

Factors affecting childhood immunization in Lao People's Democratic Republic: A cross-sectional study from nationwide, population-based, multistage cluster sampling

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Summary

Vaccines are one of the most important achievements in public health, and a major contributor to this success is the Expanded Programme on Immunization (EPI). The effective vaccination series of the EPI should be used by its target population. Various factors influence the utilization of the EPI vaccination series. In Lao People's Democratic Republic (Lao PDR), immunization coverage was lower than the regional average. This study evaluates risk factors affecting immunization underutilization among children five to nine years of age. It is a cross-sectional study from nationwide, population-based, multistage cluster sampling. The children who have received 'standard six' antigens and those who have been partially immunized are compared. In a bivariate analysis, household occupation, maternal age, means of transportation, time to the nearest health facilities, the child's birthplace, birth attended by medical staff, and notification of vaccination date by medical staff, village authority, or megaphone were associated with vaccination status. The final multivariate logistic regression model revealed that maternal age and notification of vaccination date by the village authority increased the odds of full vaccination, while notification of vaccination date by megaphone had decreased those odds. Further detailed qualitative research may be needed to discover how maternal sociodemographic factors influence the utilization of these services. Future research needs to target younger children and must include health care provider factors related to vaccination services.

Keywords: Expanded programme on immunization (EPI), full vaccination, childhood vaccination

1. Introduction

Vaccines have substantially reduced the global burden of infectious diseases. They are considered one of the most important achievements in public health and one of the most cost-effective preventive services for children (1-7). The major contributor to this success is the Expanded Programme on Immunization (EPI) of the World Health Organization (WHO), United Nations Children's Fund (UNICEF) and Global Alliance Vaccine Initiative (GAVI) (6). The EPI was launched in 1974 as a worldwide

alliance of collaborating nations whose goal was to expand immunization services and coverage (6).

The success of EPI does not only depend on effective vaccination series, but also on achieving optimal use by its target population and high immunization coverage (4,8). Pinpointing non-vaccination factors is important for achieving the EPI targets (9,10). The utilization of vaccination services depends on numerous factors such as provision of EPI services including outreach services, accessibility of these services, number of health workers, availability of safe needles, syringes, and cold chain, as well as health education and knowledge and attitude of mothers (5,11,12). Once a child enters the vaccination system, completion of the series is determined by the mother's educational level, employment status, experience with vaccination services, adequate schedule information, immigration status, and overall socioeconomic status (13-15). Various factors

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are important for the initiation and completion of the vaccination series.

The EPI was initiated in Lao People's Democratic Republic (Lao PDR) in 1979 (16). This programme greatly contributed to the progress of basic immunization coverage through the support of international partners and the government of Japan (17). However, immunization coverage in Laos PDR became stagnant after the WHO Western Pacific Region achieved regional polio eradication in 2000 (17). Immunization coverage was lower than regional average: measles immunization coverage among 1-year-olds was 64%, diphtheria tetanus toxoid and pertussis (DTP3) immunization coverage among 1-year-olds was 74%, hepatitis B (HepB) immunization coverage among 1-year-olds was 74%, tuberculosis (Bacille Calmette-Guérin vaccine: BCG) immunization coverage among 1-year-olds was 72% and polio (OPV3) immunization coverage among 1-year-olds was 76% (18,22). The risk factors for non-vaccination need to be studied to achieve optimal use of the vaccination services in Lao PDR. Therefore, the aim of this study is to evaluate risk factors affecting underutilization of childhood immunization among children five to nine years of age.

2. Material and Methods

2.1. Study location and population

Lao PDR is located in Southeast Asia and bordered by five countries: Burma, China, Vietnam, Cambodia, and Thailand. In 2010, its population was approximately 6.2 million and its under-five mortality rate was 54 out of 1,000 live births (19).

2.2. Sampling and sampling frame

This analysis has been done in the sub-population of the nation-wide survey for Hepatitis B sero-prevalence. All 143 districts in Lao PDR were stratified into two strata according to their immunization coverage. Twelve districts were randomly selected from each stratum, and two villages were selected from each district *via* probability of population proportional to size sampling. After randomly selecting 21 children (five to nine years old) and their mothers (15 to 45 years old) from the selected villages, questionnaires were administered.

One thousand and eight pairs of mothers and children were recruited and assessed for eligibility for this study. Forty-three pairs were excluded either because mothers were younger than 15 years of age or older than 45 years of age, or children were younger than five years of age or older than nine years of age. Four hundred and sixty-five pairs were excluded because they did not have vaccination certifications such as yellow cards or mother and child handbooks. Three pairs were excluded because possession of the vaccination certification was unknown.

Among the 497 pairs with the vaccination certification, 284 pairs were excluded because they could not show their certification on the day of the survey. From this, 213 pairs were included in this study.

In Lao PDR, the yellow cards or mother and child handbooks are provided to children who received any vaccination regulated by the Laos PDR Ministry of Health. Vaccination dates were transcribed from those cards, and any vaccination documentation was considered sufficient evidence (20). Each child's immunization record was checked against the EPI immunization schedule recommended by the WHO (21,22). The following categories were used: fully immunized, if the "standard six" antigens – BCG, DTP3 (3 doses), OPV3 (3 doses), and measles vaccines – have been received on the day of interview; and partially immunized, if at least one recommended vaccine dose was not given (23,24). This study compared factors between children who completed their standard vaccinations (full vaccination) and children who had not completed their vaccinations at the time of the survey (partial vaccination).

2.3. Collection of data

The survey, which used a face-to-face, interview-based questionnaire, was conducted from 25 January 2012 to 4 February 2012 by a survey team. A pilot study was conducted prior to the survey to check for clarity and consistency of the questionnaire. The survey team collected demographic information, vaccination status, and other relevant information. Each survey team had two surveyors. These surveyors received two days of training, which consisted of an overview of research methods, interview strategies, and ethical considerations. Before each interview, written consent was obtained from the child's mothers and vaccination dates were transcribed from yellow cards or mother and child handbooks.

2.4. Statistical analysis

The proportions of children who received all the recommended routine vaccination according to the policy of the Expanded Programme of Immunization (EPI) in Lao PDR and its 95% confidence interval (CI) were calculated. Bivariate analysis was performed to assess the relationship between vaccination status and its risk factors. A chi-square test was used for categorical variables and Student's *t* test was used for continuous variables. Crude odds ratios (ORs) and 95% CIs were calculated. Based on the results of the bivariate analysis, all significant factors and ethnicity were entered into the multivariate logistic regression analysis. Ethnicity was added to the final multivariate model because its diversity presented a major challenge in health service delivery due to cultural and language barriers. However, the variable "birthplace of the children" was excluded

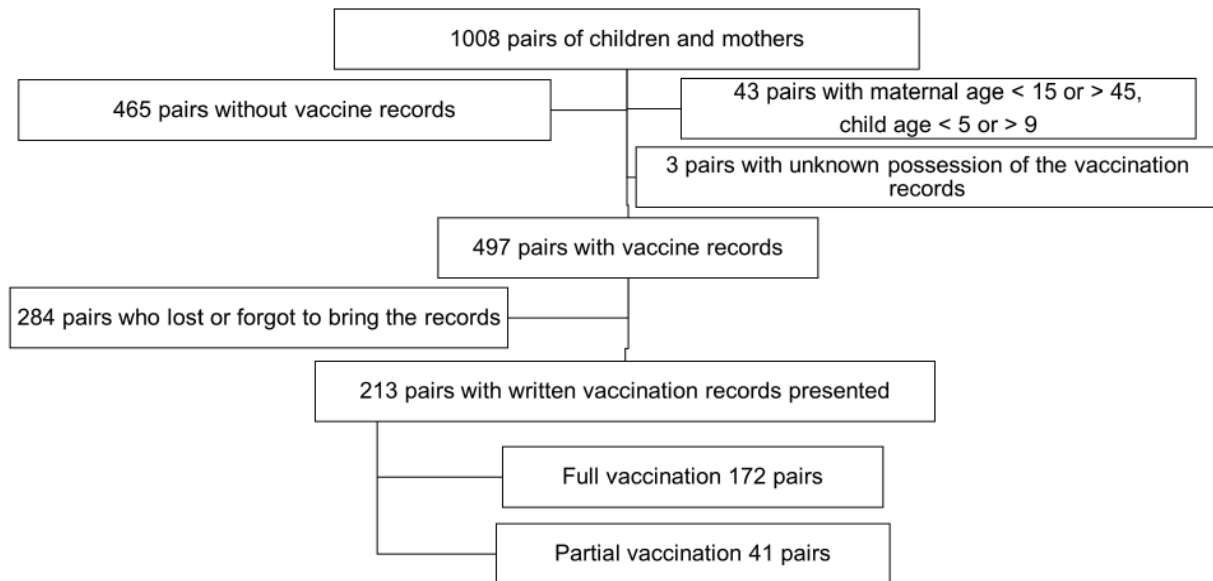


Figure 1. Study profile.

from the final multivariate logistic regression analysis since it showed the highest multicollinearity among the variables in the model. Multicollinearity was detected by using the variance inflation factor (VIF). Stata version 11.0 was used to perform all statistical analyses.

2.5. Ethical considerations

The survey was reviewed and approved by the Ethical Committee of the Ministry of Health, Lao PDR, and the institutional review board of the National Center for Global Health and Medicine, Japan (NCGM-G-001130-00). Access to selected households was granted by the Ministry of Health and the provincial and district government authorities.

3. Results

3.1. Study profile of all subjects

Figure 1 shows the profile of research subjects. 213 pairs were eligible. The case (full vaccination) group had 172 children and the control (partial vaccination) group had 41 children. The proportion of children, aged five to nine, who hold certificates of vaccination (either a yellow card, a mother and child handbook, or both) was 49.3% of the sample, while the proportion of children with an eligible record of vaccination was 21.1% of the sample (data not shown).

3.2. Proportion of children vaccinated by antigen

The statistics of children vaccinated with each antigen are presented in Table 1. All vaccination rates were over 80% except for the HepB birth dose, which

Table 1. Proportion of children having received the various EPI antigens according to vaccination cards

EPI antigen	Total (%), (n = 213)	95%CI
HepB0	19.2	13.9-24.6
BCG	97.2	94.9-99.4
OPV1	97.7	95.6-99.7
OPV2	94.8	91.8-97.8
OPV3	93.4	90.1-96.8
DPT1	98.6	97.0-100
DPT2	95.8	93.1-98.5
DPT3	93.4	90.1-96.8
MV1	83.6	78.6-88.6
Full vaccination***	80.8	75.4-86.1

***Full vaccination – BCG, diphtheria-tetanus pertussis (DTP) (3 doses), polio (3 doses), and measles vaccines

was 19.2%. Among those 19.2%, only five children received the birth dose on the day of birth or the next day. The dates for the HepB birth dose for the rest of the children (80.8%) were not accurate. This low rate and record confusion may be due to the fact that the HepB vaccination for newborns was integrated into the EPI in 2004, which gradually expanded from central hospitals to rural areas. Most (80.8%) of the children were fully immunized between the ages of five and nine, according to the recommended EPI schedule.

3.3. Risk factors of childhood immunization

Among the sociodemographic factors of the family, household occupation, maternal age, means of transportation, and time to the nearest health facilities were associated with full vaccination of the children (Table 2). Birthplace of the children and birth attended by medical staff were associated with vaccination status (Table 3). Notification of vaccination date by

Table 2. Risk factors of childhood immunization (sociodemographic factors)

Items	Full vaccination <i>n</i> = 172, (%)	Partial vaccination <i>n</i> = 41, (%)	Crude OR (95%CI)	<i>p</i> -value
Ethnicity			Reference	
Lowland Lao	102 (59.3)	25 (61.0)		
Midland Lao	61 (35.5)	14 (34.2)	1.07 (0.52-2.21)	0.86
Highland Lao	9 (5.2)	32 (4.9)	1.10 (0.22-5.43)	0.90
Household occupation			Reference	
farmer	126 (73.3)	35 (89.7)		
not farmers	46 (26.7)	4 (10.3)	0.31 (0.10-0.94)	0.03
Mean maternal age (years)	32.7 (CI; 31.8-33.7)	29.3 (CI; 27.5-31.2)		0.00
Maternal education			Reference	
no education	68 (39.5)	16 (39.0)		0.32
primary school	55 (32.0)	19 (46.3)	0.68 (0.32-1.45)	0.25
junior high school	34 (19.8)	4 (9.8)	2.00 (0.62-6.45)	0.43
high school	10 (5.8)	1 (2.4)	2.35 (0.28-19.73)	0.89
university	5 (2.9)	1 (2.4)	1.18 (0.13-10.78)	
Sex of children			Reference	
boy	74 (43.0)	21 (51.2)	0.69 (0.34-1.38)	0.29
girl	97 (56.4)	41 (46.3)		
unknown	1 (0.6)	1 (2.4)		
Mean number of children	3.4 (CI; 3.1-3.7)	3.2 (CI; 2.6-3.9)		0.71
Transportation			Reference	
walk	65 (37.8)	13 (31.7)		
bicycle	3 (1.7)	0 (0)		
bike	44 (25.6)	18 (43.9)	0.49 (0.22-1.10)	0.08
car	27 (15.7)	0 (0)		
tractor	33 (19.2)	5 (12.2)	1.32 (0.43-4.02)	0.63
boat	0 (0)	3 (7.3)		
N/A	0 (0)	2 (4.9)		
Mean time to the nearest health facilities (minutes)	29.5 (CI; 25.0-33.9), <i>n</i> = 152	48.1 (CI; 20.5-75.7), <i>n</i> = 37		0.02
Decision-maker for vaccination			Reference	
Father	36 (20.9)	9 (22.0)		
Mother	129 (75.0)	29 (70.7)	1.11 (0.48-2.56)	0.80
Grandparents	4 (2.3)	3 (7.3)	0.33 (0.06-1.76)	0.20
Village leader	2 (1.2)	0 (0)		
Others	1 (0.6)	0 (0)		

N/A; Non applicable, CI; 95% confidence interval.

Table 3. Risk factors of childhood immunization (delivery history)

Items	Full vaccination <i>n</i> = 172, (%)	Partial vaccination <i>n</i> = 41, (%)	Crude OR (95%CI)	<i>p</i> -value
Birth place of children			Reference	
provincial hospital	38 (22.1)	3 (7.3)		
district hospital	24 (14.0)	9 (16.9)	0.21 (0.05-0.86)	0.03
health centre	4 (2.3)	1 (2.4)	0.32 (0.03-3.80)	0.36
private clinic	2 (1.2)	1 (2.4)	0.16 (0.01-2.29)	0.18
home	72 (41.9)	26 (63.4)	0.22 (0.06-0.77)	0.02
bush near house	31 (18.0)	0 (0)		
N/A	1 (0.6)	1 (2.4)		
Birth attended by the medical staff			Reference	
yes	94 (54.7)	14 (34.2)	2.27 (1.09-4.69)	0.02
no	77 (44.8)	26 (63.4)		
N/A	1 (0.6)	1 (2.4)		
Birth attended by the village health volunteer			Reference	
yes	32 (18.6)	3 (7.3)	2.88 (0.83-10.10)	0.08
no	137 (79.7)	37 (90.2)		
N/A	3 (1.7)	1 (2.4)		
Birth attended by the traditional birth attendant			Reference	
yes	33 (19.2)	9 (22.0)	0.81 (0.35-1.87)	0.62
no	136 (79.1)	30 (73.2)		
N/A	3 (1.7)	2 (4.9)		
Birth attended by the family member			Reference	
yes	75 (43.6)	19 (46.3)	0.79 (0.39-1.60)	0.51
no	95 (55.2)	19 (46.3)		
N/A	2 (1.2)	3 (7.3)		
Birth attended by nobody			Reference	
yes	4 (2.3)	2 (4.8)	0.46 (0.08-2.60)	0.36
no	167 (97.1)	38 (92.7)		
N/A	1 (0.6)	1 (2.4)		

N/A; Non applicable, CI; 95% confidence interval.

Table 4. Risk factors of childhood immunization (source of information of vaccination)

Items	Full vaccination <i>n</i> = 172, (%)	Partial vaccination <i>n</i> = 41, (%)	Crude OR (95%CI)	<i>p</i> -value
Source of information of vaccination (medical staff)				
yes	129 (75.0)	32 (78.1)	0.66 (0.27-1.60)	0.35
no	43 (25.0)	7 (17.1)	Reference	
N/A	0 (0)	2 (4.9)		
Source of information of vaccination (information on the vaccination cards)				
yes	51 (24.8)	9 (22.0)	1.45 (0.64-3.29)	0.37
no	117 (68.0)	30 (73.2)	Reference	
N/A	4 (1.3)	2 (4.9)		
Source of information of vaccination (family member or friends)				
yes	40 (23.3)	14 (34.2)	0.58 (0.27-1.21)	0.14
no	129 (75.0)	26 (63.4)	Reference	
N/A	3 (1.7)	1 (2.4)		
Source of information of vaccination (TV)				
yes	67 (39.0)	13 (31.7)	1.36 (0.66-2.84)	0.40
no	102 (59.3)	27 (65.9)	Reference	
N/A	3 (1.7)	1 (2.4)		
Source of information of vaccination (local authority)				
yes	97 (56.4)	28 (68.3)	0.58 (0.27-1.22)	0.14
no	72 (41.9)	12 (29.3)	Reference	
N/A	3 (1.7)	1 (2.4)		
Source of information of vaccination date (medical staff)				
1. yes	33 (19.2)	18 (43.9)	0.31 (0.14- 0.64)	0.00
2. no	138 (80.2)	23 (56.1)	Reference	
N/A	1 (0.6)	0		
Source of information of vaccination date (village health volunteer)				
yes	62 (36.1)	24 (58.5)	1.16 (0.57-2.36)	0.68
no	108 (62.8)	16 (39.0)	Reference	
N/A	2 (1.2)	1 (2.4)		
Source of information of vaccination date (local authority)				
yes	170 (98.8)	38 (92.7)	6.71 (1.05-42.7)	0.02
no	2 (1.2)	3 (7.3)	Reference	
Source of information of vaccination date (woman's union)				
yes	78 (45.4)	19 (46.3)	0.96 (0.48-1.90)	0.91
no	94 (54.7)	22 (53.7)	Reference	
Source of information of vaccination date (official letter from district governor)				
yes	27 (15.7)	6 (14.6)	1.09 (0.42-2.86)	0.85
no	144 (83.7)	35 (85.4)	Reference	
N/A	1 (0.6)	0		
Source of information of vaccination date (megaphone)				
yes	40 (23.3)	20 (48.8)	0.32 (0.15-0.66)	0.00
no	132 (76.7)	21 (51.2)	Reference	
Source of information of vaccination date (poster)				
yes	27 (15.7)	5 (12.2)	0.57 (0.48-3.74)	0.57
no	145 (84.3)	36 (87.8)	Reference	

N/A; Non applicable, CI; 95% confidence interval.

medical staff, village authority, or megaphone was also associated with full vaccination (Table 4).

Based on the bivariate analysis all variables significantly associated with full vaccination status and ethnicity were included in the multivariate logistic regression model. The results revealed that maternal age and obtaining information of the vaccination date by the village authority increased the odds of full vaccination. However, obtaining information on the vaccination date by megaphone had decreased the odds

of full vaccination (Table 5).

4. Discussion

This study highlights the factors associated with the vaccination status of children aged five to nine in Lao PDR. Multivariate analysis of the risk factors for childhood immunization showed that maternal age and notification of the vaccination date by the village authority were positively associated with full

Table 5. Factors associated with full vaccination of children (logistic regression); occupation of household head-grouped

Factors	Adjusted odds ratio	95%CI	p-value
Sociodemographic factors			
Ethnicity	1.321	0.575-3.036	0.512
Household occupation	0.269	0.067-1.085	0.065
Maternal age	1.087	1.008-1.172	0.031
Transportation to the health facility	1.174	0.852-1.618	0.327
Time to the nearest health facility	0.989	0.977-1.001	0.076
Delivery history			
Birth attended by medical staff	2.617	0.936-7.317	0.067
Source of EPI information			
Source of information of vaccination date by medical staff	0.422	0.150-1.185	0.102
Source of information of vaccination date by local authority	17.430	1.827-166.280	0.013
Source of information of vaccination date by megaphone	0.204	0.065-0.637	0.006

immunization. Notification of the vaccination date by megaphone was negatively associated with full immunization.

4.1. Sociodemographic factors

According to the bivariate analysis, maternal age was associated with vaccination status. Furthermore, there was a linear trend that showed that full vaccination increases with maternal age. However, the relationship between childhood immunization and maternal age varies in the literature. There are some studies that show that maternal age was not associated with childhood immunization (6). One study from Africa showed the influence of younger maternal age on the utilisation of medical care (8).

This study did not show that maternal education was associated with vaccination status, which may be due to the contextual effects of maternal education on children's immunization in Lao PDR (25). Many studies have shown that maternal education or literacy is positively associated with the vaccination status of the children (1,6,8,9,13,25). In addition, some studies showed that the mother's knowledge of specific immunizations was associated with full vaccination (3,5,17). However, in Mali, Koumaré *et al.* reported no difference associated with parental knowledge about EPI diseases and full vaccination (3). In India, Parashar showed that literate women in a village may influence other women's capacity to seek and take advantage of state-provided healthcare, and even children of uneducated mothers may have better health knowledge due to residential or employment proximity to literate women through social influence (25). Further detailed research is needed to determine why maternal education was not associated with childhood immunization in this context.

Maekawa *et al.* showed that distance to health facilities in a rural region of Lao PDR was associated with vaccination status (17). This study focused on time rather than distance to health facilities since access depends on not only the distance but also the accessibility of the road and the availability of

transportation. Therefore, mean time to the nearest health facilities was associated with full vaccination status in the bivariate analysis; however, it was not significant in the logistic regression model, which may be due to the established nationwide outreach service of EPI (26). Further research is needed to explore the association of vaccination status and the actual accessibility to the vaccination sites, combining precise information on distance, time to the vaccination sites, and availability of transportation.

4.2. Delivery history

Birth attended by medical staff was associated with full vaccination of the children; however, it was not significant in the multivariate analysis. According to Maekawa *et al.*, bivariate analysis showed that immunization status was associated with whether mothers obtained information on immunisation before delivery; however, this factor was not significant in the multivariate analysis (17). Maekawa *et al.* also revealed that household visits and receipt of information before delivery influenced the number of fully immunized children. Further analysis revealed that household visits contributed to higher full-vaccination rates, especially among illiterate mothers. Therefore, it may not be sufficient to give information only once before or after the delivery; it might be better to provide information over several household visits.

4.3. Source of EPI information

The notification of the vaccination date by village authority had higher odds of full vaccination. On the other hand, notification of the vaccination date by megaphone was negatively associated with vaccination status. These results show that comprehensive and appropriate information dissemination may be key for vaccinating children against the EPI diseases (3,6).

There are several strengths in this study. This information has been collected through a nationwide survey using multistage cluster sampling. Geographically, the survey dissemination covered a wide portion of

Lao PDR and the ethnic minorities. A sampling frame allowed sampling bias to be a minimum. Only written records were used to avoid inaccuracies in vaccination history. Yellow cards and mother and child handbooks were the sole source of immunization information in this study. Parent's recall was not included in the interview. Rodewald *et al.* stated that the gold standard for measuring vaccination status, other than serological testing to detect immunity, is a parent-linked and provider-validated immunization status measure (2). Parent-linked means that parents name all immunization providers and provider-validated means obtaining the immunization records for each child and combining those data into a single record. Multiple studies have documented the inaccuracy of parents as the sole source of immunization status. The single-provider record check method, used in this study, lies between the parental recall and the parent-linked, provider-verified measure. The validity of this method depends on the frequency and reliability with which immunizations are included in the medical records (2). However, this study has several limitations. Firstly, this analysis has been done in the sub-population of the nation-wide survey for Hepatitis B sero-prevalence and only included the children and mothers who possessed any certifications of vaccination; therefore, the number of children in full and partial vaccination is skewed and no immunization or risk factor information was included from the children without the vaccination certifications. Second, the target of this study was children five to nine years old, which is older than the normal target population for a risk factor-based study. Thirdly, this study did not focus on health care provider factors, which may influence the vaccination status. Utilization of vaccination services is dependent on sociodemographic factors of the target population, as well as the number of health workers and availability of safe needles and syringes (5). Two studies show that children missed immunizations due to the provider's reluctance to vaccinate children while sick or when visiting health care centres for other purposes (9,28). This study did not focus on these provider risk factors. Lastly, this is a cross-sectional study; therefore, it is difficult to generate cause-and-effect relationships of childhood immunization and risk factors due to the study's design.

In conclusion, this study reinforces the importance of appropriate means of notification or provision of information on vaccination services in order to ensure full immunization (13). In the policy and programme level in Lao PDR, it may be necessary to implement appropriate information system on vaccination services at the community level such as mobilizing the village authorities. Older mothers showed higher odds of having fully immunized children, however, other sociodemographic factors such as maternal education was not associated with vaccination status. Further

detailed qualitative research may be needed to discover how this factor influences vaccination services, along with other maternal sociodemographic factors such as education. Future research needs to target younger children to accurately collect information on vaccination records and other sociodemographic factors. Future studies also have to include health care provider factors that affect vaccination services.

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