

Evaluation of Village-level Childhood Immunization Coverage in the Lao People's Democratic Republic: Measles as indicator?

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Abstract

Background: Outbreaks of vaccine preventable-disease control and elimination are impeded by impaired focal vaccination uptake. Therefore, we aimed at assessing vaccination uptake and comparing with passive surveillance (PS) report at village level.

Methods: A community-based cross-sectional survey was conducted in the villages covered by two health centers in Bolikhamxay province, including non-Hmong and Hmong ethnic groups. Data collection was conducted by interviewing mothers or caregivers of children aged 6 to 23 months. The vaccination status was identified by vaccination cards, and compared with PS report at village level, which was collected from health centers. The Pearson's chi-square test was used to compare these proportions, and pairwise correlation was used for the correlation of observed vaccination coverage.

Finding: Sixteen villages were included, nine were from Luk52 health center area and 7 from Namkhou health center area. There was a significantly strong correlation for pentavalent pneumococcal conjugate vaccine, Japanese encephalitis, Measles and Rubella and full immunization coverage compared to others. This correlation was not observed in the non-Hmong population. Amongst non-Hmong, the recorded coverage was lower in PS than in the survey regardless of type of vaccine. In contrast, amongst Hmong most vaccines had higher recorded coverage in PS than in the survey except Bacillus Calmette–Guérin (BCG) and hepatitis B at birth dose. MR and JEV vaccine, commonly given at the same time, were the only one that did not have significantly different coverage between PS and the survey ($p < 0.334$).

Conclusion: The mis-estimation of immunization coverage from the PS reporting system highlights further research needed to determine a better indicator of village-level vaccination coverage, but measles could be an indicator of prioritizing the settings.

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Introduction

Immunization is one of the most cost-effective public health interventions in reducing child morbidity and mortality and preventing the spread of contagious diseases, but require maintaining the appropriate vaccination uptake [1]. Therefore, the Expanded Program on Immunization (EPI) was established to ensure the protection of children against vaccine preventable diseases and to

facilitate the access to routinely recommended vaccines by increasing the immunization coverage.

Globally, about 86% of infants have completed three doses of Diphtheria Tetanus and Pertussis (DPT) and measles vaccine, a basic set of vaccine in 2018 [2], leaving 19.4 million infants worldwide unprotected against infectious diseases that can cause serious illness and disability in which 60% live in African countries [3, 4]. However, the poor monitoring, political and economic crisis challenge

the sustainable improvement of vaccination coverage, leading gain loss so quickly. The incidence of measles has globally increased from 19 cases in 2016 to 25 cases per million in 2017 [3]. Moreover, about 350,000 measles cases were reported worldwide in 2018 including countries with high vaccination coverage, representing more than double increase from the previous year [5].

In Lao People's Democratic Republic (Lao PDR), EPI launched in 1982 [6]. The program is considered to be the highest priority among the preventive programs in the country. Immunization services are provided free of charge to eligible beneficiaries in all villages and communities in Lao PDR. The infant vaccines provided in the Lao PDR include polio, tuberculosis, first dose of hepatitis B, pentavalent vaccine (Diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae), three-doses Pneumococcal Conjugate Vaccine (PCV), Inactivated Polio Vaccine (IPV), Japanese encephalitis virus, measles and rubella first and second dose. Infants could get vaccinated either through outreach or at health facilities. The outreach program is monthly organized at village by healthcare workers from health centers and district health departments [7].

It was reported that the immunization coverage in Lao PDR has been a steady improvement from 2010 to 2015. Estimated Lao DTP3 coverage has increased from 74% in 2010 to 89% in 2015, but has steadily decreased since then with estimated 2018 coverage of 68%. The similar trend was also found in measles vaccination uptake with estimated 2018 coverage of 69% [8]. The low coverage was found in ethnic minorities particularly in Hmong ethnic in which vaccine preventable-diseases outbreak has periodically occurred. This included diphtheria, polio and measles. The last outbreak of measles occurred in 2019 with the total number of cases of 379, which occurred in 10 provinces, but most in ethnic minority population [9]. This reflects the disparity of vaccination uptake in subgroup of population in which the overall coverage is misleading the program evaluation.

Due to financial and human resources constraint, evaluating is a huge challenge in low and middle-income countries to respond appropriately to the large scale of interventions like requesting by EPI program. The empirical intervention is therefore essential to improve the healthcare system, leading to improve health of the population and economic growth of the country. However, there is an urgent need of identifying the fundamental characteristics of vaccination coverage at village-level. There is no study conducted in Lao PDR to provide evidence-base of sciences in this issue. We therefore aimed at assessing the childhood vaccination status and comparing its coverage with

the passive surveillance reports at village level of Lao PDR.

the reflecting the urgent need of program evaluation. Due to the vaccination coverage trend of Lao PDR was decline since 2016, the evaluation of immunization coverage is useful for the design and implementation of interventions for the control and elimination of vaccine preventable diseases. Therefore, this study aimed at assessing the childhood vaccination status and comparing its coverage with the passive surveillance reports at village level of Lao PDR.

Methodology

Study design and sites

This study is a part of the main study, which aimed at determining the effectiveness of intervention to improve immunization coverage in ethnic group. We compared the vaccination coverage between the survey and the passive surveillance at village level. The community-based cross-sectional survey was conducted to assess the vaccination uptake in children aged 6-23 months old living in Pakkading and Phonhong districts of Bolikhamxay and Vientiane province, respectively. These districts were selected because of their ethnic diversity and previous outbreak of vaccine preventable-diseases (Figure 1) [10, 11]. Among these, we selected Hmong and non-Hmong villages serviced by the same health center. It was Namkou health center for Pakkading district and Luk52 health center for Phonhong district. Based on the sample size needed for the main study, the total of seven and nine villages were selected for Namkou health center and Luk52 health center, respectively.

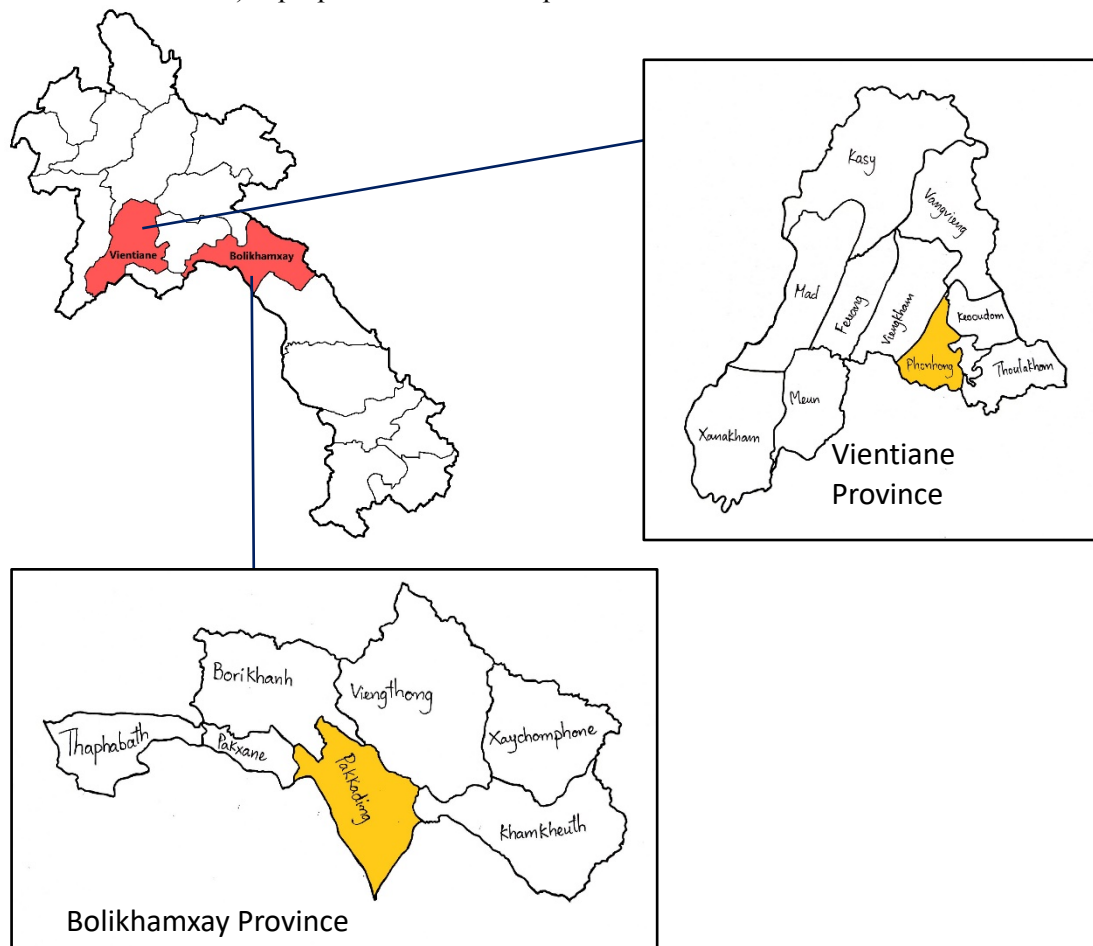
Pakkading district is bordered with southern part of Vientiane capital, along the Mekong river. The majority of ethnic group is Lao-tai ethnic. Hmong population lives at Namkhou health center area where surrounded by big market and located about 20 km from the Pakkading city center. There are only one Hmong village, which is the largest village of the area. Most of villagers are farmer and live in the poor condition despite the accessibility to health facilities and commercials. Other non-Hmong villages are dominated by Lao-tai ethnic, a main ethnicity of Lao PDR.

Phonhong district is bordered with northern part of Vientiane capital, located on the north road number 13 and classified as semi-urban setting. Luk52 health center is about 30 Km from the district hospital and is an economic zone of the district. However, many people remain relying on daily income and agriculture. This area was used to be dominated by Hmong population, but more and more mixed ethnic living in the same village.

Outcome measurement

The childhood vaccination status was assessed by either the vaccination card or maternal and child health handbook and mother recall of children aged 6-23 months. The detail of vaccination, which included type of vaccine and date of vaccination, was extracted from child vaccination card or maternal and child health handbook if it was available. The main study indicators based on vaccination card/maternal and child health handbook are 1) proportion of complete

pentavalent vaccination in children aged 6-23 months, and 2) proportion of full and measles immunization in children aged 12-23 months. The former one was defined as hepatitis B at birth dose, first, second and third doses. The full immunization was defined, based on national schedule and Lao Social Indicators Survey (LSIS) 2017 [7], as a complete pentavalent, BCG, complete polio and first dose Measles vaccines.



Data collection process

The data was collected in Pakkading district between 6 and 13 March 2019 and in Phonhong district between 3 and 10 April 2019 by well-trained data collectors. This consists of three people (2 Lao-tai and 1 Hmong ethnics) with one supervisor per group performed the data collection based on the list of eligible household provided and validated. The list of eligible households was done by Village Health Volunteers, heads of village and healthcare workers, and validated by research team. The validation was done by randomly selecting four villages, Hmong and non-Hmong per district, and 10 households were then randomly selected to check their existence.

Households were visited in the early morning and evening time when most of people stayed at home. In case of unavailable households, the team revisited twice and considered as missing cases after then. There were approximately 10-15% of missing cases in Hmong and non-Hmong per

district. After oral consent, vaccination card or maternal and child health handbook was checked out for child vaccination status, and location of the village was noted by GPS on KoBoToolbox.

The passive surveillance

The passive surveillance was conducted from the report of Luk52 and Namkhou health center. The immunization coverage for each vaccine was calculated by dividing the number of vaccinated infants (< 1 years old) by type of vaccine in 2018 to number of infants who was expectedly born in 2018. The estimated number of infants born in 2018 was calculated by multiplying the number of population in 2017 to the birth rate, which 2.8% for Borikhamxay province and 2.2% for Vientiane province (Personal communication with district health department of Pakkading and Phonhong). From the health center reports, the totally 1033 infants was estimated to be born in 2018. Of these, 417 infants live in villages serviced by Luk52

health center and 616 infants in villages serviced by Namkhou health center.

Data analyses

The data were collected using KoBoToolbox, and cleaned and analyzed using Stata version 12. The descriptive analyses were performed to describe the immunization coverage at health care and village level, using percentage drawn from frequencies. The comparison between two proportion was done using Pearson's chi-squared test. This included the comparison of immunization coverage between sources of data, ethnic groups and villages by type of vaccine. The significant level is 5%.

There is no standard cut-off point for mixed and non-mixed ethnic village, so that we used 20% of total eligible household per village as cut-off point in our study to simply the comparison. Mixed ethnic village is defined as having eligible household of 20% and more in either Hmong or non-Hmong. Hmong and non-Hmong village is considered when the proportion of eligible household of other ethnic is less than 20%.

Ethical considerations

The study was reviewed and approved by the ethical committee of Lao University of Health Sciences number. Whole participants are clearly informed about the objectives, purposes, procedures, risks and benefits, privacy and confidentiality issues of the study. After giving oral consent, they still had the right to do the interview, to refuse or to stop it whenever they wanted.

Result

Table 1: Characteristics of study villages

Characteristics		Total N(%)	Non-Hmong# N(%)	Hmong# N(%)	Mixed## N(%)
Number of village		16	9 (56.33)	5 (31.33)	2 (12.34)
Namkou health center		7 (43.75)	6 (85.71)	1 (14.29)	0
Luk52 health center		9 (56.25)	3 (33.33)	4 (44.44)	2 (22.23)
Total population					
Namkou health center		338	196 (58.00)	142 (42.00)	0
Luk52 health center		343	43 (12.54)	198 (57.73)	102 (29.74)
Eligible households					
Household with child ≥6 months	Total	681	241 (35.39)	338 (49.63)	102 (14.98)
	Vaccination card*	514 (75.47)	193 (80.08)	250 (73.96)	71 (69.61)¶
	Recall	168 (24.53)	48 (19.92)	88 (26.04)	31 (30.39)¶
Household with child ≥12 months	Total	408 (59.91)	144 (35.29)	205 (50.25)	59 (14.46)
	Vaccination card*	293 (71.81)	111 (77.08)	141 (68.78)	41 (69.49)¶
	Recall	115 (28.19)	33 (22.92)	64 (31.22)	18 (30.51)¶

Note:

Hmong and non-Hmong village is considered when the proportion of eligible household of other ethnic is less than 10%.

Mixed ethnic village is defined as having eligible household of 10% and more in either Hmong or non-Hmong.

*Children who had never been vaccinated were also included in household with vaccination card

¶ There is no significant difference among ethnics

Characteristics of study population

There were totally 16 villages of two health centers included into the evaluation, 9 villages (56.33%) from Luk52 health center and 9 non-Hmong villages. The highest proportion of non-Hmong villages was from Namkhou health center area (88.89%). At Luk52 health center, Hmong villages ranked the first (44.44%), followed non-Hmong and mixed ethnic village (33.33% and 22.23%, respectively) (Table 1). Whereas among the total of 681 eligible children aged 6-23 months recruited into the study, 408 (59.91%) were children aged 12-23 months, and Hmong villagers were predominant with almost 50% followed by non-Hmong villager (35.39%) and mixed villages (14.98%). Moreover, 514 (75.47%) and 293 (71.81%) of children aged 6-23 months and 12-23 months, respectively have had vaccination card or never been vaccinated. Of these, proportion of children with vaccination card or never been vaccinated was higher in non-Hmong villages, but not statistically significant (Table 1).

Vaccination coverage

Only children with vaccination card/maternal and child health handbook or never been vaccinated were included in the estimate of vaccination coverage from the survey (514 children). Of these, the proportion of vaccination at least a dose was 431 (83.85%), which was not significantly different when accounting those derived from recall vaccination status (87.81%). However, the significantly higher coverage of being vaccinated at least a dose was found in Lu52 health center (82.50% versus 75.30%, $p=0.033$ for including and excluding recall information) (Figure 2).

Among included children, the proportion of vaccination at least a dose was significantly higher in Namkhou than Luk52 health center (91.51% versus 75.30%, $p < 0.001$). Figure 2 showed that villages with lower vaccination coverage are located nearby each other. The vaccination coverage at least 90% was found only in non-Hmong. Meanwhile, it was more or less similar between Hmong and mixed villages regardless of distance from the health center.

There significantly had a strong correlation among complete pentavalent, JE, MR and full immunization coverage compared to other type of vaccine, but less observed in non-Hmong population. Among these, first dose of pentavalent vaccination significantly correlated with its second dose, but less with the thirist dose. The second dose was significantly more likely to correlate with third dose (Table available upon request).

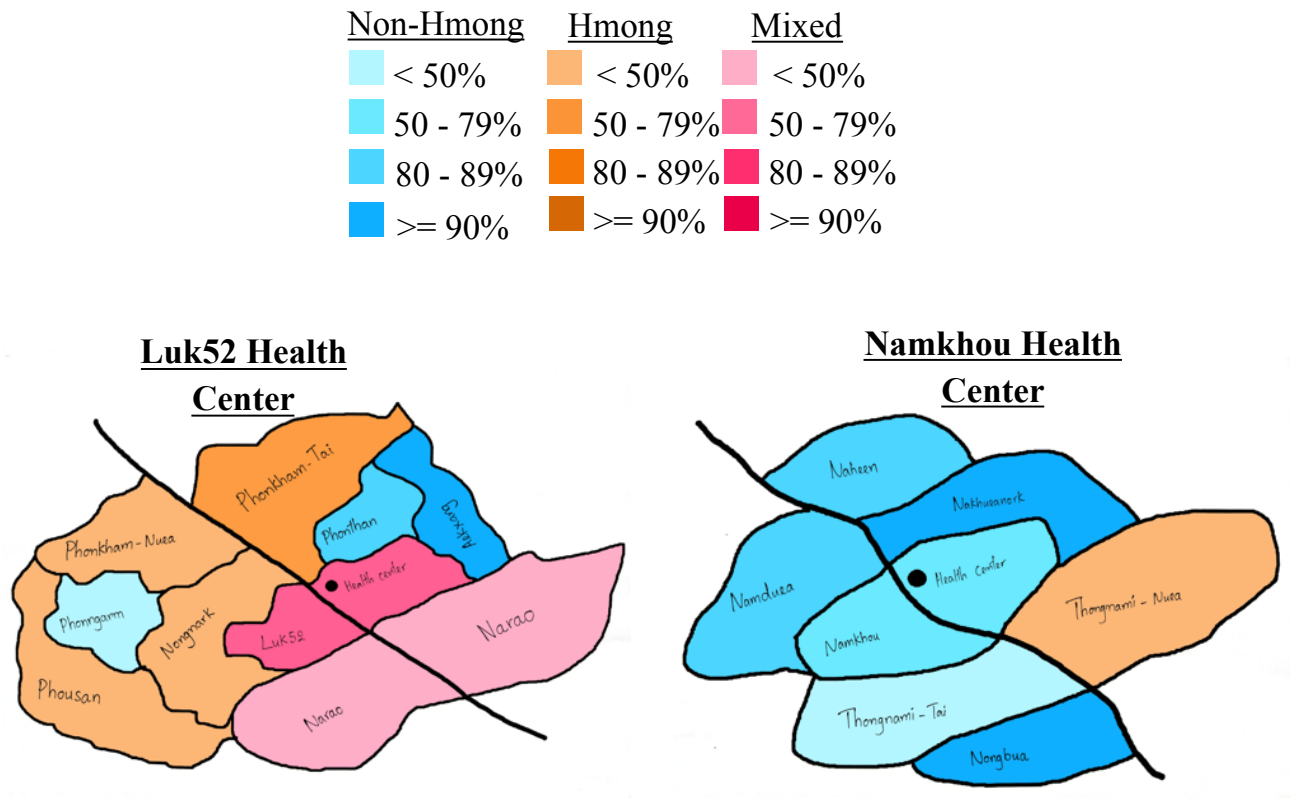


Figure 2: Village-level spatial distribution of full immunization coverage at Namkou and Luk52 health centers. The blue color represents non-Hmong, orange for Hmong and red for mixed ethnics with the lighter color, the lower immunization coverage.

Comparison of vaccination coverage by vaccine types and ethnic groups

At Namkhou health center, we found that the coverage of vaccination by vaccine type ranged from 117(70.91%) for JE vaccine to 238(87.82%) for BCG vaccine. The coverage of complete pentavalent vaccine was not significantly different from first dose of HepB, IPV, complete PCV, JE and MR1, but significantly lower than BCG. This trend was also found at Luk52 health center where JE vaccine was the lowest (47.66%) and BCG, the highest coverage (72.84%). Moreover, complete pentavalent vaccine was also similar to the one of IPV, complete PCV, JE and MR1. BCG and first dose of HepB significantly had higher coverage than other vaccine types. Nevertheless, the coverage regardless to vaccine type at this health center were significantly lower than those at Namkhou health center including full

immunization coverage (43.75% versus 60.00%) (Table 2).

Among ethnic group, we found that the vaccination coverage was significantly higher in non-Hmong ethnic regardless the vaccine types. Contrary to a comparison between Hmong and mixed ethnic villages, we found that their vaccination coverage was not significantly different in exception to BCG vaccine. For full immunization coverage, the coverage was significantly highest in non-Hmong village at Luk52 health center, but not significant different from non-Hmong at Namkou health center. Moreover, the coverage was not significantly different in Hmong village at different health center area (Table 2).

Comparing vaccination coverage between survey and passive surveillance reports

At Namkhou health center, the vaccination coverage derived from the survey was significantly

higher than passive surveillance for BCG and first dose of HepB, but significantly lower for complete pentavalent, complete PCV and full immunization coverage. Meanwhile, the one for IPV, JE and MR1 was not significantly different. The significant higher coverage of BCG and first dose of HepB and significant lower coverage of complete pentavalent were also found at Luk52 health center area. The coverage of other vaccine types and full immunization were not significantly different between survey and passive surveillance at Luk52 health center (Table 3).

We found that the vaccination coverage from active survey was significantly higher than passive surveillance in non-Hmong ethnic regardless to vaccine type. Contrary to Hmong village, the coverage was significantly lower in most vaccine types except BCG and first dose of HepB. Meanwhile, the vaccination coverage from active survey was not significantly different from passive surveillance in mixed ethnic village in exception BCG and first dose of HepB in which the coverage from active survey was significantly higher (Table 4).

Table 2: Comparing immunization coverage by health center and ethnicity villages

	Health centers			p-value	Ethnicity villages			
	Total	Namkhou Health Center	Luk52 Health Center		Non-Hmong	Hmong #	Mixed¶¶	p-value
	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
BCG	415 (80.74)	238 (87.82)	177 (72.84)	<0.001	185 (95.85)	186 (74.40)	44 (61.97)	<0.001
HepB0	390 (75.88)	219 (80.81)	171 (70.37)	0.006	176 (91.19)	173 (69.20)	41 (57.75)	<0.001
Penta 1	496 (82.94)	288 (91.43)	208 (73.50)	<0.001	228 (96.61)	218 (75.96)	50 (66.67)	<0.001
Penta 2	459 (76.76)	274 (86.98)	185 (65.37)	<0.001	223 (94.49)	189 (65.85)	47 (62.67)	<0.001
Penta 3	333 (64.79)	211 (77.86)	122 (50.21)	<0.001	181 (93.78)	120 (48.00)	32 (45.07)	<0.001
IPV§	316 (61.48)	196 (72.32)	120 (49.38)	<0.001	167 (86.53)	116 (46.40)	33 (46.48)	<0.001
PCV3†	318 (61.87)	200 (73.80)	118 (48.56)	<0.001	172 (89.12)	115 (46.00)	31 (43.66)	<0.001
JE‡	178 (60.75)	117 (70.91)	61 (47.66)	<0.001	99 (89.19)	60 (42.55)	19 (46.34)	<0.001
MR1	187 (63.82)	123 (74.55)	64 (50.00)	<0.001	100 (90.09)	68 (48.23)	19 (46.34)	<0.001
MCV2	93 (37.50)	57 (38.51)	36 (36.00)	0.688	61 (57.55)	23 (20.18)	9 (32.14)	<0.001
Full immunized¶¶	155 (52.90)	99 (60.00)	56 (43.75)	0.006	87 (78.38)	51 (36.17)	17 (41.46)	<0.001

Notes:

§ IPV is scheduled at third dose of Pentavalent

† PCV is scheduled at the same time as pentavalent vaccine

‡ JE is scheduled at the same time as first dose of Measles vaccine

¶ Full immunized refers to getting vaccinated for BCG, HepB0, complete pentavalent and PCV, IPV and first dose of MR based on LSIS definition

In Hmong village, 93.24% are Hmong ethnic

¶¶ In mixed villages, 67.65% are Hmong ethnic

For full immunization coverage, we found that the coverage from active survey was significantly higher than from passive survey in non-Hmong villages, but lower in Hmong village at Namkhou health center. Contrary to Luk52 health center area, the coverage was not significantly different in exception in some non-Hmong villages with higher coverage. This is not the case for complete pentavalent. The coverage was significantly different between active survey and passive surveillance regardless to types of village or health center area, but higher in non-Hmong (Table 5).

Discussion

Our study estimated that 84% of children aged 06-23 months received vaccination at least a dose, and only 64.79% got vaccinated with complete pentavalent vaccine. The unmet coverage target of Global Vaccine Action Plan, 80% at district level by 2015. Only BCG reached the coverage of 90%.

First dose of hepatitis B came second rank (75.88%), and other vaccines had approximately similar coverage, around 60 to 65% only. Meanwhile, full immunization coverage was the lowest, 52.90%. The coverage was lower than target of Global Vaccine Action Plan by 2015, 80% of any vaccine at district level [1]. However, the dramatic low immunization coverage was mostly contributing to Hmong population because the vaccination coverage in non-Hmong ranged from 86.53% to 95.85% for IPV to BCG, respectively with measles coverage of 90.09% despite the fact that full immunization coverage was lower than 80%. The high success and failure in immunization coverage improvement in non-Hmong and Hmong ethnic, respectively living in semi-urban setting highlighted the need of better allocation of human and financial resources including monitoring and evaluation in order to meet that target coverage of GVAP by 2020.

The complete pentavalent coverage was 64.79%. The coverage was unmet target of GVAP which coverage of DTP3 should be at least 80% by 2015 [1], but is similar to WHO estimate (68%) for the entire country of Lao PDR [8]. The coverage was also lower than neighboring countries of Lao PDR, 92% in Cambodia [13], 75% in Vietnam [14], 97% Thailand [15], 91% in Myanmar [16], and 99% in China [17]. Thus, our study confirms low complete pentavalent coverage in Lao PDR, and require further work to improve immunization strategy.

It might not effective to target increasing vaccination coverage without targeting a specific vaccine schedule and population due to human and financial resources constraint, lack of manpower to provide effective communication in low educated people, which is the case of Lao PDR or ethnic groups. Our study found that there was a strong correlation complete pentavalent, measles and full immunization coverage, but less in non-Hmong population. This indicated that non-Hmong got vaccinated regardless of their previous vaccination status compared to Hmong. Therefore, increasing complete pentavalent vaccination coverage is likely to improve other vaccines scheduled latter, and vice versa.

Meanwhile, the correlation was less between BCG or HepB0 and other vaccines regardless of ethnicity or setting despite the significant correlation. This might indicate that those received BCG or HepB0, commonly at birth, were likely to link with place of delivery than having intention to come for vaccination. People might percept a danger of delivery at home or percept that pregnancy is a condition of death that need to be aware of in comparison to vaccination. Their life experiences in seeing people died due to pregnancy and delivery warned them to go to health facilities. A study in Lao PDR showed that mobile phone notification increased the coverage of hepatitis B at birth dose [12], but this would absolutely not have an impact on other vaccines.

The Immunization coverage of BCG, first dose of HepB, complete pentavalent, IPV, complete PCV, JE and MR1 in Namkhou health center was about 11% to 27% higher than in Luk52. Moreover, we found that if compare by ethnic village, the vaccination coverage was significantly higher in non-Hmong than Hong and Mixed village (including Non-Hmong and Hmong people). Therefore, as the survey found that there are Hmong in Luk52 than Namkhou, and Hmong cultural traditions can lead to cultural misunderstanding with lack of accessing medical care service, especially immunizations are seldom up to date, this lead to low immunization coverage. It was not just Hmong in Lao PDR that have been struggling to modern medicine, but was also reported in USA where they had difficulty to adapt

and adjust to western medical culture as well as difficulty accessing the health care delivery system due to their linguistic and cultural barriers [18]. The special action plan, which includes the combination strategy move forward and backward based on available evidences and research development to provide evidence-base of sciences identifying the population perspective, belief and tradition as well as key determinants affecting their utilization of healthcare services and immunization.

In regards to compare the immunization coverage between the survey and the passive surveillance, the total survey was higher than passive surveillance reports for BCG and first dose of HepB, but the pentavalent3, IPV, JE and MR1 was not significantly different. The children usually have to receive BCG immediately after birth or when they are first in contact with health services [19]. Therefore, this is because of the villagers mostly gave birth in the district and provincial hospital than in health center, and it resulted that the first dose of birth was low in the health center report but high during survey due to this study recorded from the vaccination card report.

We found that the vaccination coverage among non-Hmong village from active survey was higher than passive surveillance, but difference among Hmong village. This was because of they thought non-Hmong village had the problem with vaccine, so they were focus only on them, and left Hmong behind because the immunization coverage was high, but when we surveyed the result was opposite. The reason that the coverage of Hmong village was high from the passive surveillance is because they might not update the number of new born. Due to the head village cannot collect the number of new born and some Hmong do not report when having the baby. By the way, it is possible that Hmong who seek services have different perceptions about the efficacy and safety of immunization in preventing disease. Another explanation is they may absence of a trusting relationship with a primary care provider. Therefore, the survey results found that they were more likely to be under-immunized or behind schedule in receiving immunization among Hmong village.

We found that MR1 or other vaccines with the same schedule and full immunization coverage were less likely to be significantly different among health center, ethnicity and village compared to other vaccines. Either one might be an appropriate indicator of immunization status at village or health center level. This means that the immunization strategy could not no longer rely its own vaccination coverage for EPI program evaluation due to error of reporting system as a result of missing out number of target population and

number of vaccinated children. This is why the outbreak remains occurring worldwide despite somehow high coverage

Limitation of the study

Our study could be representative of setting with ethnic diversity and semi-urban only, which might not be able to roll out other factors affecting vaccination uptake such as accessibility and availability of standard immunization system at health center. This is the case of Lao PDR where majority of the population live in rural and mountainous settings. Further research investigation will complete the evidence-base of sciences for better immunization strategy.

Conclusion

Village-level vaccination coverage evaluation provide evidence-base of sciences for health policy maker to investigate a better strategy of reporting system, so that the response would be taken in relevant setting, resulting in improving PEI program and national childhood vaccination coverage in Lao PDR. Measles coverage with data derived from reporting system might be an appropriate indicator of selecting setting to evaluate village-level immunization coverage in resource constraint settings.

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Table 3: Compare the source of immunization coverage between the passive surveillance and the survey reports

	Total				Namkhou Health Center				Luk52 Health Center			
	Survey	Passive Surveillance	Diff	p-value	Survey	Passive Surveillance	Diff	p-value	Survey	Passive Surveillance	Diff	p-value
	n (%)	n (%)	%		n (%)	n (%)	%		n (%)	n (%)	%	
BCG	415 (80.74)	471 (52.33)	28.41	<0.001	238 (87.82)	358 (75.05)	12.77	<0.001	177 (72.84)	113 (23.40)	49.44	<0.001
HepB0	390 (75.88)	395 (43.89)	31.99	<0.001	219 (80.81)	315 (66.04)	14.77	<0.001	171 (70.37)	80 (16.56)	53.81	<0.001
Penta 3	333 (64.79)	665 (73.89)	-9.10	<0.001	211 (77.86)	369 (88.49)	-10.63	<0.001	122 (50.21)	296 (61.28)	-11.07	0.005
IPV§	316 (61.48)	610 (67.78)	-6.30	0.017	196 (72.32)	325 (77.94)	-5.62	0.102	120 (49.38)	285 (59.01)	-9.63	0.014
PCV3†	318 (61.87)	613 (68.11)	-6.24	0.02	200 (73.80)	369 (88.49)	-14.69	<0.001	118 (48.56)	244 (50.52)	-1.96	0.638
JE‡	178 (60.75)	538 (59.78)	0.97	0.297	117 (70.91)	294 (70.50)	0.41	0.504	61 (47.66)	244 (50.52)	-2.86	0.619
MR1	187 (63.82)	544 (60.44)	3.38	0.334	123 (74.55)	331 (79.38)	-4.83	0.222	64 (50.00)	213 (44.10)	5.90	0.272
Full immunized¶	155 (52.90)	500 (55.56)	-2.66	0.457	99 (60.00)	312 (74.82)	-14.82	<0.001	56 (43.75)	188 (38.92)	4.83	0.361

Notes:

§ IPV is scheduled at third dose of Pentavalent

† PCV is scheduled at the same time as pentavalent vaccine

‡ JE is scheduled at the same time as first dose of Measles vaccine

¶ Full immunized refers to getting vaccinated for BCG, HepB0, complete pentavalent and PCV, IPV and first dose of MR based on LSIS definition

Table 4: Comparing vaccination coverage between ethnicity-based villages by vaccine types

	Non-Hmong villages				Hmong villages #				Mixed ethnic villages ¶¶			
	Survey	Passive surveillance	Diff	P-value	Survey	Passive surveillance	Diff	P-value	Survey	Passive surveillance	Diff	P-value
	n (%)	n (%)	%		n (%)	n (%)	%		n (%)	n (%)	%	
BCG	185 (95.85)	184 (51.69)	44.16	<0.001	186 (74.40)	266 (60.18)	14.22	<0.001	44 (61.97)	21 (12.96)	49.01	<0.001
HepB0	176 (91.19)	168 (47.19)	44.00	<0.001	173 (69.20)	207 (46.83)	22.37	<0.001	41 (57.75)	20 (12.35)	45.40	<0.001
Penta 3	181 (93.78)	204 (63.55)	30.23	<0.001	120 (48.00)	380 (91.13)	-43.13	<0.001	32 (45.07)	81 (50)	-4.93	0.569
IPV§	167 (86.53)	189 (58.88)	27.65	<0.001	116 (46.40)	340 (81.53)	-35.13	<0.001	33 (46.48)	81 (50)	-3.52	0.67
PCV3†	172 (89.12)	200 (62.31)	26.81	<0.001	115 (46.00)	338 (81.06)	-35.06	<0.001	31 (43.66)	75 (46.30)	-2.64	0.566
JE‡	99 (89.19)	167 (52.02)	37.17	<0.001	60 (42.55)	301 (72.18)	-29.63	<0.001	19 (46.34)	70 (43.21)	3.13	0.728
MR1	100 (90.09)	183 (57.01)	33.08	<0.001	68 (48.23)	308 (73.86)	-25.63	<0.001	19 (46.34)	53 (32.72)	13.62	0.143
Full immunized¶¶	87 (78.38)	167 (52.02)	26.36	<0.001	51 (36.17)	283 (67.87)	-31.70	<0.001	17 (41.46)	50 (30.86)	10.60	0.2

Notes:

§ IPV is scheduled at third dose of Pentavalent

† PCV is scheduled at the same time as pentavalent vaccine

‡ JE is scheduled at the same time as first dose of Measles vaccine

¶ Full immunized refers to getting vaccinated for BCG, HepB0, complete pentavalent and PCV, IPV and first dose of MR based on LSIS definition

In Hmong village, 93.24% are Hmong ethnic

¶¶ In mixed villages, 67.65% are Hmong ethnic

Table 5: Comparing vaccination coverage between the survey and the passive surveillance reports by villages

Ethnic	Village name	Complete pentavalent				First dose of MR				Full immunized			
		Survey n (%)	Passive Surveillance n (%)	Diff %	p- value	Survey n (%)	Passive Surveillance n (%)	Diff %	p- value	Survey n (%)	Passive Surveillance n (%)	Diff %	p- value
Namkhou Health Center													
Non-Hmong	Namkhou	17 (100)	19 (76.00)	24.00	0.034	8 (80.00)	16 (64.00)	19.33	0.228	7 (70.00)	13 (52.00)	18.00	0.279
	Nakhueanork	12 (100)	10 (45.45)	54.55	0.001	10 (100)	10 (45.45)	54.55	0.002	9 (90.00)	10 (45.45)	44.55	0.02
	Naheen	13 (92.86)	12 (75.00)	17.86	0.209	9 (100)	11 (68.75)	31.25	0.061	8 (88.89)	11 (68.75)	20.14	0.267
	Namduca	69 (97.18)	71 (76.34)	20.84	<0.001	37 (94.87)	54 (58.06)	37.94	<0.001	34 (87.18)	49 (52.69)	34.49	<0.001
	Thongnami-Tai	28 (82.35)	41 (57.75)	24.60	0.016	13 (68.42)	44 (61.97)	-3.35	0.755	7 (36.84)	44 (61.97)	-25.13	0.068
	Nongbua	16 (94.12)	13 (81.25)	12.87	0.277	12 (100)	17 (106.25)	-6.25	1	12 (100)	14 (87.50)	12.50	0.317
Hmong	Thongnami-Nuea§	56 (52.83)	203 (116.67)	-63.84	<0.001	34 (51.52)	179 (102.87)	-57.22	<0.001	22 (33.33)	171 (98.28)	-64.95	<0.001
Luk52 Health Center													
Non-Hmong	Phonggarm	6 (85.71)	8 (66.67)	19.04	0.366	3 (75.00)	8 (66.67)	8.33	0.690	3 (75.00)	5 (41.67)	33.33	0.285
	Aekxarng	6 (100)	13 (37.14)	62.86	0.006	1 (100)	11 (31.43)	68.57	0.048	1 (100)	10 (28.57)	71.43	<0.001
	Phonthan	14 (93.33)	17 (54.84)	38.49	0.008	7 (100)	12 (38.71)	51.29	0.005	6 (85.71)	11 (35.48)	50.23	0.022
Hmong	Phonkham-Nuea‡	10 (32.26)	40 (68.97)	-36.71	0.002	8 (40.00)	31 (53.45)	-9.97	0.418	8 (40.00)	30 (51.72)	-11.72	0.441
	Phonkham-Tai†	9 (36.00)	37 (68.52)	-32.52	0.008	7 (70.00)	29 (53.70)	14.3	0.231	5 (50.00)	28 (51.85)	-1.85	0.998
	Nongnark¶	29 (55.77)	53 (67.09)	11.32	0.202	15 (57.69)	45 (56.96)	13.37	0.171	12 (46.15)	31 (39.24)	-6.91	0.647
	Phousan¶¶	16 (44.44)	47 (90.38)	-45.94	0.008	4 (21.05)	24 (46.15)	23.07	0.048	4 (21.05)	23 (44.23)	-23.18	0.064
Mixed	Luk 52km#	16 (51.61)	29 (40.28)	11.33	0.387	11 (57.89)	22 (30.56)	23.29	0.035	10 (52.63)	20 (27.78)	24.85	0.055
	Narao##	16 (40.00)	52 (57.78)	-17.78	0.086	8 (36.36)	41 (34.44)	4.95	0.612	7 (31.82)	30 (33.33)	-1.51	0.998

Notes:

§ In Hmong village, 94.34% are Hmong ethnic; ‡ In Hmong village, 87.10% are Hmong ethnic; † In Hmong village, 84% are Hmong ethnic; ¶ In Hmong village, 100% are Hmong ethnic; ¶¶ In Hmong village, 88.89% are Hmong ethnic; # In Mixed village, 51.61% are Hmong ethnic; ## In Mixed village, 80% are Hmong ethnic