Asian Journal of Medical Research & Health Sciences, vol 1, issue 3, 2023; p52-59, doi: 10.5455/AJMRHS.1107202300013
ISSN 2583-7761

Original Research

KNOWLEDGE AND PRACTICE REGARDING THE ADMINISTRATION OF THE PENTAVALENT VACCINE AMONG HEALTH CARE WORKERS IN VIENTIANE CAPITAL, LAO PDR: A MIXED METHOD APPROACH

Bounthome Samontry, Manyvanh Vongsy, Do Thi Hanh Trang, Kongmany, Chaleunvong, Vanphanom Sychareun, Jo Durham|
*Corresponding author details: Bounthome Samontry
Article received: 1-Oct-2023, Accepted: 13- Oct 2023 Published: 5-Oct-2023

Abstract

Background The three-dose pentavalent vaccine is one of the most significant and cost-effective measure to prevent childhood mortality and morbidity due to infectious diseases. One of the main reasons for parents to accept immunizations for their children is the recommendations given by health care providers. The aim of this study is to assess the knowledge and practice of providing pentavalent vaccines and its related factors among health care workers (HCWs). **Method:** This was a cross-sectional analytical study, using the mixedmethod approach that combines qualitative and quantitative methods. The study was conducted in nine district hospitals and 33 health centres in Vientiane Capital. In total, 184 health care workers were involved in the study and in-depth interviews were conducted with 12 HCWs. The quantitative data was entered using Epi Data and analysed using Stata 14.1. Descriptive and inferential statistics were applied to determine the factors associated with the knowledge and the practice of pentavalent vaccines. A thematic analysis was applied to the qualitative data. **Results:** From among 184 respondents, the results showed that more than half (63.3%) had poor knowledge of the pentavalent vaccine while about two thirds (65.7%) reported good practices for deliveringthe pentavalent vaccine. In the multiple logistic regression, significant factors associated with the knowledge of the pentavalent vaccine werethequalification of HCWs (AOR=2.6, 95% CI=1.1 – 6.3, p=0.030), receiving training on vaccines (AOR=3.4, 95% CI=1.7 – 6.8, p<0.001), and incentives related to working for vaccination programmes(AOR=2.7, 95% CI=1.2 – 6.1, p=0.020).The practice of immunization. **Conclusion:** The data from this research indicated that more than half of the HCWs had poor knowledge about the pentavalent vaccine, despite vaccination practice being relatively good. There was a correlation between improved knowledge, with those HCWs who had higher education,and received trainingand incentives. These findings demonstrate there is a need for more efficient training and the continuous education of HCWs in the field of immunization.

Key Words: Pentavalent vaccine, health care workers, knowledge and practice.

Introduction

Vaccination is one of the most cost-effective public health measures to reduce preventable, premature, child mortality and morbidity due to infectious disease [1, 2]. The Expanded Program on Immunization (EPI) contributed advances in developing and introducing new vaccines and expanding the reach of immunization programmes, contributing to decreased childhood mortality. Despite this progress, equity gaps remain within and between countries. The COVID-19 pandemic and its associated disruptions have also affected vaccinationrates withDTP3 (third dose of diphtheria, tetanus toxoid and pertussis-containing vaccine) immunization coverage among one-year-olds globally decreasing from 86% in 2019 to 81% in 2021.

In the Lao PDR, a lower-middle income country in Southeast Asia, the three-dose diphtheria-tetanus-pertussis (DTP) vaccine now administered as the pentavalent vaccine, was first introduced in 1979. The pentavalent vaccine was introduced to replace the DPT (Diphtheria, pertussis and tetanus) vaccine to increase the uptake of the hepatitis B (Hb) and Haemophilus influenza type b(Hib). In Lao PDR pentavalent vaccine was introduced in 2009 and is scheduled at 6, 10 and 14 weeks of age. Coverage has gradually increased, although DPT3 coverage remains low and has contributed to several diphtheria outbreaks [3, 4, 5, 6]and pertussis is thought to be prevalent [7].Coverage for the first dose in 2017 was 72.5%, while the second dose was 67.2% and the third dose was 60.8%[6].There are also some inconsistencies in recording vaccine completion. For example, in 2019, WHO/UNICEF estimated coverage for the third dose of the pentavalent diphtheria-tetanus-pertussis-hepatitis B-haemophilus influenzae type b vaccine (pentavalent vaccine) as 80%, while the country's official estimates was on 92% in the same year [8].

Health care workers' knowledge and practices in immunization, especially the pentavalent vaccines are influential factors in preventing vaccine failures and promoting vaccine uptake and adherence to the schedule [9,10, 11]. One of the main reasons for parents to accept pentavalent immunizations for their children isit being recommendedby health care workers (HCWs), including among parents and patients with negative vaccine attitudes [12]. This underlines the important role of HCWs in increasing parents' confidence in immunization by dealing with their concerns, answering their questions and convincingly resolving their doubts [11]. Despite the recognized importance of HCWs knowledge and practice in ensuring vaccination effectiveness, there is limited research evidence (both published and unpublished) about the knowledge and practice of the pentavalent vaccine by health care workersin Lao PDR. The aim of this study is to assess the knowledge and practice of pentavalent vaccine administration and its related factors among HCWs.Understanding the gaps in knowledge and factors associated with vaccine provider practices can contribute to the development of interventions to improve vaccine recommendations and improve immunization coverage rates and ultimately support a decline in infant mortality rates due to vaccine-preventable diseases[12].

Materials and Methods

Design and setting

This is a mixed method, cross-sectional analytical study using qualitative and quantitative data to provide a more complete description of a HCWs knowledge and practice. The quantitative component was used to describe the knowledge, practice and identify correlations between variables by using the face-to-face administered questionnaire. The qualitative componentwas used to complement the quantitative method by exploring the practice of pentavalent vaccines among health workers and the constraints they faced in Vientiane Capital.

Study sites

The capital city for the Lao PDR, Vientiane Capital City, is situated in the central belt of the country covering nine districts with a population density of 209 people per square kilometers. According to the 2015 Census, the population at that time was 820,940 with 78% residing in urban areas, 22% in rural areas with a road and 0.1% in rural areas without a road [13]. The Vientiane Capital Health Department estimates in 2021 of the total population, 90,161 were children aged 1-4 years [13].

There arenine districts within Vientiane Capital, namely Sangthong, Naxaithong, Sikhottabong, Chanthabouly, Xaysettha, Sisattanak, Hadxayfong, Xaythany and Maypakngum. Of these nine districts four are urban and five are semi-rural. The Vientiane CapitalHealth Office is responsible for health promotion in the city, including the expanded programme on immunization (EPI) which includes the pentavalent vaccine. Vaccination of children with vaccines included in the EPI is provided at no cost. Within each of the nine districts, there is a district hospital, and a total of 33 health centers.The total number of health staff administered bythe Vientiane Capital Health Office is 804, including 665 staff workingat the district hospitals,of which 32 health care workers working in the mother and child units and provide vaccination services with a total of152 staff work at the health centers, all of whom can provide vaccination services work in these health facilities. For this study, two district hospitals in urban areas and two district hospitals in semi-rural districts, along with their affiliated health centers were selected, making a total of four district hospitals and eight health centers.

Participants

In the quantitative component, participants were purposively identified and consisted ofmedical doctors, nurses, midwives, pharmacists, and lab technicians working in the EPI programs. All health care workers

who provided vaccination services in the nine district hospitals and 33 health centers were considered for inclusion. At each district hospital and health center, the list of staff responsible for vaccination and working in the mother and child health division was prepared. The study recruited all 32 staff working at the mother and child units and 152 health staff at the health centers, with a total sample size of 184 HCWs. For the qualitative component,participants were from the health centers and consisted of medical doctors, nurses, midwives, pharmacists, lab technicians and12 HCWs involved in immunization services from one health service setting in each region were selected usingcriteriasampling, for in-depth interviews.

Research instruments and measurements

Quantitative

The questionnaire for the quantitative componentconsisted of socio-demographic characteristics, the knowledge and practice regarding the delivery of the pentavalent vaccine. The socio-demographic questions included items related to sex, age, education level, professional qualifications, working experience and workplace.To examine knowledge of vaccinations, there were 24 items, of which tenwere positively worded and 14 negatively worded. Nine questions regarded possible precautions and contraindications and were adapted based on Al-Ayed and Sheik [14]. Six questions asked about doses and routes of administration and were adapted from Salem [15]. Four questions related to the timing of vaccine administration based on the yellow card utilized in Lao PDR and five questions about side effects drawn from Karami [16]. Each question offered a "True or False" option.

To calculate the total knowledge score of the pentavalent vaccine, we calculated the scores of responses given to the 24 questions. Every correct answer was given one point, while incorrect answers received 0 points, making the total possible score 24. The study used a cut-off selection based on the distribution of the data along a natural median divide to differentiate between poor and good knowledge. Those HCWs whose knowledge score was equal to and lower than median was classified as poor knowledge, while those whose score was higher than median,classified as having good knowledge.

The practice questions consisted of 20 questions, of which four were adapted from the research of Al-Ayed and Sheik [14] and 15 adapted from the research of El Shazly et al[17] and investigated the individuals' practices. Each answer had a Likert scale type response with the options, always, sometimes or never. Every correct answer was given one point, while incorrect answers received zero points. This resulted in a score range from 0 to 20 points. The median (±standard deviation) value was used as the cut-off for defining good practice (values ≥ median) and poor practice (values <median) [18,19]. The minimum score was 2 and the maximum was 20.

Qualitative

The qualitativecomponent explored the practice of vaccinations among health workers and the constraints to their knowledge and practice. The guidelines for the in-depth interviews were adapted from the research of Karafillakis et al [20]. The in-depth interview guidelines included socio-demographic information, the pentavalent vaccine status, knowledge and practices towards the pentavalent vaccine, and barriers to providing vaccines in service and also for outreach. The in-depth interviews with key informants were audio recorded and transcribed verbatim, while also having notes taken.

Statistical analysis

Quantitative Analysis

The demographic data was presented as percentages, frequencies, means and standard deviations, including minimums and maximums. A logistic regression was used for examining associations in the univariate analyses using the STATA software. All the p-values were two-sided and considered significant at $p<0.05$. Multiple logistic regressions were selected after showing significance in the univariate logistic regression, which was set at a p-value of 1.5 and a 95% confidence interval. Variables that were found to be significant in the univariate logistic regression with a p-value of 0.05 were entered into the multiple logistic regression in order to control confounding. A stepwise backward method was also applied. For multiple logistic regressions, the significance was set up forvariables with p-values of 0.05 and 95% confidence intervals. Variables with the largest p-values were then removed one at a time until only significant variables were left in the final model.

Qualitative analysis

A thematic analysis was employed divided into six stages[21]. The interviews were transcribed verbatim in Lao language and checked with notes taken during the interviews. Thetranscripts. were analysed manually with the researchers reading the transcripts several times to get an overview of the material and to compare it with other research. Next, the researcherscoded the data individually before sharing codes to reach a consensus. Common meanings were identified, summarized andlabelled with codes, and different sub-categories which were tabulated to identify the main themes.

Ethical approval

This study was conducted after receiving ethical approval of the Ethical Committee for Health Research of the University of Health Sciences in Lao PDR (Approval Number 198/19 Vientiane, dated August 15, 2019;) and Hanoi University of Public Health in Vietnam (Approval No. 019-451IDD-YTCC, dated September 30, 2019). Informed consent from health care workers was obtained in written form after explaining the design, the objectives and benefits of the study. Participants were assured of the voluntary nature of the study and that all information would was confidential with no names recorded on the questionnaires or transcripts. The participants were also assured they hadthe right to end participation in the research at any time they wished.

Results

One hundred and eighty-four participants were recruited into the study, of which 51.6% wereaged over 50 years, 78.8% were female, 79.3% were currently married, 54.3% had a middle level of education and 32% had bachelor's degrees. Slightly less than two fifths of the respondents (38.5%) were nurses, and 68.3% of respondents had workingexperience in EPI services foroverfive years. Only 41.7% of the participants said they had received EPI training, with 40% saying they had received training about the cold chain system and possible side effectsof the pentavalent vaccine.A total of 78.2% respondents said when working in EPI they received additional incentives (Table 1).

Table 1 Socio-demographic characteristics of participants

Socio-demographic Factors	Number (N=184)	Percentage (%)
Age (years)		
< 20	35	19.0
21– 49	54	29.3
>50	95	51.6
Sex		
Male	39	21.2
Female	145	78.8
Marital status		
Married	146	79.3
Single	38	20.6
Qualification		

Medical doctor	32	17.3
Nurse	71	38.5
Pharmacist	21	11.4
Lab technician	11	5.9
Midwife	26	14.1
Health workers middle & high levels	23	12.5
Education levels		
Bachelor degree	59	32.0
Diploma	25	13.5
Associate diploma	100	54.3
Work experience		
≤ 2 years	11	5.9
3-5 years	49	26.6
>5 years	124	67.3
Workplace		
District hospital	43	23.3
Health care centre	141	76.6
Training about vaccines		
No	69	37.5
Yes	115	62.5
Information training		
Basic vaccination skills	19	16.5
Using thecold chain system	46	40.0
Side effects	2	1.7
Training covering all aspects of vaccination	48	41.7
Received incentives for performing vaccinations		
No	40	21.7
Yes	144	78.2

Knowledge of health care workers about immunization with the pentavalent vaccine

The median knowledge of the pentavalent vaccine was 18with a minimum of 7, and a maximum of 22 (Table 2). A total of 47.3% of participants demonstrated a poor level of knowledge.Regarding the knowledge of possible precautions and contradictions, slightly more than one fifth of participants answered correctly the statement "Vaccinating children with an oral temperature of 38 degrees Celsius should be avoided". Slightly higher than half participants (55.4%) agreed that "Injectable pentavalent vaccines should not be administered to children with acute diarrhea". Most participants had a good knowledge on the correct number of doses and routes of administration.For example, more than 90% said that the pentavalent vaccine should be injected in 3 doses/IM. Similarly, most had very good knowledge about the times of vaccination with over 90% of respondents saying the pentavalent vaccine could be given to any child aged more than 6 weeks and up to 1 year of age, and that the vaccine's third dose should be injected one month after the second dose. The HCWs however had relatively low levels of knowledge of the possible side effects of the vaccine, for example, 10.8% reported that children could have a loss of appetite after receiving the pentavalent vaccine.

The qualitative study also demonstrated a good level of knowledge regarding the doses, routes and frequency of administration of pentavalent vaccines. All HCWs included in the qualitative component said thepentavalent vaccines required three doses withthe time for administration being children under one year of ageand intervalsbetween does beingsix weeks apart. This awareness is illustrated with the following quote:

> *"The pentavalent vaccine dose is 0.5ml and I use an auto-disable (AD) syringe.Normally we will inject the pentavalent vaccine into children in three separate doses, the first dose is given to the child aged 45 days, the second dose is given to the child aged 65 days and the third doseto the child 95 day of age" (12 HCWs).*

A knowledge of the side effects from the pentavalent vaccine is important for health care providers in order to explain the possible reactions that might occur after immunization and to get parents' support for their children's vaccination. Affirming the quantitative data, overall levels of knowledge of side-effects were lower than knowledge about dose side-effects that were mentioned includedhigh temperatures, redness, tenderness and swelling at the injection site. A few HCWs also mentioned the possibility of anaphylactic shock, where the vaccine was stored incorrectly or due to biochemical factors linked to the recipient. A couple ofHCWs said potential side-effects could include:

> *"After vaccination your child will probably have a high temperature, redness, tenderness or swelling at the injection site" (Female HCW, aged 24 years).*

Table 2 Knowledge of HCWs regarding the pentavalent vaccines

No.	Variable	Number (%)	
		Incorrect	Correct
Knowledge of possible precautions and contraindications to vaccinations			
1	Injectable pentavalent vaccines should not be administered to children with acute diarrhea	82 (44.5)	102 (55.4)
2	A family history of convulsions is a contraindication to pentavalent vaccinations	31 (16.8)	153 (83.1)
3	Pentavalent vaccines can be administered to children who have colds and coughs	83 (45.1)	101 (54.8)
4	Children with an oral temperature of 38 Celsius or higher should not be vaccinated	142 (77.1)	42 (22.8)
5	Children who suffered inconsolable crying for more than 3 hours after the previous pentavalent vaccine should be given half of the usual pentavalent	18 (9.7)	166 (90.2)
6	Vaccinations are contraindicated in children who suffer longstanding respira cardiovascular or liver diseases	45 (24.4)	139 (75.5)
7	Children with medicated epilepsy should not receive the DTP vaccination	54 (29.3)	130 (70.6)
8	Soreness, redness or swelling following an injectable vaccine contraindicate the use o	53 (28.8)	131(71.2)

	pentavalent vaccine		
9	Severe anaphylactic reaction to the pentavalent vaccine contraindicates further doses of vaccine	142 (77.1)	42 (22.8)
Knowledge on dose and routes of administration			
10	The pentavalent vaccine should be injectedin 3 doses/IM	16 (8.7)	168 (91.3)
11	Diphtheria vaccineshould be given through injection	4 (2.1)	180 (97.8)
12	Tetanus vaccine should be given by injection	4(2.1)	180 (97.8)
13	Pertussisvaccine should be administered orally	31(16.8)	153 (83.1)
14	Hep B vaccine should be given orally	13 (7.0)	171 (92.9)
15	Hib B vaccine should be given orally	10 (5.4)	174 (94.5)
Knowledge regarding times for vaccine administration			
16	1st dose ofthe pentavalent vaccine is injected at 6 weeks	45 (24.4)	139 (75.5)
17	Pentavalent vaccine can be given to any child aged more than 6 weeks and up to 1 ye age.	16 (8.7)	168 (91.3)
18	The 2nd dose of the pentavalent vaccine is injected 45 days after the 1st	71 (38.5)	113 (64.4)
19	Pentavalent vaccine's 3rd dose should be injected one month after the 2nd dose	10 (5.4)	174 (94.5)
Knowledge of health care workers about the side effects			
20	After injecting the pentavalent vaccine children will have redness, tenderness and/or swe at the injection site	47 (25.5)	137 (74.4)
21	Children could havea loss of appetite after receivingthe pentavalent vaccine	164 (89.1)	20 (10.8)
22	Fever (high temperature above 38C) – is more common after receiving the second and doses.	48 (26.0)	136 (73.9)
23	A child who has had a severe reaction to the pentavalent vaccine earlier should not be g another dose	28 (15.2)	156 (84.7)
24	DPT boosters are given at 16-24 months and 7-8 years and will continue as before.	87 (47.2)	97 (52.7)
Overall, Knowledge of HCP on vaccination			
Good knowledge (≥ median)	97	52.7	
Poor knowledge (<median)	87	47.3	
Mean=17.23 SD±2.701, Median=18, Min=7, Max 22			

Practice of health care workers relating to pentavalent immunization

Overall, the practice for general pentavalent vaccinesby HCWs was good. The majority of HCWs (over90%) reported the correct practice for specific measures for the pentavalent vaccine,answering six of seven questions correctly (Table 3).Health care workers reported very good practice related to verifying medical records.However, less than half of the HCWs correctly answered the statements "Ask the parents of children about their history of blood transfusions or the administration of blood products in the last few weeks" (44.5%) and "Ask the parents of children about their current use of immuno-suppressive medications" (40.2%). In relation to the specific measures of the pentavalent vaccine, more than 90% suggested that "Proper dose: 0.5 ml DPT vaccine, 0.5 ml HB vaccine and 0.5 ml Hib vaccine" (92.9%) and "Proper position of the child" (93.4%). Overall, 65.7% of HCWs reported good practice.

Correct vaccine preparation includes using standard procedures (hand washing, skin preparation using antiseptics, etc.), the selection of an appropriate syringe and needle, the inspection of vials and ampoules to check the expiry date and vaccine vial monitors (VVMs) to ensure that vaccines and diluents are in good condition, vaccine reconstitution for those vaccines that require it, and keeping vaccines cold during the immunization session. Most participantsreported good practicesin thepreparation steps such as looking at the immunization card first to verify the recording of age, registering the date of vaccination, preparing vaccines and all equipment for vaccination, utilizing a safety box for the disposal syringes and needles, and preparing the correct posturefor children before delivering of the injection. The following quotes illustrate some of the example's participants gave, related to preparing and delivering the vaccine:

> *"I wash my handswith soap, preparing cotton in warm water and keepingthe vaccine in the refrigerator to ensure reconstituted vaccines are cold, I place the vial or ampoule with the reconstituted vaccine into the spaces on the foam pad (a piece of soft foam that fits on top of the ice-packs to keep it cold during my immunization session." (Female HCW,48 years).*

Table 4 Practice of HCWs regarding pentavalent vaccine

No.	Variable	Correct practice (n=184)	
		n	(%)
Preparatory steps			
1	Welcome the beneficiary	148	80.4
2	Verify records, including the age, and the date of vaccination of the beneficiary	180	97.8
3	Ask the parents of children about previous vaccines or reactions	166	90.6
4	Ask the parents of children about the presence of an immune comprised individual in the housel	125	67.9
5	Ask the parents of children about the history of blood transfusion or the administration of b products in the last few weeks	82	44.5
6	Ask the parents of children about the current use of immuno- suppressive medications in the chi	74	40.2
7	Ask aboutpotential contraindications	145	78.8
8	Explain about the vaccine and the disease it Prevents	174	94.5
9	Check the expiratory date and vaccine vial monitor (VVM) of vaccines before use	178	96.7
General vaccine measures			
10	Wash hands before conducting the session	151	82.0
11	Write the date of reconstitution on the vial	142	77.1
12	Do not massage the injection site after the vaccine injection	164	89.1

13	Proper disposal of all medical sharp waste		179	97.2	
Specific measures for the pentavalent vaccine					
14	(PENTA vaccine) Proper position of the child		171	92.9	
15	(PENTA vaccine) Proper dose: 0.5 ml DPT vaccine, 0.5 ml HB vaccine and 0.5 ml Hib vaccine		172	93.4	
16	(PENTA vaccine) Angle of insertion of needle: 90 degrees		165	89.6	
17	Explain that fever may occur after some injections		174	94.5	
18	Tell the parents to return to the health centreif the side effects seem serious		172	93.4	
19	Remind parents about the next visit and tell them to bring the card with them		178	96.7	
20	Explain that a fever may occur after some injections and disappears after 3 days		174	94.5	
	Overall Practice of HCP on vaccination				
	Goodpractice (≥ median)	62	121	65.7	33.7
	Poorpractice (<median)	122	63	34.2	66.3
	Mean=16.92 SD±2.698, Median=17, Min= 2, Max=20				

Competency of health care workers

In the qualitative analysis we found all participants felt they needed additional training would further develop their competency, knowledge and practice. For example, short course training, particularly for new staff, on routine immunizations and effective communication skills was suggested to help refresh health providers' knowledge and practice. Participants strongly recommended that refresher training on side effects should be provided at least once a year for all levels of HCWs.Participants felt this would help to increase confidence and reduce the risk of errors. In addition, the HCWssuggested there is a need for more substantial, long-term training, including effective communication skills, particularly counselling skills and a comprehensive vaccine courseintegrated into the curriculum of medical schools, and offered as extra-curricular courses to providers, as one health manager said:

> *"I do not have any special knowledge about vaccines, especially about the Penta vaccine, because I am a physiotherapist and I have no specialization about immunization.If possible, I would like head office to have training at least once a year for improvingour knowledge and practice skills"(HCW at health centre, 31 years old).*

Factors associated with aknowledge of the pentavalent vaccine

An attempt to identify the best model for a knowledge of the pentavalent vaccine is presented in Table 4 which shows the multivariate logistic regression analysis of factors associated with knowledgeand ofthe pentavalent vaccine. The independent variables had to be significantly correlated with the dependent variables with a p-value <0.05 in the univariate analysis to be included in the multivariate analysis in order to control the confounding variables such as working experience, training relatedto vaccines, information about vaccine training, and incentives related to working with vaccinations. A backward stepwise was performed to determine the association between factors and a knowledge of the pentavalent vaccine.Significant factors from the multiple logistic regression results showed that being medical doctors (AOR=2.6, 95% CI=1.1–6.3, p=0.030), receiving training on vaccines (AOR=3.4, 95% CI=1.7–6.8, p<0.001), and incentives for working in the vaccination programmes(AOR=2.7, 95% CI=1.2–6.1, p=0.020) were asscoiated with knowledge of HCWs of pentavalent.

Table 5: Multivariate logistic regression analysis of factors associated with knowledgeof the pentavalent vaccine

Variable	Good Knowledge of the pentavalent vaccine		Crude		Adjusted		P-value
	N	%	COR	95% CI	AOR	95% CI	
Age (years)							
<= 20	21	60.0	1				
>20	76	51.0	0.7	0.3 - 1.5			
Sex							
Male	19	48.7	1				
Female	78	53.8	0.9	0.5 - 1.9			
Marital status							
Married	81	55.5	1				
Single	16	42.1	0.6	0.3 – 1.2			
Qualification							
Nurse/midwife/Phar/La	75	49.3	1		1		
Medical doctor	22	68.8	2.3	1.0 – 5.1	2.6	1.1 – 6.3	0.033
Education levels							
<= Diploma	63	50.4	1				
Bachelor degree	34	57.6	1.2	0.6 – 2.3			
Work experience							
≤ 2 years	4	36.4	1				
>2 years	93	53.8	3.2	0.8–12.4			
Workplace							
District hospital	23	53.5	1				
Health care centre	74	52.5	1.3	0.7 – 2.7			
Training related to vaccines							
No	22	31.9	1				
Yes	75	65.2	4.0	2.1 – 7.6	3.4	1.7 – 6.8	< 0.001
Incentives							
No	11	27.5	1				
Yes	86	59.7	3.9	1.8 – 8.4	2.7	1.2 – 6.1	0.020
Reported Practice							
Poor	32	50.8	1				
Good	65	53.7	1.1	0.6 – 2.1			

Discussion

Knowledge

Overall, knowledge of pentavalent vaccine was low to moderate, with slightly less than half of respondents (47.3%) demonstrating a low level of knowledge regarding the vaccine. Reasons for low levels of knowledge among HCWs could relate to overall education levels,[10] with just one third of the participants studying at the middle level of associate diploma. Medical doctors and nurses who had a bachelor degree have better knowledge compared with nurses who had diploma of nursing, health workers, and medical assistants. Low levels of knowledge may also relate to the different trainings the HCWs had received that might not have dovetailed neatly with their everyday work responsibilities. The finding of low levels of pentavalent vaccination knowledge differs from other studies in Egypt [17] and Thailand [22]. One explanation for this differnce may be due to the general low level of edcuation of participants, with just one third of the participants having completed an associate diploma.As with our study, other studies, have reported higher educationlevels is acssociated with higher levels of knowedge related to vaccination [23, 24]. Differences may also related to the extent to which HCWs work focussed on immunization, compared to other aspects of their work responsibilities. Other reasons for differences between our findings and other studies may relate to methodological issues related to sampling and measures used. In separate research conducted in Laos at the central hospitals, it was found that nearly 90% of HCWs had a knowledge of Hep B prevention through the use of vaccines[2523].

The findings from the in-depth interviews contradicted the findings from the quantitative research, as slightly higher than half participants had good level of knowledge regarding the doses, routes and frequency of administering the pentavalent vaccine. The qualitative findings highlighted misunderstandings about potential side-effects the pentavalent vaccine. This is a concern because being able to provide information to patients about potential side-effects is an essential component of vaccination counselling. This study indicates the need for increasing the knowledge of HCW in relation to vaccination given the documented association between higher HCW knowledge levels and higher vaccination rates[2624] and the important role HCWs can play in reinforcing health promotion knowledge within the community [2624].

Practice

While levels of knowledge were low-moderate, the study revealed generally good levels practice levels in managing and administering the pentavalent vaccine. The reasons might be that most participants were HCWs responsible for the vaccination. 62.7% had previously received training in immunization, so they had gained practical knowledge in the administration of vaccinations from experts or from those that were qualified in this field, and then they passed on their own expertise [2725].It is also likely that through their work, HCWs gain practical knowledge and learn from colleagues, helping them to integrate formal knowledge with their practical experience[22].The findings also highlighted however, some gaps in good practice, some of which were related to health service factors such as incorrect arrangement of the vaccines in the refrigeration units,no recording of the refrigeration temperature on the weekends, and no instruments prepared to provide first-aid in the event of undesirable symptoms following immunization [2826].

Thestudyhighlighted severalmisunderstandings about the potential side-effects the pentavalent vaccine. This is a concern because being able to provide information to patients about potential side-effectsis an essential component of vaccination counselling. Misunderstandings and a lack of confidence in vaccine safety, and concerns about adverse events, are identified as one of the key factors in refusing vaccines. HCWs therefore need to be provided accurate, evidence-based knowledge so they can be empowered to confidently recommend the pentavalent vaccineand communicate it is a safe and lifesaving intervention.

Factors associated with knowledge

Health care workers who are medical doctors had more knowledge than medical assistant which is expected medical doctors have higher training and they are more competent that medical assistant. In terms of knowledge, our results demonstrate that physicians are more knowledgeable, compared to nurses, about the effectiveness of the vaccine in preventing infection and its related serious morbidity and mortality (p-value < 0.001). The previous research by Swarnkar et al has shown that the higher education of workers has an impact on their knowledge and practices [10]. In addition, a study in Kenya found most nurses with a diploma or degree in nursing had a good knowledge of Adverse Experiences Following Immunization (AEFI) surveillance. Similarly, those with a diploma or degree in nursing were almost two times more likely to have a good knowledge towards AEFI surveillance [19]. Nurses who had a bachelor of nursing had a better knowledge compared with nurses who had a diploma of nursing, general health workers and physicians [17].

The present study also found that HCWs received training on vaccination have better knowledge than HCWs who did not. This also underscores the importance of training in supporting good practice. This finding is similar to other studies for example research done in Egypt and Thailand showed that the knowledge score was significantly higher in HCWs who had training courses compared to those who did not [17, 22]. In contrast, research by Swamkar et al found a non-significant (P=-.095) negative correlation between previous trainings taken and the HCWs' knowledge regarding immunization [10].Many studies have identified regular training improves the knowledge and practices of HCWs, suggesting the quality of training is as, or more, important than number of trainings [22, 29]. Training can provide an opportunity to provide health staff with up-to-date information and allow them to be able to discuss the current vaccine related issues[22]. The content, breadth and depth of information should be adjusted based on the roles and job responsibilities and HCWs, especially when delivering new immunization services[3028].

HCWs who received an incentive to attend training had more knowledge on pentavalent vaccines than those who did not. This could be because incentives improve motivation and contribute to thelearning process. Previous studies have shown positive incentives help to eliminate potential infringements of HCW's rights and would likely be cost-effective for participating health care institutions [3128, 3229]**.** It is possible that HCWs perceive financial incentives differently on the basis of their salary levels. It is important to ensure that the financial incentives are not so large however, that they could be perceived as coercive for HCWs with relatively low incomes.

Limitation

The study has several limitations. Firstly, cross-sectional design only provides a snapshot of the knowledge among HCWs and is not suitable for causal relationships. Secondly, the use of a questionnaire with closed-ended answers might have missed some pertinent concerns, although this was in part compensated for through the qualitative interviews. The small sample size. The generalization of the findings to other provinces should be treated cautiously as this study was conducted only in Vientiane Capital of Lao PDR.

Conclusion

This research showed that about half of the HCWs had low knowledge ofthe pentavalent vaccine.Of particular concern, was the finding thatHCWs had a poor knowledge of the side effectsassociated withthe pentavalent vaccine. This is important as providing accurate information about side-effects is a critical component of patient-centred care and enablingpatients to make an informed choice. However, the vaccination practice level of the studied HCWs was good. Factors related to knowledge of pentavalent vaccines was related to qualification, training and incentives. Hence training for immunization should be providedto health care workers at least twice a year to improve their knowledge and practice skills. It is important the risks and benefits of the pentavalent vaccine are clearly understood by HCWs so they can provide effective counselling to parents and other care givers so they can understand the reason for vaccine recommendations. To ensure optimal immunization effectiveness,continuous training and regular supervision on EPI are necessary for HCWs.

Abbreviations

AEFI	Adverse Events Following Childhood Immunization
DTP	Diphtheria Tetanus Pertussis

EPI	Expanded Program on Immunization
Hib B	HaemophilusInfluenzae Type B
Hep B	Hepatitis B
HCWs	Health Care Workers
VRE	Vaccine Safety-Related Event

Acknowledgments
I offer my sincere thanks to the Ministry of Health of the Lao PDR, Hanoi University of Public Health and the LEARN project. In addition, I owe a great debt to all the teachers and reviewers who have supported my studies and research.

Authors' contributions
VS, MV and KC developed the research proposal, designed the instrument, collected data in the field sites,analysed the data and wrote the draft manuscript. BS, JD and DT contributed to the statistical analysis and interpretation of results. Finally, VS, DT, BS and JD made contributions to manuscript revision. All authors read and approved the final manuscript.

Funding
This study was funded by the Ministry of Health of the Lao PDR and the LEARN Project.

Availability of data and materials
The datasets analysed during the current study are not publicly available due to the privacy policy imposed by the UHS, but may be available from the corresponding author on reasonable request.

Ethics approval and consent to participate
This study was approved by the National Ethics Committee for Health Research, Ministry of Health, Lao PDR, and reviewed by the International Review Board of the Hanoi University of Public Health. All HCWs included in the sample agreed to participate in the survey and signed the informed consent form.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

References

[1] Sychareun V, Rowlands L, Vilay P, Durham J, Morgan A. *The determinants of vaccination in a semi-rural area of Vientiane City, Lao People's Democratic Republic: a qualitative study*. Health Res Policy Syst, 2019. **17**(1): p. 2.

[2] Xeuatvongsa A, Hachiya M, Miyano S, Mizoue T, Kitamura Tl. *Determination of factors affecting the vaccination status of children aged 12-35 months in Lao People's Democratic Republic*. Heliyon, 2017. **3**(3): p. e00265.

[3] Phoummalaysith B, Yamamoto E, Xeuatvongsa A, Louangpradith V, Keohavong B, Saw YM, et al. *Factors associated with routine immunization coverage of children under one year old in Lao People's Democratic Republic*. Vaccine, 2018. **36**(19): p. 2666-2672.

[4] Black AP, Nouanthong P, Nanthavong N, Souvannaso C, Vilivong K, Jutavijittum P, et al. *Hepatitis B virus in the Lao People's Democratic Republic: a cross sectional serosurvey in different cohorts*. BMC Infect Dis, 2014. **14**: p. 457.

[5] Nanthavong N, Black AP, Nouanthong P, Souvannaso C, Vilivong K, Muller C P, et al. *Diphtheria in Lao PDR: Insufficient Coverage or Ineffective Vaccine?* PLOS ONE, 2015. **10**(4): p. e0121749.

[6] Lao Statistical Bureau. *Lao Social Indicator Survey II 2017-18*. 2018, https://lao.unfpa.org/en/publications/lao-social-indicator-survey-ii-2017-18-0.

[7] Kleine, D.; Billamay, S.; Chanthavilay, P.; Mongkhoune, S.; Keokhamphoui, C.; Souksakhone, C.; Nouanthong, P.; Khamphaphongphane, B.; Muller, C.P.; Black, A.P. Pertussis in Lao PDR: Seroprevalence and disease. *Int. J. Infect. Dis.* **2020**, *95*, 282–28

[8] Gavi, The Vaccine Alliance. Lao country Factsheet 2022. Available at (https://www.gavi.org/programmes-impact/country-hub/west-pacific/lao-pdr).

[9] Hefele L, Syphan S, Xayavong D, Homsana A, Kleine D, Chanthavilay P, et al. *Timeliness of immunisation with the pentavalent vaccine at different levels of the health care system in the Lao People's Democratic Republic: A cross-sectional study*. PLoS One, 2020. **15**(12): p. e0242502.

[10] Swarnkar M, Baig V N, Soni SC, Shukla US, Ali J. *Assessment of Knowledge and Practice about Immunization among Health Care Providers*. National journal of community medicine, 2016. **7**: p. 281-285.

[11] Schuler M, Schaedelin S, Aebi C, Berger C, Crisinel PA, Diana A, et al. *Attitudes of Swiss Health Care Providers Toward Childhood Immunizations*. Pediatr Infect Dis J, 2017. **36**(6): p. e167-e174.

[12] Dempsey A F, Pyrzanowski J, Lockhart S, Campagna E, Barnard J, O'Leary ST. *Parents' perceptions of provider communication regarding adolescent vaccines*. Hum Vaccin Immunother, 2016. **12**(6): p. 1469-75.

[13] National Statistic Bureau. *Results of Population and Housing Census 2015*. 2015, https://lao.unfpa.org/en/publications/results-population-and-housing-census-2015-english-version.

[14] Al-Ayed IH, Sheik S, *Knowledge & practices of childhood immunization among primary health care providers in riyadh city: part II - precautions and contraindications to vaccination*. J Family Community Med, 2006. **13**(1): p. 19-24.

[15] Salem ME-HI, Khali SAS, Mahmoud MMR , *Assessment of Expanded Program of Immunization Provided for Children less than Five Years in Family Health Centers at Cairo Governorate*. Acta Scientific Pharmaceutical Sciences, 2018. **2**(10): p. 67-78.

[16] Karami, M., et al., *Adverse events following immunization with pentavalent vaccine: experiences of newly introduced vaccine in Iran*. BMC Immunol, 2017. **18**(1): p. 42.

[17] El Shazly H, Khalil N, Ibrahem R, Abdel Wahed S, *Knowledge and practice of healthcare providers as regards routine children vaccination in primary healthcare facilities of Quewisna District, Menoufia Governorate*. Menoufia Medical Journal, 2016. **29**(4): p. 1018-1024.

[18] Warner EL, Ding Q, Pappas L, Bodson J, Fowler B, Mooney R, et al. *Health Care Providers' Knowledge of HPV Vaccination, Barriers, and Strategies in a State With Low HPV Vaccine Receipt: Mixed-Methods Study*. JMIR Cancer, 2017. **3**(2): p. e12.

[19] Masika CW, Atieli H, Were T, *Knowledge, Perceptions, and Practice of Nurses on Surveillance of Adverse Events following Childhood Immunization in Nairobi, Kenya*. Biomed Res Int, 2016. **2016**: p. 3745298.

[20] Karafillakis E, Dinca I, Apfel F, Cecconi S, Wűrz A, Takacs J, et al. *Vaccine hesitancy among healthcare workers in Europe: A qualitative study*. Vaccine, 2016. **34**(41): p. 5013-5020.

[21] Maguire M, Delahunt B. *Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars*. All Ireland Journal of Higher Education, 2017. **9**(3).

[22] Widsanugorn O, Suwattana O, Harun-Or-Rashid M, Sakamoto J. *Healthcare workers' knowledge and practices regarding expanded program on immunization in Kalasin, Thailand*. Nagoya J Med Sci, 2011. **73**(3-4): p. 177-85.

[23] Riccio, M.; Marte, M.; Imeshtari, V.; Vezza, F.; Barletta, V.I.; Shaholli, D.; Colaprico, C.; Di Chiara, M.; Caresta, E.; Terrin, G.; et al. Analysis of Knowledge, Attitudes and Behaviours of Health Care Workers towards Vaccine-Preventable Diseases and Recommended Vaccinations: An Observational Study in a Teaching Hospital. Vaccines 2023, 11, 196. https://doi.org/10.3390/ vaccines11010196

[24] Liu, Y.; Ma, C.; Jia, H.; Xu, E.; Zhou, Y.; Zhang, Z.; Lu, L.; Rodewald, L.; Hao, L.Knowledge, attitudes, and practices regardinghepatitis B vaccination among hospital-based doctors and nurses in China: Results of a multi-site survey. Vaccines **2018**, 36, 2307–2313

[25] Sengchaleun V, Khampanisong P, Aye-Soukhathammavong P, Reinharz D, Black A. *Knowledge, attitudes and practices regarding vaccination among healthcare workers in Lao PDR.* Southeast Asian J Trop Med Public Health, 2019. **50**(2): p. 383-391.

[26] Ansong D, Osei FA, Enimil A, Kofi B., Nyanor I, Amuzu E, et al. *Knowledge and Competencies of Vaccinators on Routine Childhood Vaccination in Ghana*. Journal of Vaccines & Vaccination, 2018. **09**.

[27] Rutchanagul P, Sangnimitchaikul W, *A study of the self-perceived competencies regarding the knowledge and skills of healthcare providers in the Expanded Program on Immunization in Thailand: A mixed-methods study*. Journal of Health Research, 2019. **33**.

[28] World Health Organization. Regional Office for the Western, P., *Vaccine safety communication : guide for immunization programme managers and national regulatory authorities*. 2016, Manila: WHO Regional Office for the Western Pacific.

[29] Onprasonk Widsanugorn, Onprasonk Suwattana, Md. Harun-Or-Rashid And Junichi Sakamoto. Healthcare Workers' Knowledge And Practices Regarding Expanded Program On Immunization In Kalasin, Thailand. Nagoya J. Med. Sci. 2011;73:177-185.

[30] LeBaron CW, Chaney M, Baughman AL, Dini EF, Maes E, Dietz V, Bernier R. *Impact of measurement and feedback on vaccination coverage in public clinics, 1988-1994*. Jama, 1997. **277**(8): p. 631-5.

[31] World Health Organization and UNICEF, *1 in 10 infants worldwide did not receive any vaccinations in 2016*. 2017.

[32] Anikeeva O, Braunack-MayerA, Rogers W. *Requiring influenza vaccination for health care workers.* Am J Public Health, 2009. **99**(1): p. 24-9.