capital, large city; small city; village; countryside), and political region (variable V024 of module 66: the country's 25 regions). As an indicator of recent migration, the variable years living in the place of residence (variable V104 of module 66) was recovered.

STATISTICAL ANALYSIS

We estimate the point frequencies of the characteristics of the study population with their respective 95% confidence intervals (CI 95%). We also estimate compliance with measles vaccination (first dose and booster dose) at the national, regional and sociodemographic levels. The comparison of proportions for independent samples was carried out using the chi-square test.

For the multivariate analysis, the following independent variables were considered: age in months of the child under the age of five, place of growth and development control, type of residence area, years living in the place of residence, and place of birth, because in the bivariate analysis they presented a significant association with measles vaccination (first dose or booster dose). Also included in the model were: highest educational level of the mother and wealth index due to their inclusion in multivariate models in similar studies (14.15). We carried out a logistic regression analysis considering as a dependent variable the first dose of the measles vaccine and another model for the booster dose. We calculate odds ratios (OR) adjusted with CI 95%.

We conducted the statistical analysis considering the complex sampling of the ENDES. The adjustment variables were weighting factor (female factor V005), sample stratum number (V022), and cluster number (V001), all located in module 66. We consider a p value of less than 0.05 to be statistically significant. We use the statistical package Stata version 15.0 (StataCorp, College Station, Texas, USA). The databases for the first and booster dose analysis are in supplementary material.

ETHICAL ISSUES

ENDES databases are publicly accessible and respect the confidentiality of participants. This work was approved by the Research Unit of the School of Health Sciences of Universidad Nacional de Cajamarca.

RESULTS

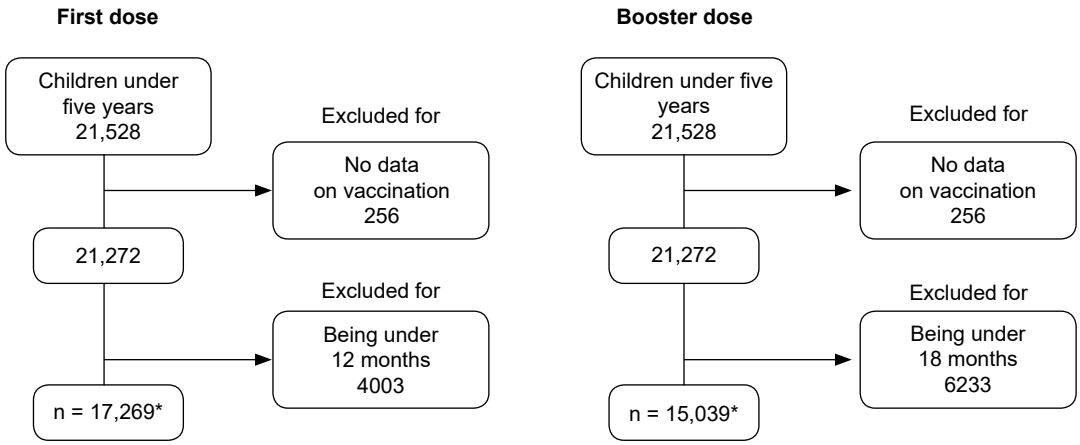
Out of 21,528 children under the age of five, 256 were excluded because they did not have any data on vaccination for the first and booster dose, 4003 were under the age of 12 months, and 6233 were under the age of 18 months. Finally, the analysis for the first dose included information on 17,269 children, whereas the estimate for booster dose coverage was calculated on 15,039 children (Figure 1).

Regarding the portability of the vaccination card (yes, seen), this was 77.1% (CI 95%: 75.8-78.3) for the first dose and 76.1% (CI 95%: 74.7-77.4) for children due for the booster dose. The mothers' average age was 30.5 years (CI 95%: 30.3-30.8), only 36.7% (CI 95%: 34.9-38.4) of them reached secondary education level and 88.4% (CI 95%: 87.4-89.4) reported having had six or more prenatal controls. Regarding children, the mean age was 34.9 months (CI 95%: 34.5-35.2), 83.0% (CI 95%: 81.9-84.0) were born in public health facilities. 66.5% (CI 95%: 64.9-68.0) had growth and development control, of which 96.2% (95% CI: 95.5-96.8) were performed in public health facilities. 79.0% (CI95%: 77.6-80.3) had health insurance (Table 1).

ESTIMATION OF COVERAGE BASED ON VACCINATION CARD AND ASSOCIATED FACTORS

National coverage for the first dose was 70.2% (CI 95%: 68.8-71.6) and for the booster dose 52.0% (CI 95%: 50.5-53.6). In the bivariate analysis, a statistically significant association was found for the two doses with the age of the child (value of p <0.001), growth and development control (value of p <0.001), place of growth and development control (value of p <0.001), and living five to more years in the place of residence (value of p=0.011 for the first dose and value of p=0.003 for the booster dose). In addition, the first dose was associated with type of residence area (value of p=0.026) and the booster dose with the place of birth (value of p=0.019) (Table 1).

The results of multivariate analysis show that, after controlling the other predictor variables, children aged 24-35 months were more likely to be vaccinated for the first dose (OR: 1.59, CI 95%: 1.28-1.97) and booster



*Denominator for the calculation of the estimated vaccination coverage. The sample for the booster dose is included in the sample for the first dose.

Figura 1. Flowchart of the selection criteria applied for the conformation of the sample from the 2017 Demographic and Family Health Survey.

dose (OR 2.04: CI 95%: 1.62-2.56) compared to children aged 12-23 months and 18-23 months respectively, that children undergoing growth and development control in the private sector were less likely to be vaccinated for the first dose (OR: 0.30, CI 95%: 0.21-0.43) and booster dose (OR: 0.26, CI 95%: 0.17-0.40) than those controlled in the public sector (Table 2).

In the analysis by region, for the first dose, the highest point estimate was obtained by Tacna (78.6%) and the lowest by Junín (55.9%); for the booster dose, the highest point estimate was in Madre de Dios (67.9%) and the lowest was in Junín (40.1%) (Table 3).

Taking into account the mother's report too, national coverage for the first dose was 87.8% (CI 95%: 86.9-88.7) and for the booster dose 52.2% (CI 95%: 50.6-53.8). In the analysis by region, for the first and booster dose, the highest point estimates were obtained by Madre de Dios (93.0% and 69.0% respectively) and the lowest by Junín (80.8% and 40.1% respectively) (Table 3).

At the national level, for the first dose, the difference between the point estimate between the coverage obtained from the "vaccination card + mother's report" and "vaccination card" was 17.6 percentage points (pp); the difference for the booster dose was 0.2 pp. At the regional level the range of such differences for the first dose was 11.3 to 24.9 pp and for the booster dose 0.0 to 0.6 pp (Table 3).

DISCUSSION

In our study, 70.2% of Peruvian children aged 12 to 59 months who participated in ENDES 2017 received the first dose of measles vaccine, whereas only half of children may have received the booster dose from 18 months of age. These coverage estimates include vaccination information for children under the age of 5 years and are a form of estimation used in other studies relying on population surveys [14-18]. The estimated coverage would be below the 95.0% established for the first and booster dose nationwide, which is part of the objective to be reached by 2020 [3].

Our estimates differ from those generated by routine reports from 2017 in health facilities in Peru. According to them, 83.0% of one-year-old children had received the first dose, and 66.0% of 18-month-old children had received the booster dose [19]. The differences are explained by the estimation methods used; as previous studies indicate, estimation from routine reports may overestimate vaccination coverage [12].

Most of the studies that have estimated measles vaccination coverage using Demographic and Health Surveys (DHS) were conducted in African countries. Two studies were carried out in Senegal, reporting coverage of 82.1% in 2199 children aged 12 to 23 months (DHS 2010-2011) (15) and 79.2% in 2444 children aged 12 to 23 months (DHS 2013-2014) (20); In Congo, coverage was reported to be 70.0% in 6947 children aged 6 to 59 months (DHS 2013-2014) (16); in Ethiopia, coverage was 55.7% in 1927 children aged 12 to 23 months (DHS 2011) (17); finally, in Pakistan, coverage was reported to be 62.5% in 9177 children aged 0 to 60 months (DHS 2006-2007) [14]. In our study, considering this form of estimation, national coverage was 17.6 percentage points higher for the first dose, whereas the variation for the booster dose was minimal, with less than one percentage point difference.

Table 1. Sociodemographic characteristics and proportion of measles vaccination in children under the age of five of women enrolled in the 2017 Demographic and Family Health Survey.

Characteristic	First dose (n= 17,269)			Booster dose (n= 15,039)		
	Proportion as per characteristic	Coverage of first dose * (12 to 59 meses)	P value †	Proportion as per characteristic	Coverage of booster dose * (18 to 59 meses)	P value †
	(CI95%)	(CI95%)		(CI95%)	(CI95%)	
Mother's age (years)			0.461			0.701
15-19	14.8 (13.9-15.8)	70.7 (67.4-73.8)		14.7 (13.7-15.8)	52.1 (48.4-55.8)	
20-24	15.1 (14.1-16.1)	68.5 (65.6-71.3)		15.2 (14.2-16.3)	51.0 (47.5-54.4)	
25-29	14.9 (14.0-15.9)	71.8 (69.0-74.4)		15.2 (14.2-16.2)	54.6 (51.2-57.9)	
30-34	15.2 (14.2-16.3)	68.8 (65.0-72.2)		15.1 (14.1-16.2)	52.4 (48.5-56.3)	
35-39	15.2 (14.2-16.3)	72.4 (68.8-75.8)		15.2 (14.1-16.4)	52.1 (48.2-56.0)	
40-44	12.6 (11.6-13.7)	68.4 (64.2-72.4)		12.4 (11.3-13.5)	52.2 (47.9-56.5)	
45-49	12.1 (11.2-13.0)	71.0 (66.8-74.8)		12.2 (11.3-13.2)	49.4 (44.8-53.9)	
Highest educational level of the mother			0.941			0.390
Tertiary	36.7 (34.9-38.4)	70.4 (68.0-72.7)		36.5 (34.6-38.3)	51.2 (48.5-54.0)	
Secondary	44.3 (42.7-45.9)	69.9 (67.8-71.9)		44.3 (42.7-46.0)	52.9 (50.7-55.2)	
Elementary	17.3 (16.1-18.6)	70.8 (68.1-73.3)		17.5 (16.3-18.9)	52.0 (48.8-55.2)	
No education	1.7 (1.4-2.0)	70.0 (63.1-76.2)		1.7 (1.4-2.0)	45.4 (37.7-53.3)	
Prenatal controls (≥ 6 controls)			0.397			0.291
Yes	88.4 (87.4-89.4)	70.8 (69.3-72.2)		88.5 (87.4-89.6)	52.7 (51.0-54.4)	
No	11.2 (10.2-12.2)	68.6 (64.3-72.6)		11.1 (10.1-12.3)	50.1 (45.0-55.1)	
Doesn't know	0.4 (0.3-0.6)	77.7 (60.0-89.0)		0.4 (0.2-0.6)	67.4 (44.1-84.4)	
Age of child under five years (months)			<0.001			<0.001
12-23 (18-23)	26.7 (25.6-27.9)	68.6 (66.1-71.1)		16.1 (15.1-17.2)	41.3 (37.8-44.9)	
24-35	24.6 (23.5-25.7)	75.1 (72.5-77.5)		28.2 (26.9-29.4)	54.9 (51.8-58.0)	
36-47	25.5 (24.3-26.7)	70.3 (67.6-72.8)		29.2 (27.9-30.6)	52.8 (50.0-55.5)	
48-59	23.1 (22.1-24.2)	66.9 (64.2-69.5)		26.5 (25.3-27.7)	54.7 (51.9-57.5)	
Place of birth			0.178			0.019
Home	6.3 (5.7-7.0)	69.7 (64.8-74.3)		6.1 (5.5-6.8)	52.6 (46.5-58.7)	
Public sector	83.0 (81.9-84.0)	70.8 (69.0-72.3)		82.6 (81.4-83.6)	52.7 (51.0-54.3)	
Private sector	9.5 (8.7-10.4)	65.7 (61.0-70.1)		10.1 (9.2-11.0)	45.5 (41.1-50.0)	
Non-governmental organizations	0.2 (0.1-0.4)	76.0 (53.1-89.9)		0.2 (0.1-0.4)	41.2 (17.6-69.6)	
Other	1.0 (0.7-1.3)	71.6 (58.4-81.9)		1.0 (0.7-1.4)	62.6 (48.6-74.8)	
Growth and development monitoring			<0.001			<0.001
Yes	66.5 (64.9-68.0)	79.2 (77.6-80.6)		63.2 (61.5-64.8)	61.9 (60.0-63.8)	
No	33.3 (31.8-34.8)	52.9 (50.4-55.5)		36.6 (34.9-38.2)	35.4 (33.0-37.9)	
Doesn't know	0.2 (0.2-0.4)	3.1 (0.7-13.3)		0.3 (0.2-0.4)	0.0 (0.0)	
Place growth and development monitoring			<0.001			<0.001
Public sector	96.2 (95.5-96.8)	80.0 (78.4-81.4)		95.9 (95.1-96.6)	63.0 (61.1-64.9)	
Private sector	3.1 (2.5-3.7)	55.6 (47.2-63.6)		3.3 (2.7-4.0)	32.4 (24.0-42.1)	
Non-governmental organizations	0.1 (0.1-0.3)	59.7 (26.2-86.1)		0.2 (0.1-0.3)	51.4 (19.5-82.2)	
Other	0.6 (0.4-1.0)	75.9 (55.3-88.9)		0.6 (0.4-1.1)	46.2 (23.0-71.2)	

* Yes: vaccinated (dated) + vaccinated (undated), on card for first or booster dose; No: unvaccinated + vaccinated as reported by mother + does not know

† Chi-square test

CI95%: 95% confidence interval

(Continued on page 615)

Table 1. Sociodemographic characteristics and proportion of measles vaccination in children under five of women enrolled in the 2017 Demographic and Family Health Survey. *(from page 614)*

Characteristic	First dose (n= 17,269)			Booster dose (n= 15,039)		
	Proporción según característica	Coverage of first dose * (12 to 59 months)	P value †	Proportion as per characteristic	Coverage of booster dose * (18 to 59 meses)	P value†
	(CI95%)	(CI95%)		(CI95%)	(CI95%)	
Wealth index			0.394			0.474
Wealthier	21.0 (18.8-23.4)	70.7 (66.6-74.4)		20.9 (18.7-23.3)	50.5 (46.3-54.6)	
Wealthy	21.0 (19.3-22.7)	70.5 (67.5-73.3)		21.3 (19.5-23.1)	51.2 (47.7-54.8)	
Middle	19.9 (18.5-21.4)	68.2 (65.4-70.8)		19.9 (18.4-21.5)	51.2 (48.0-54.3)	
Poor	19.6 (18.1-21.2)	69.8 (67.3-72.2)		19.4 (17.9-21.0)	53.7 (50.6-56.8)	
Poorer	18.6 (17.2-20.0)	72.2 (70.1-74.2)		18.5 (17.1-20.0)	53.9 (51.5-56.3)	
Health insurance						
Private insurance			0.414			0.352
Yes	1.4 (1.0-2.0)	75.8 (61.2-86.1)		1.4 (1.0-2.0)	59.8 (43.1-74.4)	
No	98.6 (98.0-99.0)	70.2 (68.7-71.6)		98.6 (98.0-99.0)	51.9 (50.4-53.5)	
EsSalud/IPSS			0.457			0.269
Yes	24.1 (22.6-25.6)	71.1 (68.2-73.9)		24.1 (22.5-25.7)	50.5 (47.2-53.8)	
No	75.9 (74.4-77.4)	70.0 (68.4-71.4)		75.9 (74.3-77.5)	52.5 (50.8-54.2)	
Armed or police forces			0.665			0.177
Yes	1.1 (0.8-1.6)	66.5 (47.3-81.5)		1.0 (0.7-1.5)	40.7 (25.9-57.4)	
No	98.9 (98.4-99.2)	70.3 (68.8-71.7)		99.0 (98.5-99.3)	52.2 (50.6-53.7)	
Seguro Integral de Salud (SIS)			0.344			0.283
Yes	52.7 (50.6-54.7)	69.6 (67.8-71.4)		52.7 (50.7-54.8)	52.8 (50.8-54.8)	
No	47.3 (45.3-49.4)	70.9 (68.8-73.0)		47.3 (45.2-49.3)	51.2 (48.8-53.5)	
Healthcare Provider			0.616			0.834
Yes	2.1 (1.7-2.8)	73.1 (60.8-82.6)		2.2 (1.7-2.9)	50.6 (37.2-63.9)	
No	97.9 (97.2-98.3)	70.2 (68.7-71.6)		97.8 (97.1-98.3)	52.1 (50.5-53.6)	
Natural region			0.723			0.501
Metropolitan Lima	33.8 (30.3-37.6)	70.0 (66.5-73.3)		34.1 (30.6-37.9)	50.8 (47.1-54.4)	
Other coastal areas	23.3 (21.0-25.8)	69.8 (67.5-72.0)		23.1 (20.8-25.6)	52.2 (49.7-54.7)	
Jungle	12.4 (11.0-14.0)	69.3 (66.8-71.8)		12.4 (10.9-14.0)	54.2 (51.1-57.3)	
Highlands	30.4 (27.9-33.1)	71.2 (69.3-73.1)		30.4 (27.8-33.0)	52.4 (50.3-54.5)	
Type of place of residence			0.026			0.126
Urban	79.3 (77.8-80.8)	69.6 (67.9-71.3)		79.3 (77.8-80.8)	51.5 (49.7-53.4)	
Rural	20.7 (19.2-22.2)	72.6 (70.6-74.5)		20.7 (19.2-22.2)	53.9 (51.5-56.3)	
De facto place of residence			0.219			0.430
Capital, big city	33.8 (30.3-37.6)	70.0 (66.5-73.3)		34.1 (30.6-37.9)	50.8 (47.1-54.4)	
Small city	24.5 (22.3-26.8)	70.3 (68.1-72.4)		24.1 (21.9-26.4)	51.6 (49.2-53.9)	
Village	21.0 (19.5-22.6)	68.3 (65.9-70.6)		21.1 (19.6-22.7)	52.7 (50.1-55.4)	
Countryside	20.7 (19.2-22.2)	72.6 (70.6-74.5)		20.7 (19.2-22.2)	53.9 (51.5-56.3)	
Years living in the place of residence			0.011			0.003
<5	16.5 (15.5-17.6)	66.4 (63.1-69.5)		18.3 (17.2-19.4)	47.0 (43.5-50.6)	
≥5	83.5 (82.4-84.5)	70.7 (69.1-72.3)		81.7 (80.6-82.8)	53.0 (51.2-54.7)	
Has a vaccination card			<0.001			<0.001
Without card	0.7 (0.5-0.9)	9.5 (4.9-17.6)		0.6 (0.4-0.9)	2.6 (1.1-6.5)	
Yes, seen	77.1 (75.8-78.3)	90.5 (89.5-91.3)		76.1 (74.7-77.4)	68.0 (66.3-69.7)	
Yes, not seen	18.2 (17.1-19.5)	2.0 (1.4-2.8)		18.9 (17.7-20.2)	1.1 (0.7-1.8)	
No longer has a card	4.0 (3.5-4.6)	2.5 (1.1-5.5)		4.4 (3.8-5.1)	1.8 (0.6-5.4)	

* Yes: vaccinated (dated) + vaccinated (undated), on card for first or booster dose; No: unvaccinated + vaccinated as reported by mother + does not know
† chi-square test
CI 95%: 95% confidence interval

Table 2. Characteristics associated with measles vaccination of children under five of women enrolled in the 2017 Demographic and Family Health Survey

Characteristic	First dose * (n = 17,269) (12 to 59 months)			Booster dose * (n = 15,039) (18 to 59 months)		
	AOR	CI 95%	P value	AOR	CI 95%	P value
Mother's highest educational level						
Tertiary	Ref			Ref		
Secondary	1.01	0.83 - 1.23	0.906	1.14	0.93 - 1.40	0.200
Elementary	0.90	0.68 - 1.20	0.465	0.95	0.72 - 1.25	0.708
No education	0.73	0.44 - 1.21	0.222	0.63	0.39 - 1.03	0.068
Age of child under five years (months)						
12-23 (18-23)	Ref			Ref		
24-35	1.59	1.28 - 1.97	< 0.001	2.04	1.62 - 2.56	< 0.001
36-47	1.21	0.95 - 1.54	0.129	1.75	1.40 - 2.20	< 0.001
48-59	1.20	0.96 - 1.51	0.116	2.32	1.84 - 2.94	< 0.001
Place of birth						
Public sector	Ref			Ref		
Home	0.94	0.68 - 1.31	0.718	0.88	0.63 - 1.24	0.472
Private sector	0.80	0.58 - 1.09	0.161	0.72	0.57 - 0.92	0.009
NGO	0.63	0.23 - 1.71	0.360	1.16	0.29 - 4.62	0.832
Place of growth and development monitoring						
Public sector	Ref			Ref		
Private sector	0.30	0.21 - 0.43	< 0.001	0.26	0.17 - 0.40	< 0.001
NGO	0.38	0.09 - 1.62	0.190	0.57	0.13 - 2.49	0.453
Wealth index						
Wealthier	Ref			Ref		
Wealthy	0.99	0.73 - 1.36	0.971	1.10	0.83 - 1.45	0.524
Middle	0.77	0.55 - 1.07	0.122	1.00	0.77 - 1.30	0.988
Poor	0.90	0.64 - 1.25	0.515	1.15	0.86 - 1.53	0.350
Poorer	0.77	0.51 - 1.17	0.219	1.13	0.77 - 1.64	0.538
Type of place of residence						
Urban	Ref			Ref		
Rural	1.41	1.08 - 1.83	0.011	1.04	0.79 - 1.36	0.777
Years living in place of residence						
<5	Ref			Ref		
≥5	1.23	0.99 - 1.53	0.064	1.37	1.12 - 1.69	0.003

* Yes: vaccinated (dated) + vaccinated (undated), on card for first or booster dose; No: unvaccinated + vaccinated as reported by mother + does not know
NGO: Non-Governmental Organizations, AOR: Adjusted Odds Ratio, CI 95%: 95% Confidence Interval
Ref: reference category

The goal for international plans is that at least 80.0% of municipalities (or its equivalent) in a country achieve 95.0% coverage or more for each dose (3.19). While we did not show coverage at the district level, but at the regional level, the study found that no Peruvian region achieved 95.0% coverage for the first dose and booster dose. We found variable coverage between regions, and only the regions of Arequipa, Huánuco, Ica, Lambayeque, Loreto, Madre de Dios, and Tacna exceed 90.0% if we consider the information obtained from both the vaccination card and the mother's report.

In our study we used as numerator the children aged 12 to 59 months and 18 to 59 months whose first dose and booster dose against measles could be verified with the vaccination card (dated or not). On the other hand, the denominator included for the first and booster dose all children in the age groups previously indicated. This definition makes it possible to reduce the possibility of misclassification biases. We were unable to assess the time of vaccination (exact age of application), i.e. whether such vaccinations were administered, according to national technical regulations, at 12 and 18 months. Considering this, the coverage estimates provided do not consider the opportunity component, which has been addressed in other studies [14,18].

We found that children with growth and development controls in the public sector who reside in rural areas are more likely to have their first dose of measles vaccination. Factors independently associated with having booster

Table 3. Compliance with measles vaccination in children under the age of five years of mothers enrolled in the 2017 Demographic and Family Health Survey, by region

Political Region	Recorded vaccination card *		Recorded on vaccination card + mother's report †		Differences between point estimations	
	First dose (n = 17,269) (12 to 59 months) (a)	Booster dose (n = 15,039) (18 to 59 months) (c)	First dose (n = 17,269) (12 to 59 months) (b)	Booster dose (n = 15,039) (18 to 59 months) (d)	(b-a)	(d-c)
	(CI95%)	(CI95%)	(CI95%)	(CI95%)	%	%
Amazonas	73.8 (69.8-77.5)	59.5 (54.6-64.2)	89.7 (86.7-92.1)	59.6 (54.7-64.3)	15.9	0.1
Ancash	66.9 (62.7-70.9)	49.9 (45.1-54.7)	86.3 (82.9-89.1)	49.9 (45.1-54.7)	19.4	0.0
Apurimac	69.0 (64.7-73.0)	49.1 (44.8-53.5)	87.8 (84.6-90.3)	49.4 (45.1-53.8)	18.8	0.3
Arequipa	73.4 (69.1-77.3)	53.1 (48.6-57.6)	90.7 (87.6-93.0)	53.2 (48.6-57.6)	17.3	0.1
Ayacucho	69.3 (64.1-74.0)	46.3 (41.7-51.1)	85.0 (81.4-88.0)	46.4 (41.8-51.2)	15.7	0.1
Cajamarca	73.5 (69.1-77.5)	57.2 (52.3-62.0)	89.9 (87.3-91.9)	57.6 (52.7-62.4)	16.4	0.4
Callao	63.0 (58.8-67.0)	48.1 (43.5-52.7)	86.0 (82.2-89.1)	48.1 (43.5-52.7)	23.0	0.0
Cusco	68.6 (61.5-74.9)	51.3 (43.4-59.1)	81.7 (75.9-86.3)	51.3 (43.4-59.1)	13.1	0.0
Huancavelica	75.0 (69.3-80.0)	52.1 (46.1-58.0)	86.3 (81.6-89.9)	52.4 (46.3-58.4)	11.3	0.3
Huánuco	68.6 (63.3-73.4)	48.0 (41.0-55.0)	90.4 (87.4-92.8)	48.0 (41.0-55.0)	21.8	0.0
Ica	73.9 (68.1-79.0)	59.7 (52.5-66.5)	92.6 (89.3-94.9)	59.8 (52.6-66.7)	18.7	0.1
Junin	55.9 (49.4-62.3)	40.1 (32.7-47.9)	80.8 (74.4-86.0)	40.1 (32.7-47.9)	24.9	0.0
La Libertad	65.1 (59.8-70.0)	47.1 (41.8-52.4)	88.6 (85.2-91.4)	47.1 (41.8-52.4)	23.5	0.0
Lambayeque	75.8 (70.4-80.4)	60.0 (53.0-66.5)	90.9 (87.0-93.7)	61.4 (54.4-68.0)	15.1	0.4
Lima	70.7 (66.8-74.3)	50.9 (46.9-54.9)	87.5 (84.9-89.6)	50.9 (46.9-54.9)	16.8	0.0
Loreto	76.7 (71.9-80.8)	62.2 (55.9-68.0)	90.9 (87.4-93.5)	62.2 (55.9-68.0)	14.2	0.0
Madre de Dios	78.2 (72.6-82.9)	67.9 (62.0-73.3)	93.0 (88.9-95.7)	69.0 (63.4-74.1)	14.8	1.1
Moquegua	72.5 (65.9-78.3)	51.3 (44.5-58.1)	89.8 (85.4-93.0)	51.3 (44.5-58.1)	17.3	0.0
Pasco	73.8 (68.1-78.8)	60.1 (53.5-66.4)	86.6 (81.8-90.3)	60.1 (53.5-66.4)	12.8	0.0
Piura	71.6 (67.2-75.7)	49.7 (45.1-54.4)	87.4 (84.2-90.1)	50.2 (45.6-54.8)	15.8	0.5
Puno	77.9 (70.0-84.3)	65.0 (56.6-72.6)	89.6 (84.2-93.3)	65.0 (56.6-72.6)	11.7	0.0
San Martin	67.5 (61.7-73.0)	50.2 (43.7-56.8)	87.8 (83.8-91.0)	50.8 (44.5-57.2)	20.3	0.6
Tacna	78.6 (73.5-83.0)	64.8 (58.6-70.6)	90.7 (87.3-93.2)	64.8 (58.6-70.6)	12.1	0.0
Tumbes	65.6 (59.9-70.8)	45.6 (39.7-51.7)	81.4 (76.2-85.6)	45.6 (39.7-51.7)	15.8	0.0
Ucayali	67.2 (62.4-71.6)	51.7 (46.4-57.1)	89.3 (86.2-91.8)	51.8 (46.4-57.2)	22.1	0.1
Total	70.2 (68.8-71.6)	52.0 (50.5-53.6)	87.8 (86.9-88.7)	52.2 (50.6-53.8)	17.6	0.2

* Yes: vaccinated (dated) + vaccinated (undated), recorded on card for first or booster dose; No: unvaccinated + vaccinated as reported by mother + does not know
† Yes: vaccinated (dated) + vaccinated (undated) + reported by mother, for first or booster dose; No: not vaccinated + does not know
CI 95%: 95% confidence interval

doses were having growth and development controls in the public sector and residing five to more years in their current address. We also found that giving birth in private health facilities is associated with not taking the booster dose. That is to say that for those children whose growth and development controls are carried out in public facilities, the probability of receiving the two doses of measles vaccine is greater. This factor could be associated, in turn, with residing five or more years in their current address, which would allow consistent access to health facilities, especially public ones, as well as greater fidelity to their services, including growth and development controls, as well as vaccination.

A study with similar methodology on vaccination against hepatitis B in newborns found that the factors linked to vaccination were access to institutional childbirth and those associated with it, such as insurance [13]. Hepatitis B vaccine for newborns should be given within the first 24 hours of life, which is encouraged when delivery takes place in the health facility. On the contrary, the first dose of the measles vaccine must be administered after a year. Therefore, to get the vaccine, the child must go to the health facility during those months of life, which may be associated with having growth and development controls and having a permanent place of residence.

Studies conducted in population surveys have found that both measles vaccination [16] and full vaccination [14,15,17] were associated with a better wealth quintile. In our study, such statistical association was not found; on the contrary, a previous evaluation of vaccination coverage with hepatitis B at birth in Peru reported that among those with the lowest wealth index, vaccination coverage was better [13]. Another factor that has been associated with full vaccination is a better educational level of the mother [14,15,17], however, we did not find a relation between educational level and vaccination coverage in the first and booster dose. Finally, prenatal control has also been associated with compliance with the vaccination schedule [15], which has not been found in this analysis either.

The study presented the following limitations: it does not provide estimates of annual coverage that allow us to compare with the results from other studies or reports that do; since it is a secondary source study, coverage could only be evaluated in some interest subgroups; the time of vaccination could not be evaluated either, and whether vaccination really took place as close as possible to the child's 12 and 18 months of age. For the application of the selection criteria, we excluded information of 20.0% of minors for the first dose and 30.0% for the booster dose. However, this was necessary to avoid selection bias; the global estimation of vaccination coverage due to the reporting component of the mother and its response categories may be affected by a memory bias or social desirability. Finally, we could not evaluate the contraindications for the vaccine: severe immunodeficiency, severe allergic reaction to a previous dose of vaccine, and reaction to vaccine components [8].

In conclusion, seven out of ten Peruvian children aged 12 to 59 months who participated in ENDES 2017 received the first dose of measles vaccine, and only five out of ten received the booster dose. Vaccination coverage varied among regions; however, no region in Peru reached 95.0% coverage for the first and booster dose. Among children with growth and development controls in the public sector, coverage of the first dose reached 80.0%, whereas the booster dose reached 63.0%. The main modifiable factor associated with measles vaccination was the place where growth and development controls were performed and living five or more years in the current place of residence was a factor independently associated with the booster dose.

To eradicate measles, it is essential to maintain high levels of population immunity, which requires reaching and maintaining at least 95.0% coverage for both the first and second doses. Measles outbreaks are one of the first indicators of weakness of a country's vaccination program [3]. We recommend developing research on the implementation of public policies that evaluate the opportunity to apply this vaccine and the factors that determine it, as well as complementing the approach to compliance and coverage of the complete vaccination scheme in children at the national level through studies based on population health surveys. Finally, improvements in routine records such as the use of electronic nominal vaccination records or electronic cards will allow for more valid estimates of vaccination coverage.

Authors' Contributions: This study is KVU's original idea, who was also responsible for data analysis and interpretation (with guidance from JANO, FR and JCRH). KVU, JANO, FR, and JCRH have participated in the design of the study and writing the article and have approved its final version.

Funding: This study has been self-financed by KVU. JANO's participation has been financed by Universidad Nacional de Cajamarca. JCRH and FR's participation has been partially funded by the National Institute of Health. Part of the time JCRH invested in this project was also funded by Universidad de San Martin de Porres.

Conflicts of Interest: FR works as Scientific Editor of the Peruvian Journal of Experimental Medicine and Public Health (Revista Peruana de Medicina Experimental y Salud Pública, RPMESP). The other authors declare that they have no conflicts of interest.

Supplementary Material: Available in the electronic version of the RPMESP.

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