Heliyon

ELSEVIER

Received:
12 February 2017
Revised:
26 February 2017
Accepted:
9 March 2017

Heliyon 3 (2017) e00265

Determination of factors affecting the vaccination status of children aged 12–35 months in Lao People's Democratic Republic

Anonh Xeuatvongsa [a], Masahiko Hachiya [b], Shinsuke Miyano [b], Tetsuya Mizoue [c], Tomomi Kitamura [b,*]

[a] *Deputy Director of the Mother and Child Health Center/National Manager of the National Immunization Program, Ministry of Health, Lao People's Democratic Republic: Ban Vutnak, Sisattanak District, Vientiane, Lao People's Democratic Republic*

[b] *Bureau of International Health Cooperation, National Center for Global Health and Medicine, 1-21-1 Toyama, Shinjuku, Tokyo 162-8655, Japan*

[c] *Center for Clinical Sciences, National Center for Global Health and Medicine, 1-21-1 Toyama, Shinjuku, Tokyo 162-8655, Japan*

* Corresponding author.

E-mail address: tkitamura.imcj@gmail.com (T. Kitamura).

Abstract

Vaccines are one of the most important achievements in public health, and a major contributor to this success is the Expanded Programme on Immunization. The utilisation of vaccination services and completion of the recommended schedule are determined by numerous factors. In Lao People's Democratic Republic (Lao PDR), the overall immunisation coverage has been improving. However, notwithstanding the improvement in immunisation coverage and the supplementary immunisation activities, there have been measles, diphtheria, and polio outbreaks in the country. The recent multicounty study of household health surveys revealed that the within-country economic-related inequality in the delivery of a vaccine was still high in Lao PDR.

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Our previous work evaluated the factors associated with vaccination status among the children aged 5–9 years old, which was older age group for this type of study. This study evaluated factors that affect vaccination status among children aged between 12 and 35 months. It is a nationwide population-based cross-sectional study that used data obtained through multistage cluster sampling. We found that the proportion of infants who were fully immunised was lower than the national target and that "maternal ethnicity" (odds ratio (OR) 0.34, 95% confidence interval [CI]: 0.20–0.60), "paternal education" (OR 1.87, 95% CI: 1.12–3.10), and "source of information about vaccination date by medical staff" (OR 1.65, 95% CI: 1.01–2.71) were significantly associated with the children's vaccination status. Numerous factors are associated with the completion of the recommended vaccine schedule, and some factors are location-specific. Identification of these factors should lead to actions for facilitating the optimal use of vaccination services by all the children in Lao PDR.

Keywords: Pediatrics, Immunology, Public health

1. Introduction

Vaccination is considered one of the most important and cost-effective public health services for children [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]. Significant progress has been made towards the development of effective national immunisation programmes, and 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 immunisation services and coverage in order to save children from life-threatening, disabling vaccine-preventable diseases [6, 11]. The EPI has contributed to improvements in coverage; however, the proportion of children completing the recommended vaccination schedule has not increased as anticipated [4, 8, 12]. The identification of factors resulting in the failure to vaccinate or to complete the vaccination schedule is important in order to achieve the EPI targets [13, 14]. The utilisation of vaccination services and completion of the recommended schedule are determined by numerous factors [5, 11, 15, 16, 17, 18, 19, 20, 21, 22]. A systematic review by Rainey et al. and a review by Favin et al. identified reasons for failing to vaccinate or to complete the vaccination schedule, and categorised these into four groups according to whether factors were related to 1) the immunisation system, 2) communication and information, 3) family characteristics, and 4) parental attitudes and knowledge [8, 23]. The reasons for failing to vaccinate or complete the vaccination schedule are multi-factorial; and while no single intervention can address all the identified barriers to timely childhood vaccination, some difficulties are more easily remedied than others [8]. Reasons related to the immunisation system can be addressed by immunisation

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

program managers through established interventions as follows: training of health workers to reduce missed opportunities, strategies to improve communication, and the enhancement of outreach services to remove barriers to vaccination [8, 24]. However, other factors such as parental education, cultural mores, and the role of gender and religious beliefs are complex, country- or region-specific, and difficult to interpret [8, 20, 23]. Thus, location-specific enquiry is required to address factors related to the failure to vaccinate or complete vaccination schedules [23, 25].

The EPI was initiated in Lao People's Democratic Republic (Lao PDR) in 1979 [26]. Immunisation coverage had improved in that measles (MCV1) immunisation coverage was 87%, diphtheria tetanus toxoid and pertussis (DTP3) immunisation coverage was 88%, tuberculosis (BCG) immunisation coverage was 82%, and polio (OPV3) immunisation coverage was 88% in 2014 [27]. The country experienced measles outbreaks between 2012 and 2014, diphtheria outbreaks between 2012 and 2013, and polio outbreaks between 2015 and 2016, despite an improvement in immunisation coverage and several supplementary immunisation activities [28]. The recent multicounty study of household health surveys revealed that Lao PDR was one of the countries where the within-country economic-related inequality in the delivery of three doses of the combined DTP vaccine was highest [10]. The reasons for failing to vaccinate or complete the vaccination schedule need to be studied in order to achieve optimal use of the vaccination services by all the children in Lao PDR and to achieve the national goal of ensuring that at least 95% of infants are fully vaccinated by 2025 [29]. Previously, we have studied the factors associated with the vaccination status among the children aged between 5 and 9 years old [30]. The aim of this study was to identify factors associated with vaccination status among children aged between 12 and 35 months which is normal target population for investigating the factors.

2. Materials and methods

2.1. Study location and population

Lao PDR is a landlocked country in Southeast Asia, bordered by five countries, namely Burma, China, Vietnam, Cambodia, and Thailand. The latest data from the WHO showed that its population was approximately 6.7 million (2013) and the under-5-year-old mortality rate was 71 per 1,000 live births (2012) [31].

2.2. Sampling and sampling frame

The study was conducted to fulfil the following two objectives: 1) to estimate population-based measles and rubella immunity, and 2) to identify factors associated with the vaccination status of the cohort. The sample size was calculated based on the expected measles and rubella IgG sero-prevalence, level of

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

confidence interval, margin of error, design effect, and loss to follow-up. The results of the investigation on first objective will be reported elsewhere. Twenty-six districts were randomly selected by using probability proportional to size from 143 districts, resulting in ten provinces out of seventeen provinces and one municipality, which are scattered all over the country; moreover, two villages were randomly selected from each district using the same sampling strategy as that used for the selection of districts. Eight children (aged between 12 and 35 months) and their caretakers were randomly selected after listing all the candidates in each selected village.

For this study, 416 pairs of children and their caretakers were recruited and assessed for eligibility. Of these pairs, 15 were excluded because the children were aged <12 months or >35 months. A further 84 pairs were excluded because they did not have any vaccination record such as vaccination cards or mother and child handbooks. Finally, data from 317 pairs of children and their caretakers were analysed in this study.

In Lao PDR, the vaccination cards or mother and child handbooks are provided to children who receive any vaccination regulated by the Lao PDR Ministry of Health. Vaccination dates were transcribed from the vaccination cards or mother and child handbooks. Where vaccination dates were inaccurately recorded or not recorded, vaccinations were considered as not given. Each child's vaccination record was checked against the recommended EPI immunisation schedule [32]. Table 1 shows the immunisation schedule in Lao PDR. The following categories were used: fully immunised, if the "standard six" antigens—BCG, DTP3 (3 doses), OPV3 (3 doses), and measles vaccines—had been given by the day of interview; and partially immunised, if at least one recommended vaccine dose had not been given [19, 26, 33]. This study compared children who completed their standard vaccinations (fully immunised/vaccinated) with children who had not completed their vaccinations (partially immunised/vaccinated) at the time of the survey.

Table 1. Vaccination schedule in Lao PDR (2011) (43).

Vaccine	Schedule
HepB	birth
BCG	birth
OPV	6,10,14 weeks
DTwPHibHep	6,10,14 weeks
Measles	9 months

*BCG; Bacille Calmette-Guérin vaccine, DTPHibHep; Diphtheria and tetanus toxoid with pertussis, Hib and Hep B vaccine, HepB; Hepatatis B vaccine, OPV; Oral Polio vaccine.

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

2.3. Collection of data

The survey was conducted between January 2014 and February 2014. A survey team consisting of two surveyors and one supervisor collected demographic information, vaccination status, and other relevant information by using a face-to-face, interview-based questionnaire. The surveyors received 2 days of training, covering an overview of research methods, interview strategies, and ethical considerations. Before each interview, written consent was obtained from the child's caretakers.

2.4. Statistical analysis

Bivariate analysis was performed to assess the relationship between vaccination status and factors relevant to vaccination status. The chi-square test was used for categorical variables, and the Student's *t* test was used for continuous variables. Crude odds ratios (ORs) and 95% confidence intervals (CIs) were calculated by using logistic regression. Multivariate analysis was performed, and the criterion for selecting the independent variables included in the multivariate analysis was the significant level of association with vaccination status in the bivariate analysis ($p < 0.1$). This did not apply to the following variables: "source of information of vaccination (radio/TV)", "source of information of vaccination date (family member/friend)", and "source of information of vaccination date (radio/TV)", as the number of subjects per category was zero. The variable "paternal ethnicity" was excluded from the final multivariate logistic regression model, as it showed the highest multicollinearity among the variables in the model (variance inflation factor: VIF > 10). Backward stepwise selection was applied with the level of significance for variables to remain in the final model set at 0.05. A P value of <0.05 was considered statistically significant. Stata version 11.0/14.0 was used to perform all the statistical analyses.

2.5. Ethical considerations

The survey was reviewed and approved by the ethical committee of the Ministry of Health, Lao PDR (025NECHR), and the institutional review board of the National Center for Global Health and Medicine, Japan (NCGM-G-001459-00). 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 the subjects

Fig. 1 shows the profile of the study subjects. For the analysis, 317 children aged between 12 and 35 months were eligible, after excluding those whose ages were

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

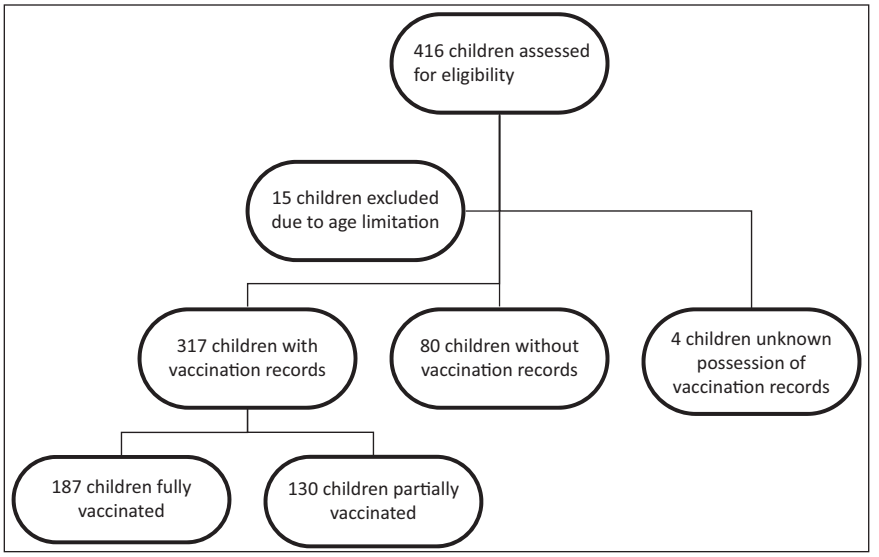

Fig. 1. Study profile.

outside the target age range, those who did not have any records for vaccination, and those for whom data regarding possession of vaccination records were unknown.

Among the eligible study subjects, the proportion of children holding a vaccination card or a mother and child handbook, or both was 39.1%, 36.6%, and 24.3%, respectively. In total, 187 children (59%) were fully immunised and 130 children (41%) were partially immunised.

3.2. Factors associated with vaccination status

Factors relating to family characteristics such as maternal/paternal ethnicity (maternal ethnicity: OR 0.31, 95% CI: 0.18–0.53, paternal ethnicity: OR 0.32, 95% CI: 0.19–0.54), maternal/paternal occupation (maternal occupation: OR 2.60, 95% CI: 1.57–4.33, paternal occupation: OR 2.05, 95% CI: 1.26–3.33), and maternal/paternal education (maternal education: OR 1.66, 95% CI: 1.05–2.61, paternal education: OR 2.16, 95% CI: 1.34–3.48) were associated with full vaccination of the children (Table 2). Health system and health service utilisation factors such as time taken to reach the nearest health facilities (OR 0.60, 95% CI: 0.37–0.96), birthplace of the children (OR 2.15, 95% CI: 1.34–3.45), and vaccination within the hospital setting (OR 2.42, 95% CI: 1.53–3.84) or as part of an outreach activity (OR 0.48, 95% CI: 0.30–0.78), were associated with full vaccination status (Table 3). Source of information regarding the vaccination from the vaccination card (OR 2.02, 95% CI: 1.17–3.50) or radio/TV, and notification of the vaccination date by medical staff (OR 1.67, 95% CI: 1.06–2.63), family members/friends, or radio/TV were also associated with full vaccination status (Table 4).

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Table 2. Family characteristic-related factors of childhood vaccination status.

	Fully immunised <N=187> (%)	Partially immunised <N=130> (%)	Crude OR (95% CI)	p-value
Sex of children				0.35
Boy	95 (50.80)	73 (56.15)	References	
Girl	92 (49.20)	57 (43.85)	1.24 (0.79–1.94)	
Mean maternal age (years) ± SD	28.41 ± 0.46	28.33 ± 0.62		0.91
Maternal ethnicity				<0.01
Laolum	155 (83.33)	79 (60.77)	References	
Non Laolum	31 (16.67)	51 (39.23)	0.31 (0.18–0.53)	
Maternal occupation				<0.01
farmer	103 (55.08)	99 (78.15)	References	
not farmers	84 (44.92)	31 (23.85)	2.60 (1.57–4.33)	
Maternal education				0.03
Primary school	81 (44.02)	73 (56.59)	References	
More than primary school	103 (55.98)	56 (43.41)	1.66 (1.05–2.61)	
Mean paternal age (years) ± SD	33.59 ± 0.68	35.14 ± 0.75		0.66
Paternal ethnicity				<0.01
Laolum	144 (83.24)	77 (61.11)	References	
Non Laolum	29 (16.76)	49 (38.89)	0.32 (0.19–0.54)	
Paternal occupation*				<0.01
farmer	87 (50.29)	85 (67.46)	References	
not farmers	86 (49.71)	41 (32.54)	2.05 (1.26–3.33)	
Paternal education**				<0.01
Primary school	51 (29.65)	60 (47.62)	References	
More than primary school	121 (70.35)	66 (52.38)	2.16 (1.34–3.48)	
Mean number of children (children) ± SD (<15 years old)	2.44 ± 0.08	2.27 ± 0.13		0.23

CI; 95% confidence interval.

Fully immunised– BCG, diphtheria-tetanus perttusis (DTP) (3 doses), polio (3 doses), and measles vaccines.

* There are 18 missing values.

** There are 19 missing values.

The multivariate logistic regression model revealed that "maternal ethnicity" (OR 0.34, 95% CI: 0.20–0.60), "paternal education" (OR 1.87, 95% CI: 1.12–3.10), and "source of information about vaccination date by medical staff" (OR 1.65, 95% CI: 1.01–2.71) were significantly associated with full vaccination status (Table 5).

4. Discussion

This study found that 187 children (59%) were fully immunised and 130 children (41%) were partially immunised. It also identified factors associated with the

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Table 3. Health system and health service utilisation factors of childhood vaccination status.

	Fully immunised <N=187> (%)	Partially immunised <N=130> (%)	Crude OR (95% CI)	p-value
Time taken to the nearest health facilities				0.03
<30 minutes	130 (69.52)	75 (57.69)	Reference	
>= 30 minutes	57 (30.48)	55 (42.31)	0.60 (0.37–0.96)	
Birth place of children*				<0.01
Health facility	127 (68.28)	65 (50.00)	2.15 (1.34–3.45)	
not health facility	59 (31.72)	65 (50.00)	Reference	
Received vaccination in hospital**				<0.01
yes	110 (59.46)	49 (37.69)	2.42 (1.53–3.84)	
no	75 (40.54)	81 (62.31)	Reference	
Received vaccination in health centre***				0.27
yes	45 (24.46)	39 (30.00)	0.76 (0.46–1.25)	
no	139 (75.54)	91 (70.00)	Reference	
Received vaccination in outreach in village****				<0.01
yes	51 (27.42)	57 (43.85)	0.48 (0.30–0.78)	
no	135 (72.58)	73 (56.15)	Reference	

* There are 1 missing value.
** There are 2 missing values.
*** There are 3 missing values.
**** There are 1 missing value.

vaccination status of children aged between 12 and 35 months in Lao PDR and showed that maternal ethnicity, paternal education, and notification of the vaccination date by medical staff were associated with full vaccination status.

4.1. Family characteristic-related factors

Rainey et al. found that family characteristics relevant to vaccination status included caretaker ethnicity, socio-economic status, and education level [8].

Caretaker age is not mentioned in the list compiled by Rainey et al. but is often described as one of the risk factors for the vaccination status of the children, particularly maternal age. However, the association between childhood vaccination status and maternal age is controversial in the literature [5, 6, 8, 22, 24, 33]. Our previous study conducted among the children aged 5–9 years old has shown that full vaccination increases with maternal age [30]. This study showed no association between both maternal and paternal ages and vaccination status in this age group.

The relationship between childhood vaccination status and maternal/paternal ethnicity is also controversial [11, 28, 34, 35]. The reasons for this phenomenon are complex and often location specific [11]. One study in Lao PDR showed that

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Table 4. Communication, information, and knowledge factors of childhood vaccination status.

	Fully immunised <N=187> (%)	Partially immunised <N=130> (%)	Crude OR (95% CI)	p-value
Source of information of vaccination				
From medical staff[+]				0.31
yes	113 (61.08)	72 (55.38)	1.26 (0.80–1.99)	
no	72 (38.92)	58 (44.62)	Reference	
From village health volunteer[++]				0.33
yes	61 (33.15)	50 (38.46)	0.79 (0.50–1.27)	
no	123 (66.85)	80 (61.54)	Reference	
From information written on the vaccination cards[+++]				0.01
yes	56 (30.27)	23 (17.69)	2.02 (1.17–3.50)	
no	129 (69.73)	107 (82.31)	Reference	
From family member or friends[#]				0.69
yes	4 (2.17)	2 (1.54)	1.42 (0.26–7.88)	
no	180 (97.83)	128 (98.46)	Reference	
From radio/TV[##]				<0.01
yes	0 (0.00)	5 (3.85)		
no	184 (100.0)	125 (96.15)		
From poster[###]				0.23
yes	0 (0.00)	1 (0.77)		
no	184 (100.0)	129 (99.23)		
From local authority[x]				0.66
yes	68 (36.76)	51 (39.23)	0.90 (0.57–1.43)	
no	117 (63.24)	79 (60.77)	Reference	
From women's union[xx]				0.29
yes	16 (8.65)	16 (12.31)	0.67 (0.32–1.40)	
no	169 (91.35)	114 (87.69)	Reference	
Number of source of information of vaccination[xxx]				0.66
1	104 (56.52)	78 (60.00)	References	
2	46 (25.00)	33 (25.38)	1.05 (0.61–1.78)	
>=3	34 (18.48)	19 (14.62)	1.34 (0.71–2.53)	
Source of information of vaccination date				
From medical staff[a]				0.03
yes	101 (54.30)	54 (41.54)	1.67 (1.06–2.63)	
no	85 (45.70)	76 (58.46)	Reference	
From village health volunteer[b]				0.93
yes	60 (32.61)	43 (33.08)	0.98 (0.61–1.58)	
no	124 (67.39)	87 (66.92)	Reference	

(*Continued*)

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Table 4. (*Continued*)

	Fully immunised <N=187> (%)	Partially immunised <N=130> (%)	Crude OR (95% CI)	p-value
From information written on vaccination card[c]				0.07
yes	71 (38.38)	37 (28.46)	1.57 (0.96–2.55)	
no	114 (61.62)	93 (71.54)	Reference	
From family member or friend[d]				<0.01
yes	0 (0.00)	5 (3.85)		
no	184 (100.0)	125 (96.15)		
From radio/TV[e]				<0.01
yes	0 (0.00)	5 (3.85)		
no	184 (100.0)	125 (96.15)		
Froom poster[f]				0.78
yes	2 (1.09)	1 (0.77)	1.42 (0.13–15.80)	
no	182 (98.91)	129 (99.23)	Reference	
From local authority[g]				0.37
yes	59 (32.07)	48 (36.92)	0.81 (0.50–1.29)	
no	125 (67.93)	82 (63.08)	Reference	
From woman's union[h]				0.70
yes	21 (11.35)	13 (10.00)	1.15 (0.55–2.39)	
no	164 (88.65)	117 (90.00)	Reference	
From megaphone[i]				0.22
yes	7 (3.80)	9 (6.92)	0.53 (0.19–1.47)	
no	177 (96.20)	121 (93.08)	Reference	
From official letter from district governor[j]				0.14
yes	3 (1.64)	0 (0.00)		
no	180 (98.36)	130 (100.0)		
Number of source of information of vaccination date[j]				0.75
0–1	105 (57.38)	79 (60.77)	References	
2	41 (22.40)	29 (22.31)	1.06 (0.61–1.86)	
>=3	37 (20.22)	22 (16.92)	1.27 (0.69–2.31)	

Source of information of vaccination: [+]there are 2 missing values.[++]there are 3 missing values.[+++]there are 2 missing values. [#]there are 3 missing values. [##] there are 3 missing values. [###]there are 3 missing values. [x] there are 2 missing values. [xx]there are 2 missing values. [xxx]there are 3 missing values.

Source of information of vaccination date: [a]there are 1 missing value. [b]there are 3 missing values. [c]there are 2 missing values. [d]there are 3 missing values. [e]there are 3 missing values. [f]there are 3 missing values. [g]there are 3 missing values. [h]there are 2 missing values. [i]there are 3 missing values. [j]there are 4 missing values.

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Table 5. Multivariate analysis of the factors associated with childhood vaccination status.

Factors	Adjusted OR (95% CI)	p-value
Maternal ethnicity		<0.01
Laolum	Reference	
Non Laolum	0.34 (0.20–0.60)	
Paternal education		0.016
Primary school	Reference	
More than primary school	1.87 (1.12–3.10)	
Information of vaccination date by medical staff		0.045
yes	1.65 (1.01–2.71)	
no	Reference	

The variables included in the model were "Maternal ethnicity", "Maternal/Paternal occupation", "Maternal/Paternal education", "Time taken to the nearest health facility", "Birth place", "Received vaccination at hospital", "Received vaccination during outreach activity", "Information of vaccination by vaccination card", Information of vaccination date by medical staff", and "Information of vaccination date by vaccination card". Backward stepwise selection was applied.
"Paternal ethnicity" was dropped due to multicollinearity.

Laolum, which was considered to be a dominant ethnic group, was better vaccinated than the other ethnic groups [28]. A qualitative literature review conducted in Lao PDR found that immunisation obstacles are rather linked to culture and ethnicity, as the health system tends to be tailored to the culture and predominance of ethno-medical beliefs among the ethnically dominant group [36]. Multivariate analysis showed the association between ethnicity of the mother and child vaccination status. Father's ethnicity was excluded from the final multivariate logistic regression model because of high multicollinearity.

Numerous studies have shown the association between failure to vaccinate or complete the vaccination schedule and maternal/paternal occupation or low socio-economic status of the household, as maternal/paternal occupation is often considered to be a proxy for the level of income/socio-economic status of the household [8, 9, 10, 11, 12, 13, 17, 22, 23, 36, 37, 38, 39]. Maekawa et al. found no association between vaccination status and maternal/paternal occupation in Lao PDR [40]. This finding may be explained by the fact that the EPI programme in Lao PDR is free of charge; therefore, maternal/paternal occupation may not affect vaccination status. Alternatively, it can be explained by the possibility that outreach services can reduce socioeconomic differentials [18]. Final multivariate analysis of this study did not show any association between vaccination status and maternal/paternal occupation. However, Hossenpoor et al. reported a large difference in the national DTP3 immunisation coverage between the richest and

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

poorest quintiles in Lao PDR; hence, the within-country economic-related inequality should be investigated in future studies [10].

Many studies have shown that maternal education or literacy is positively associated with the vaccination status of children, such as complete and timely immunisation [1, 5, 6, 12, 13, 18, 19, 28, 38, 40, 41]. However, Parashar's study showed that a child's vaccination status is affected not only by maternal education level but also by education level of women in the wider context, at the community level [38]. Johri et al. suggest that improving health literacy may circumvent barriers due to low education level and improve vaccination coverage [24]. A study conducted in Lao PDR demonstrated that maternal education is associated with immunisation services attendance [39]. Three further studies in Lao PDR showed that maternal education or literacy is associated with vaccination status [28, 36, 40]. Fewer studies have measured and showed the significant association between paternal education and vaccination status [13, 24, 42, 43]. In Lao PDR, one study found that low paternal education level was a risk factor of non-vaccination [39]. Bivariate analysis revealed that maternal/paternal education was associated with vaccination status. The association with paternal education was significant in the multivariate analysis.

4.2. Health system and health service utilisation factors

Access to the nearest health facilities is one of the well-known factors associated with vaccination status [6, 8, 23, 28, 34, 39, 40]. Three studies from Lao PDR demonstrated that distance to the health facility or the zone of residence is associated with vaccination status [28, 39, 40]. This study focused on time, rather than distance, to health facilities because access depends not only on distance but also on road accessibility and on the availability of transportation. Time taken to the nearest health facility was not significantly associated with vaccination status in the multivariate analysis.

Evidence shows an association between vaccination status and the location where caretakers or children receive health-care services [5, 8, 21]. Caretakers' experiences of health-care services and the information provided during the services may shape their attitude towards future use of health services, but this is context specific [9, 21, 23, 25, 28, 39, 43]. This study showed that facility-based delivery, that is, vaccination within a hospital or outreach setting, was associated with full vaccination of the children in the bivariate analysis. However, this association was not significant in the multivariate analysis.

4.3. Communication, information, and knowledge factors

A number of studies found that comprehensive and appropriate information provision and access to information affect vaccination status [3, 6, 36]. Several

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

studies from Lao PDR showed that maternal knowledge of diseases targeted by immunisation programs and of immunisation age and schedules are associated with vaccination status [39, 40, 44]. The local authority such as chief of village is considered to be a key person to disseminate information regarding health in the village and our previous study in Lao PDR showed that notification of the vaccination date by the local authority increased the odds of children being fully vaccinated [30]. Nanthavong et al. reported that the absence of advice given at birth independently associated with non-vaccination of children [28]. This study showed that notification of vaccination date by medical staff increased the odds of full vaccination status and this finding may imply that the increased number of contacts between the caretakers and the medical staff.

Another study showed that use of appropriate information and communication strategies through the radio and TV increased vaccination coverage when the information or message were adapted to the local cultural health belief system or perspective, so that information was understandable and acceptable [6, 36]. In Lao PDR, IEC materials related to immunisation such as posters are distributed to the health facilities by the Ministry of Health and the radio and TV are also used to disseminate information about vaccination campaigns. This study showed that a limited number of subjects made use of information provided through the radio, TV, or posters.

This study has several limitations. First, all the children and their caretakers who did not possess any certification of vaccination were excluded from this analysis. Children and mothers with vaccination cards were compared with those without. The following factors were associated with "possession of vaccination cards": time taken to reach the nearest health facility, absence of traditional birth attendants at the time of birth, and vaccination within a hospital or health centre setting (data not shown). Second, only written records (vaccination cards and mother and child handbooks) were used in order to avoid inaccuracies in the vaccination history. Parent recollection of vaccination was not accepted. Vaccination cards and mother and child handbooks were the sole source of immunisation information in this study. Third, this study did not focus on immunisation system factors, except for access to and distance from vaccination services [8]. Factors such as the availability of health-care workers and equipment for vaccination, and the limited knowledge of health-care workers, resulting in missed opportunities to vaccinate, were not included [5, 6, 8, 13]. Fourth, which information or knowledge is useful for caretakers is not clear, as this study did not investigate the information obtained by caretakers. Finally, this was a cross-sectional study; therefore, a cause-and-effect relationship between childhood immunisation and risk factors was difficult to identify.

This study is the only nationwide study to identify factors associated with the vaccination status of children in Lao PDR, except for the Multiple Indicator Cluster

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Survey (MICS) data analysis and systematic review of qualitative data conducted by the Swiss Centre for International Health to investigate the association between gender and immunisation [36]. The MICS data analysis showed that maternal education and maternal tetanus toxoid status were strongly associated with child immunisation status, and the review of qualitative data indicated that socio-demographic factors, community awareness on immunisation, and quality of services were associated with vaccination status [36].

5. Conclusions

This study found that the proportion of infants who were fully immunised was still lower than the national target and maternal ethnicity, paternal education, and notification of the vaccination date by medical staff were associated with full vaccination status. It also found that TV, radio, and posters were underutilised sources of information on vaccination programs or of vaccination date notification. This finding suggests that targeted and culturally acceptable sub-group specific messages, using appropriate means of communication, are necessary [39]. It also suggests that fathers may play a role in decision-making as well and that the vaccination status may be improved by providing health education to improve health literacy of both mothers and fathers [24, 39]. This study highlights that health-care workers should clearly provide information on vaccinations, including the vaccination schedule.

The completion of the recommended vaccine schedule is determined by numerous factors, and some of these are location specific. Identification of these factors should result in actions facilitating the optimal use of vaccination services by all the children in Lao PDR.

Declarations

Author contribution statement

Tomomi Kitamura and Anonh Xeuatvongsa: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Masahiko Hachiya: Conceived and designed the experiments; Wrote the paper.

Shinsuke Miyano: Conceived and designed the experiments.

Tetsuya Mizoue: Analyzed and interpreted the data; Wrote the paper.

Funding statement

This work was supported by The Grant for National Center for Global Health and Medicine (27–4).

http://dx.doi.org/10.1016/j.heliyon.2017.e00265

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgments

We express our sincerest gratitude to all the health authorities of Lao PDR and to the children and their caretakers who participated in this study.

We thank Dr Ikuma Nozaki for his advice on the manuscript.

References

[1] K. Muhsen, R. Abed El-Hai, A. Amit-Aharon, H. Nehama, M. Gondia, N. Davidovitch, et al., Risk factors of underutilization of childhood immunizations in ultraorthodox Jewish communities in Israel despite high access to health care services, Vaccine 30 (2012) 2109–2115.

[2] L. Rodewald, E. Maes, J. Stevenson, B. Lyons, S. Stokley, P. Szilagyi, Immunization performance measurement in a changing immunization environment, Pediatrics 103 (1999) 889–897.

[3] A.K. Koumare, D. Traore, F. Haidara, F. Sissoko, I. Traore, S. Drame, et al., Evaluation of immunization coverage within the Expanded Program on Immunization in Kita Circle, Mali : a cross-sectional survey, BMC Int. Health Hum. Rights 9 (2009) S13.

[4] R.W. Linkins, D.A. Salmon, S.B. Omer, W.K. Pan, S. Stokley, N.A. Halsey, Support for immunization registries among parents of vaccinated and unvaccinated school-aged children: a case control study, BMC Public Health 6 (2006) 236.

[5] O.O. Odusanya, E.F. Alufohai, F.P. Meurice, V.I. Ahonkhai, Determinants of vaccination coverage in rural Nigeria, BMC Public Health 8 (2008) 381.

[6] K. Jamil, A. Bhuiya, K. Streatfield, N. Chakrabarty, The immunization programme in Bangladesh: impressive gains in coverage but gaps remain, Health Policy Plan. 14 (1999) 49–58.

[7] J. Xie, W.H. Dow, Longitudinal study of child immunization determinants in China, Soc. Sci. Med. 61 (2005) 601–611.

[8] 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.

[9] H.J. Larson, C. Jarrett, E. Eckersberger, D.M. Smith, P. Paterson, Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007-2012, Vaccine 32 (2014) 2150–2159.

[10] A. Hosseinpoor, N. Bergen, A. Sholotheuber, M. Gacic-Dobo, P.M. Hansen, K. Senouci, et al., State of inequality in diphtheria-tetanus-pertussis immunisation coverage in low-income and middle-income countries: a multicountry study of household health surveys, Lancet Glob. Health 4 (2016) e617–e626.

[11] A. Sheikh, B. Iqbal, A. Ehtamam, M. Rahim, H.A. Shaikh, H.A. Usmani, et al., Reasons for non-vaccination in pediatric patients visiting tertiary care centers in a polio-prone country, Arch. Public Health 71 (2013) 19.

[12] G.B. Fosu, Childhood morbidity and health services utilization: cross-national comparisons of user-related factors from DHS data, Soc. Sci. Med. 38 (1994) 1209–1220.

[13] S.D. Torun, N. Bakirci, Vaccination coverage and reasons for non-vaccination in a district of Istanbul, BMC Public Health 6 (2006) 125.

[14] D.A. Salmon, L.H. Moulton, S.B. Omer, M.P. DeHart, S. Stokley, N.A. Halsey, Factors associated with refusal of childhood vaccines among parents of school-aged children: a case-control study, Arch. Pediatr. Adolesc. Med. 159 (2005) 470–476.

[15] V. Balraj, S. Mukundan, R. Samuel, T.J. John, Factors affecting immunization coverage levels in a district of India, Int. J. Epidemiol. 22 (1993) 1146–1153.

[16] C. Perks, M.J. Toole, K. Phouthonsy, District health programmes and health-sector reform: case study in the Lao People's Democratic Republic, Bull. World Health Organ. 84 (2006) 132–138.

[17] A. Topuzoglu, G.A. Ozaydin, S. Cali, D. Cebeci, S. Kalaca, H. Harmanci, Assessment of sociodemographic factors and socio-economic status affecting the coverage of compulsory and private immunization services in Istanbu, Turkey, Public Health 119 (2005) 862–869.

[18] D. Bishai, E. Suzuki, M. McQuestion, J. Chakraborty, M. Koenig, The role of public health programmes in reducing socioeconomic inequities in childhood immunization coverage, Health Policy Plan. 17 (2002) 412–419.

 http://dx.doi.org/10.1016/j.heliyon.2017.e00265

[19] K. Streatfield, M. Singarimbun, I. Diamond, Maternal education and child immunization, Demography 27 (1990) 447–455.

[20] W. Ha, P. Salama, S. Gwavuya, C. Kanjala, Is religion the forgotten variable in maternal and child health? Evidence from Zimbabwe, Soc. Sci. Med. 118 (2014) 80–88.

[21] C.A. Moyer, L. Tadesse, S. Fisseha, The relationship between facility delivery and infant immunization in Ethiopia, Int. J. Gynaecol. Obstet. 123 (2013) 217–220.

[22] M. Ganczak, G. Dmytrzyk-Danilow, B. Karakiewicz, M. Korzen, Z. Szych, Determinants influencing self-paid vaccination coverage, in 0-5 years old Polish children, Vaccine 31 (2013) 5687–5692.

[23] M. Favin, R. Steinglass, R. Fields, K. Banerjee, M. Sawhney, Why children are not vaccinated: a review of the grey literature, Int. Health 4 (2012) 229–238.

[24] M. Johri, S.V. Subramanian, M.P. Sylvestre, S. Dudeja, D. Chandra, G.K. Kone, et al., Association between maternal health literacy and child vaccination in India: a cross-sectional study, J. Epidemiol. Community Health 69 (2015) 849–857.

[25] C. Gowda, S.E. Schaffer, K. Kopec, A. Markel, A.F. Dempsey, Does the relative importance of MMR vaccine concerns differ by degree of parental vaccine hesitancy?: An exploratory study, Hum. Vaccin. Immunother. 9 (2013) 430–436.

[26] WHO, International Review of the Expanded Programme on Immunization in the Lao People's Democratic Republic [PDF], World Health Organization, Geneva, 2012. (cited 12.05.2015; accessed 29.06.2016) http://www.wpro.who.int/immunization/documents/Intl_Review_of_EPI_in_Lao.pdf.

[27] UNICEF, Lao People's Democratic Republic: WHO and UNICEF estimates of immunization coverage: 2014 revision [PDF], World Health Organization, 2015. (updated 07.07.2015; cited 12.06.2015; accessed 29.06.2016) http://data.unicef.org/fckimages/uploads/immunization/lao_peoples_democratic_republic.pdf.

[28] N. Nanthavong, A. Black, P. Nouanthong, C. Souvannaso, K. Vilivong, C. Muller, et al., Diphtheria in Lao PDR: insufficient coverage or ineffective vaccine? PloS ONE 10 (4) (2015) e0121749.

[29] Ministry of Health, Lao People's Democratic Republic: National Strategy and Action Plan for Integrated Services on Reproductive, Maternal, Newborn and Child Health 2016–2020, (2016).

 http://dx.doi.org/10.1016/j.heliyon.2017.e00265

[30] T. Kitamura, K. Komada, A. Xeuatvongsa, M. Hachiya, Factors affecting childhood immunization in Lao People's Democratic Republic: a cross-sectional study from nationwide population-based, multistage cluster sampling, Biosci. Trends 7 (2013) 178–185.

[31] WHO, Lao People's Democratic Republic: WHO statistical profile [PDF], World Health Organization, 2015. (cited 12.06.2015; accessed 29.06.2016) http://www.who.int/gho/countries/lao.pdf?ua=1.

[32] UNICEF, WHO. Immunization Summary [PDF], The United Nations Children's Fund, 2003. (accessed 29.06.2016) http://www.unicef.org/immunization/files/EN-ImmSumm-2013.pdf.

[33] E. Robert, M. Dramaix, B. Swennen, Vaccination coverage for infants: cross-sectional studies in two regions of Belgium, Biomed. Res. Int 2014 (2014) 838907.

[34] A.J. Gage, Familial and socioeconomic influences on children's well-being: an examination of preschool children in Kenya, Soc. Sci. Med. 45 (1997) 1811–1828.

[35] J. Rosenthal, L. Rodewald, M. McCauley, S. Berman, M. Irigoyen, M. Sawyer, et al., Immunization coverage levels among 19- to 35-month-old children in 4 diverse, medically underserved areas of the United States, Pediatrics 113 (2004) e296–302.

[36] A. Hilber, X. Bosch-Capblanch, C. Schindler, L. Beck, F. Sécula, O. McKenzie, et al., Gender and Immunisation: Summary report for SAGE, (2010), pp. 206. (accessed 30.12.2015) http://www.who.int/immunization/sage/1_immunization_gender_reports_without_graphics.pdf.

[37] F.T. Cutts, D.C. Glik, A. Gordon, K. Parker, S. Diallo, F. Haba, et al., Application of multiple methods to study the immunization programme in an urban area of Guinea, Bull. World Health Organ. 68 (1990) 769–776.

[38] S. Parashar, Moving beyond the mother-child dyad: women's education, child immunization, and the importance of context in rural India, Soc. Sci. Med. 61 (2005) 989–1000.

[39] M. Phimmasane, S. Douangmala, P. Koffi, D. Reinharz, Y. Buisson, Factors affecting compliance with measles vaccination in Lao PDR, Vaccine 28 (2010) 6723–6729.

[40] M. Maekawa, S. Douangmala, K. Sakisaka, K. Takahashi, O. Phathammavong, A. Xeuatvongsa, et al., Factors affecting routine immunization coverage among children aged 12-59 months in Lao PDR after regional polio eradication in western Pacific region, Biosci. Trends 1 (2007) 43–51.

 http://dx.doi.org/10.1016/j.heliyon.2017.e00265

[41] T.A. Lim, L. Marinova, M. Kojouharova, S. Tsolova, J.C. Semenza, Measles outbreak in Bulgaria: poor maternal educational attainment as a risk factor for medical complications, Eur. J. Public Health 23 (2013) 663–669.

[42] R.F. Brugha, J.P. Kevany, A.V. Swan, An investigation of the role of fathers in immunization uptake, Int. J. Epidemiol. 25 (1996) 840–845.

[43] A. Rammohan, N. Awofeso, R.C. Fernandez, Paternal education status significantly influences infants' measles vaccination uptake, independent of maternal education status, BMC Public Health 12 (2012) 336.

[44] K. Phouphenghack, W. Kamsrichan, S. Vorakitpokatorn, Knowledge and perception of mothers about immunization of children under 3 years of age in the Saythany distric. Vientiane, Lao P.D.R, J. Public Health 5 (2007) 107–116.

http://dx.doi.org/10.1016/j.heliyon.2017.e00265