สถานการณ์การบริหารจัดการวัคซีนและระบบลูกโซ่ความเย็นของบุคลากรสาธารณสุข ในหน่วยบริการปฐมภูมิจังหวัดเชียงใหม่
Situation of Vaccine and Cold-Chain System Management Among Public Health Personnel in Primary Care Units at Chiang Mai Province

นิพนธ์ต้นฉบับ **Original Article**

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บทคัดย่อ

วัตถุประสงค์: เพื่อระบุสถานการณ์การบริหารจัดการวัคซีนโดยบุคลากรสาธารณสุขในหน่วยบริการปฐมภูมิจังหวัดเชียงใหม่ และเหตุปัจจัยที่ส่งผลต่อการบริหารจัดการดังกล่าว **วิธีการศึกษา:** งานวิจัยแบบผสมผสาน เริ่มจากการสำรวจสถานการณ์โดยใช้แบบสอบถามกับบุคลากรผู้รับผิดชอบงานวัคซีนในโรงพยาบาลส่งเสริมสุขภาพตำบลทุกแห่งในจังหวัดเชียงใหม่จำนวน 236 คน เพื่อประเมินการดำเนินงาน ความรู้ของบุคลากร ความพร้อมของสิ่งสนับสนุน และผลกระทบจากลักษณะภูมิประเทศ และสัมภาษณ์เชิงลึกใน 12 คน เพื่อทำความเข้าใจเพิ่มเติมจากผลการสำรวจที่ได้ เก็บข้อมูลระหว่างมิถุนายนถึงตุลาคม 2563 วิเคราะห์ข้อมูลเชิงปริมาณด้วยสถิติเชิงพรรณนา และวิเคราะห์เชิงเนื้อหาสำหรับข้อมูลเชิงคุณภาพ **ผลการศึกษา:** บุคลากรผู้รับผิดชอบงานวัคซีนในโรงพยาบาลส่งเสริมสุขภาพตำบลปฏิบัติตามแนวทางการจัดการวัคซีนได้อย่างถูกต้อง แต่มีบางประเด็นที่บางส่วนยังปฏิบัติไม่ถูกต้องมากกว่า 20% เช่น การทำให้น้ำแข็งเริ่มละลาย (conditioning icepack) การบันทึกอุณหภูมิตู้เย็น และการจัดการในกรณีฉุกเฉิน พบว่าบุคลากรขาดความรู้ในเชิงเทคนิคที่เกี่ยวกับการจัดการระบบลูกโซ่ความเย็น เช่น อุณหภูมิในระบบ คุณสมบัติของวัคซีนแต่ละชนิด และการอ่านเครื่องหมาย Vaccine Vial Monitor เป็นต้น การโยกย้ายกำลังคน งบประมาณ และอุปกรณ์ในระบบลูกโซ่ความเย็น สัมพันธ์กับความพร้อมของการบริหารจัดการระบบ หน่วยงานที่กระจายวัคซีนระดับอำเภอสำคัญต่อการสนับสนุนการจัดการวัคซีน **สรุป:** บุคลากรผู้รับผิดชอบงานวัคซีนระดับปฐมภูมิในจังหวัดเชียงใหม่สามารถบริหารจัดการวัคซีนและห่วงโซ่ความเย็นได้ดี แต่สามารถพัฒนาเพิ่มเติมในเรื่องความรู้ด้านคุณสมบัติของผลิตภัณฑ์ที่สัมพันธ์กับการจัดการห่วงโซ่ความเย็น และพัฒนาระบบการสนับสนุนการจัดการด้านกำลังคน งบประมาณ และอุปกรณ์ในระบบลูกโซ่ความเย็นอย่างเหมาะสม

คำสำคัญ: การบริหารจัดการวัคซีน , ระบบลูกโซ่ความเย็น, โรงพยาบาลส่งเสริมสุขภาพตำบล, หน่วยบริการปฐมภูมิ

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Abstract

Objective: To determine the situation of vaccine and cold-chain system management at primary care units in Chiang Mai Province and rationale and issues related to the management **Methods:** Mixed method approach was used, starting with a survey of 236 health personnel responsible for vaccine management at sub-district health promoting hospitals, Chiang Mai Province, to access their practice, knowledge, availability of supports, and impacts of the area's geographics on the vaccine and cold-chain management. The in-depth interview on done with 12 selected personnel. Data were collected from June to October 2020. Descriptive statistics and content analysis were used to analyze quantitative and qualitative data, respectively. **Results:** Survey respondents properly followed vaccine practice guideline; but more than 20% failed to comply with issues such as conditioning icepack, recording refrigerator temperature, and managing cold- chain system in emergency situations. Survey respondents lacked technical knowledge related to vaccine and cold- chain system such as required temperature, vaccine's specific characteristics, and Vaccine Vial Monitor mark. Healthcare-system factors related to the vaccine and cold-chain management included personnel turnover, and availability of budget and equipment. A district- level vaccine depot was a major support for the system. **Conclusion:** Personnel in sub-district health promoting hospitals, Chiang Mai province followed vaccine and cold-chain management guideline. Technical knowledge on vaccine characteristics related to system operation could be improved. Sub- district hospitals should be provided with manpower, budgetม and equipment for proper cold-chain system.

Keywords: vaccine management, cold chain system, health promoting hospital, primary care unit

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Introduction

Vaccines are the most effective and cost effective protection against disease.[1–3] The World Health Organization focuses its policy on reducing morbidity or mortality from communicable diseases that can be prevented by vaccines with the goal of eradication of critical diseases and strengthening of sustainable immunization programs.[3] Every country around the world, including Thailand, uses immunization as an effective tool for prevention and control of communicable diseases.[4,5]

According to Thailand 2017 surveillance report, the northern region had highest rates of morbidity with preventable infectious diseases such as mumps (4.65 per

100,000 population) and tetanus (0.22 per 100,000 population), compared to other regions. Chiang Mai was on the country's top five measles morbidity rates (14.70 per 100,000 population) and the country's top 10 rubella morbidity rates (1.09 per100,000 population).[6]

A reason for the high rates of preventable infectious diseases is due to the quality of vaccine and cold-chain system management. From the 2017 assessment report of the Office of Disease Prevention and Control Region 1, Chiang Mai, several issues of the vaccine and cold-chain system management in sub-district health promoting hospitals were related to temperature control on vaccine transportation and storage, supervision of the cold-chain system equipment, refrigerator temperature monitoring, and no emergency plan for cold-chain system breakdown.[7]

The problems in vaccine and cold-chain system management occur in other areas as well.[8,9] In sub-district health promoting hospitals, or primary care units, vaccine storage is an ongoing problem where refrigerator temperature is out of the proper range. Expired vaccine is found in the refrigerator, and it is not placed separately according to the type of vaccine.[10-12] In previous studies, factors affecting vaccines and cold-chain system administration consists of personnel's internal and external factors. Internal factors include knowledge, attitudes, and behaviors of individuals.[13] External factors include the unit's manpower, management systems, and availability of resources.[14] These factors are necessary for developing an appropriate operating system for vaccine, resulting in people and society getting the most of vaccines in preventing diseases.

In planning of a system, it is necessary to consider the contexts and nature of the area. Since Chiang Mai consists mainly of mountainous area (80%) followed by a plain area, a river basin and mountain foothills.[15] Furthermore, some areas are not easy to access due to poor transportation and utilities such as limited electricity. These geographical characteristics and personnel's demographic characteristics affect vaccine management.[13,14] To better design a vaccine management system specific to Chiang Mai area, it is crucial to understand the situation of vaccine and cold-chain system management at primary care facilities which is the point of contact before the vaccine is administered to the public.

This study aimed to 1) describe the situation of vaccine and cold-chain system management at primary care units in Chiang Mai province, from vaccine distribution, transportation, to storage, and 2) explore rationale and issues related to the management including personnel's internal factors (i.e., knowledge) and external factors (i.e., manpower, budget, organization management, cold-chain equipment, supports from the district-level vaccine depot, and geographic context). This research used a mixed-method approach where a quantitative study allows the researcher to understand the overall situations, and a qualitative study helps the researcher obtain deeper information to gain further understanding of the situations.

Methods

Mixed method was implemented where a qualitative method was used to explain quantitative findings. A quantitative research used a self-administered questionnaire to survey vaccine and cold-chain system management among personnel of sub-district health promoting hospitals all around Chiang Mai. The results of the survey were used to develop a semi-structured interview guide to collect qualitative data by in-depth interviews with 12 personnel responsible for vaccine management at sub-district health promoting hospitals. The study was approved by the Human Research Ethics Committee from the Faculty of Pharmacy, Chiang Mai University on February 17, 2020 (IRB Approval No. 02/2563). All prospective informants and survey respondents were informed about the objectives, process, and voluntary, anonymitity and confidentiality nature of the study. Written informed consent form was obtained from all informants while implied consent was obtained from all mail survey respondents.

Survey of vaccine and cold chain system management

Population and sample

Data were collected from personnel responsible for vaccine and cold-chain at all sub-district health promoting hospitals (267 hospitals) in Chiang Mai province between June - July 2020. List of potential respondents and their contact information was received from the Vaccine Workgroup, Communicable Disease Department, Chiang Mai Provincial Health Office.

Survey instrument

A questionnaire was developed from literature review, and national standard practice guidelines on vaccine and cold-

chain management. It consisted of 5 parts. The **first part** collected information of respondent's work experience, and prior training on vaccine and cold-chain management. The **second part** assessed the respondents' knowledge on vaccine and cold-chain system management. The questions on knowledge used a multiple-choice format, with 3 possible answers (yes, no, and unsure). The **third part** asked about availability of vaccine and cold-chain system supports which included supports on manpower, budget, equipment, administration on vaccine and cold-chain management at the sub-district health promoting hospitals and support from the district vaccine depot. The availability of resources and level of supports were assessed by a 5-level Likert scale ranging from 5 (very high) to 1 (very low).

The **fourth part** assessed the impact of area geography on the management of the vaccine and the cold-chain system. The response was a 5-level Likert scale ranging from 5 (very much) to 1 (very little). In the **fifth part**, the respondents were asked about practice on vaccine and cold-chain system management in disbursement, transportation, and storage in normal and emergency situations. The questions on practice were multiple-choice with 3 possible answers (not at all practice, practice sometimes and regular practice).

The questionnaire was checked for content validity by 3 experts working on vaccine and cold-chain management system and public health at the provincial level. An Index of Item-Objective Congruence (IOC) was used. Questions with IOC of less than 0.5 point were revised according to experts' recommendations. At the second round of review, every question item gained more than 0.5 IOC point. Then, the instrument was examined for its internal consistency reliability with 20 personnel responsible for the vaccine and cold-chain system management at sub-district health promoting hospitals in Lamphun province. The questionnaire was found to have acceptable reliability with Cronbach's alpha coefficients of at least 0.70 for all parts.

Data collection procedure

The questionnaire was sent to potential participants by mail. On the 15th day after it was sent, the researcher called to the non-respondents, and resent the documents if they notified that they did not receive them. On the 30th day, the researcher followed up the non-respondents again by telephone.

Data analysis

The data were analyzed using descriptive statistics (frequency with percentage and mean with standard deviation). All analyses were performed using STATA/Windows version 14.0.

Semi-structure interviews on vaccine and cold-chain system management

Key informants

The investigators selected key informants for insights and explanations of the survey results. By purposive sampling, 12 key informants were selected from the pool of survey respondents. In sample selection, we ensured that we had representatives of those having different length of experience, working in different area (urban, lowland, and backcountry), and having different levels of knowledge on practice of vaccine and cold-chain system management (identified from the survey).

Instruments

A semi-structured interview guide was developed from the survey results and literature review. Content validity was examined by an expert in behavioral research. The questions were revised according to comments and recommendations of the experts. The interview guide was pre-tested with 2 practitioners to ensure understanding of the questions and quality of interview procedures. The final questions for in-depth interviews included 1) management of vaccines at their setting, 2) understanding of background knowledge on vaccines and the cold-chain system, 3) actual practices in the cold-chain system and rationale behind the practices, and 4) effects of geographical settings on vaccine operations such as distance, travel difficulties or power outage.

Data collection procedure

In October 2020, the investigator contacted potential key informants by telephone to explain the research details and asked for participations. The interviews were conducted at the sub-district health promoting hospitals where the informant was working. The main investigator (FN) was the sole interviewer with permission to voice record the conversation in advance. The interview took approximately 60 minutes. Once the interview was completed, the investigator summarized the key findings and asked the informants to verify the information accuracy. Within a week, the interview

transcription was sent to the informants by e-mail to confirm the correctness of the information once again.

Data analysis

After conveying all information verbatim, the main investigator (FN) read the entire content and organized data into groups according to pre-specified and emerging codes. The investigator developed working hypotheses and identified themes and sub-themes. Working hypothesis, themes and sub-themes were verified with the co-investigator (PS). Disagreement was discussed until consensus. After that, the investigator synthesized and organized related contents to create a summary.

Results

The survey questionnaire was mailed to 267 key personnel responsible for vaccine and cold-chain management in primary care units in Chiang Mai province. A total of 236 questionnaires were returned representing a 88.39% response rate. Their age was 39.68 ± 9.95 years by average (Table 1). Majority of the respondents were women (86.44%), professional nurse (65.25%), with more than 20 years of working in public health (39.83%), with not more than 10 years in vaccine and cold-chain system management (69.91%). About two-thirds had a training in vaccine and cold-chain system management (62.29%). Among those who had the training, the majority had the training more than a year ago (48.30%) (Table 1). In the in-depth interview, a total of 12 key informants had a mean age of 41.33 ± 10.02 years with the position of professional nurse working in urban, lowland, and backcountry areas of 2, 6, and 4 people, respectively.

Data from the interviews revealed that a short experience on vaccine and cold-chain management among the personnel was due to high staff turn-over rate. Many personnel were professional nurses who got transferred from a district hospital to a sub-district health promoting hospital. They had never overseen vaccine systems while working in the hospital. Thus, they had to start learning about vaccine and cold-chain management after the transfer.

"People has been moving and transferring around within a district. To change their workplace, their job responsibilities change. Most hospital nurses have never been in charge of vaccine (system management) before. After moving to a sub-district hospital, they had to learn all about vaccine." (an officer at lowland area level 1)

"Whenever there is a new staff, we have to rearrange and reassign work responsibilities, who works on which job." (an officer at lowland area level 2)

Table 1 Demographic and health-related characteristics of the survey respondents (N = 236).

Personal Information	N	%
Gender		
Men	32	13.56
Women	204	86.44
Age (years), mean ± SD, (min, max)	39.68 ± 9.95 (22, 61)	
Position		
Professional nurse	154	65.25
Public health officer	42	17.80
Community health official	36	15.25
Director of sub-district health promoting hospital	4	1.69
Experience working in public health (years)		
≤ 10	85	36.02
11 - 20	57	24.15
> 20	94	39.83
Experience in vaccine and cold-chain systemmanagement (years)		
≤ 10	165	69.91
11 - 20	42	17.80
> 20	29	12.28
Training in vaccine and cold-chain system management	147	62.29
The latest period of receiving the training (n = 147)		
3 months ago	14	9.52
1 year ago	62	42.18
More than 1 year	71	48.30

Vaccine and cold-chain system management in primary care units

For practices related to vaccine management, majority of the personnel followed established national guidelines at all stages. However, but there were some steps that more than 20% of them failed to practice regularly (Table 2). These steps were conditioning icepack before packing, rehearsing for cold-chain system management under an emergency, and transferring vaccine to a nearby sub-district health promoting hospital when cold-chain system breakdown for more than 24 hours.

Data from the in-dept interviews revealed that these suboptimal practices require in-depth and technical knowledge of vaccines and cold-chain systems to make a reasonable decision. Scientific knowledge of these issues was not available for the practitioners, even in meetings organized by a district vaccine depot. The meetings were aimed to display vaccine standard of practices such as how to prepare vaccines bill or arrange vaccines in a refrigerator, rather than to provide in-depth knowledge on vaccine's properties and cold-chain systems. This resulted in unawareness of the personnel in fully complying with practice guideline.

"I don't really know. Some people do not really know why some vaccines are sensitive to cold or heat. Usually, there is a pictogram showing where, in the refrigerator, to place a vaccine, and practitioners will follow it without knowing what they are doing for." (an officer at lowland area level 1)

Table 2 Practices on vaccine and cold- chain system management of the survey respondents (N = 236).

Operation	Regular practice	
	N	%
Vaccine disbursement		
Estimate volume of disbursement monthly for sufficient services	227	96.19
Consider target group and rate of loss in the estimation	227	96.19
Record vaccine requisition information in complete details	224	94.92
Submit vaccine requisition as specified	229	97.03
Prepare an up-to-date vaccine registration records (Stock card)	205	86.86
Vaccine transportation		
Pack the BCG, MMR and JE vaccines in a light-protected plastic container before packing in vaccine box	207	87.71
Make sure the ice pack starts conditioning before packing into a vaccine carrier	167	**70.76**
Put corrugated plastic sheets on all 4 sides of the vaccine carrier to prevent the ice pack from direct contact with the vaccine	178	**75.42**
Check temperature in a vaccine carrier to a range of +2 to +8 °C before packing	203	86.02
Put a thermometer or data logger in a vaccine carrierto monitor the temperature	195	82.63
Vaccine storage		
Once vaccinated, the vaccine is placed immediately back in a refrigerator	230	97.46
Place a thermometer in close proximity to cold-sensitive vaccines; DTP-HB, HB	216	91.53
Use vaccines based on the First-Expired, First-Out principle	228	96.61
Record a temperature of a refrigerator twice daily, in morning and evening	205	86.86
Monitor temperature of a refrigerator between +2 to +8 °C in normal compartment and -15 to -25 °C in freezer compartment, and check the refrigerator annually	191	80.93
Cold-Chain System Planning		
Clearly establish a cold-chain system emergency plan	221	93.64
Maintain equipment in the cold-chain system in a ready-to-use condition	223	94.49
Rehearse cold-chain practices in an emergency situation, at least once a year	120	**50.85**
Transfer vaccines to a nearby sub-district health promoting hospital or district hospital, if a cold-chain system breakdown for more than 24 hours	166	**70.34**
Ask for vaccine information from a district-level vaccine warehouse pharmacist in situations of emergency and uncertain of quality of vaccines	191	80.93

Knowledge of vaccine and cold- chain system management

Regarding knowledge of vaccine and cold-chain system management, it was found that, although most practitioners in the survey could follow the practice guideline regularly, their scientific knowledge behind the practices were quite modest (Table 3). Relatively low proportions of survey respondents answered temerapture-realted questions correctly (11.44% to 51.27%) including required temperature in cold- chain system and management of cold-chain devices such as Vaccine Vial Monitor (VVM) and Freeze Watch in both normal and emergency situations.

Table 3 Knowledge of vaccine and cold- chain system management of the survey respondents (N = 236).

Issue questions	People with correct answer	
	N	%
A water bottle with a lid should not be placed at the bottom shelf of the refrigeratorinwhich vaccinesare stored because it will make unstable temperature.†	216	91.53
Storing HB and DTP vaccines in a freezer or at temperatures below 0 °C, will cause immediatly vaccine deterioration. †	204	86.44
Vaccine refrigerator temperature should be kept at -15 to -25 °C in freezer compartment, and 2 - 8 °C at normal compartment. Some medicines such as drops and injections can be stored together. †	193	81.78
Vaccine refrigerator temperature should be recorded at least once daily, in the morning or evening (not except holidays).	155	65.68
Inactivated vaccines should be placed at the coldest part of a refrigerator. Live vaccines could be placed at any places for both dry powder and liquid forms.†	140	59.32
To prevent frost-sensitive vaccines from freezing, a thermostat should be adjusted to 2 - 4 °C.	121	**51.27**
OPV vaccine is heat sensitive, but it is not light sensitive, so they do not need to be stored in a box or brown zippered bag. †	120	**50.85**
Vaccine defrosting solution can be kept out of the refrigerator. However it must be stored at a temperature of 2 - 8 °C for 24 hours before use.	107	**45.34**
When taking out frozen ice packs from a refrigerator, it must be put into a vaccine carrier immediately. †	105	**44.49**
Vaccine Vial Monitor (VVM) is used to indicate if the vaccine has exposed to heat for a period of time. If the indicated color becomes lighter, the vaccine has deteriorated. †	80	**33.90**
If the power goes out for more than 5 hours, place vaccines in another refrigeratoror store in a vaccine carrier at 2 - 8 °C. †	77	**32.63**
Temperature of a vaccine thermometer should be calibrated at least twice a year. †	77	**32.63**
Vaccines are sensitive to temperatures that are extremely hot or cold. All vaccines are sensitive to cold and some are sensitive to heat. †	54	**22.88**
Freeze Watch (FW) is a device used to indicate that a vaccine may hit the freezing point and become deteriorated. †	32	**13.56**
Cold-chain system means keeping the vaccine in 2 - 8 °C condition at all times from the host hospital to the service recipient. †	27	**11.44**

† The correct answer to the statement is "wrong."

Findings from in- depth interviews provide additional reasons behind the misunderstandings and sub-optimal practices. Some personnel though that a cold chain required refrigerated storage, but transportation was excluded. They answered that a cold chain required keeping vaccine in cool temperatures but were unaware of a specific temperatures that must be in range of +2 and +8 degrees Celsius. The informants added that they did not know any of scientific information behind the required practice guidelines.

"I have never known about a VVM mark, never observed, never looked for it." (an officer in a backcountry area level 2)

"I must admit that I have no knowledge on how to do it, but in my opinion it must be in cold. When taking it out of a fridge, I just pack it without waiting for (conditioning) it." (an officer in a backcountry area level 1)

Supports for vaccine and cold-chain system management

Support for the vaccine and cold-chain system operations of their work system included the topics of manpower, budget, equipment, hospital administration and supports from a district-level vaccine depot. Based on the survey, all questions in each of all topics were rated as moderate to high level with the range of 3.08 – 4.24 out of points. Most questions in the topic of support from a district-level vaccine depot had the highest scores (3.30 – 4.23 points). On the other hand, most questions in the topic of budget had the lowest scores (3.08 - 3.31 points) (Table 4).

Table 4 Opinions on availability of vaccine and cold-chain system supports among the survey respondents (N = 236).

Support aspects	Mean*	SD
Manpower		
There is a sufficient number of personnel responsible for vaccine management.	3.66	0.91
Personnel has well knowledge and skills in vaccine management.	3.65	0.73
Personnel receives regular training on vaccine management.	3.06	1.00
Budget		
Budget to support the implementation of vaccinemanagement is sufficient.	3.27	0.97
Budget to support the implementation of vaccine management is timely.	3.31	0.95
Budget to purchase equipment in the cold-chain systemis sufficient.	3.16	0.93
Budget for purchase of equipment in thecold-chain system is timely.	3.08	0.96
Management within a sub-district health promoting hospital		
The responsible personnel is appointed with clear operational goals.	3.69	0.86
There is a clear appointment of personnel responsible for the administration of the vaccine.	4.24	0.70
Personnel receives regular training on vaccine management, at least once a year.	3.10	1.20
The work is evaluated in order to achieve the set goals.	3.85	0.86
Supervisors provide support and trust in personnel.	4.07	0.72
Equipment in the cold-chain system		
Equipment in a cold-chain system is sufficient.	3.56	0.82
Equipment in a cold-chain systemis timely allocated.	3.48	0.84
Equipment in a cold-chain system that has been allocated is at standard quality.	3.83	0.72
Process of purchasing equipment in the cold-chain system is not complicated.	3.41	0.84
There is a replacement for an equipment in the cold-chain system when damaged.	3.24	0.94
Purchasing equipment in the cold-chain focuses on quality rather than price.	3.64	0.81
Support from a district-level vaccine depot		
Establish a clear and step-by-step guidline for vaccinedisbursement	4.23	0.74
Establish a guideline for vaccine transportation according to cold-chain standards	4.16	0.81
Organize a training on vaccine management and cold chain system at least once a year	3.30	1.24
Organize a monitoring of vaccine and cold-chain system management at least once a year	3.59	1.11
Vaccine consultation system is provided in various channels, i.e. telephone, email and line.	4.06	0.86
There are guidelines to help when an emergency occurs in the cold-chain system.	3.90	0.93

* Possible mean score of 5 points.

However, from in-depth interviews where the researcher has an opportunity to discuss in depth and to observe the availability of supports, it was found that some units lacked appropriate equipment in the cold-chain system, such as vaccine carrier, thermometer, and icepacks. In some places, there was only one vaccine carrier that can be used (Figure 1) and insufficient number of icepacks for emergency situations. Some non-standard equipment such as picnic boxes were found. Data logger devices were found but were not used or out-of-order.

"Equipment for cold-chain is not enough. There is only one thermometer that can be used for only one vaccine carrier. Some are broken, but we have no budget to fix it. We just keep it." (an officer in a backcountry area level 2)

Figure 1 Vaccine carrier is out-of-order and unavailable. Picnic box that do not meet the cold-chain system standards is used.

Impacts of area geographical contexts on vaccine and cold-chain system operation

Survey results showed that majority of the respondents reported that impacts on vaccine and cold chain system administration by difficulty in accessing the area and in traveling, distance from sub-district health promoting hospital to district-level vaccine warehouse and to service units in a village, and utility system problems such as power outages were at low (24.15%, 27.12%, and 31.36%, respectively) to moderate (31.78%, 30.93%, and 25.42%, respectively) levels. Slightly different from those three factors, the number of service units such as community health service centers had the impact at very low, low, and moderately (30.08%, 22.46%, and 30.08%, respectively) (Table 5).

Table 5 Impacts of setting's geography on vaccine and cold chain system administration among the survey respondents (N = 236).

Geographical contexts	Impact on vaccine management, N (%)					Mean	SD
	Most	More	Moderate	Low	Very low		
Difficulty in accessing the area and in traveling	16 (6.78)	32 (13.56)	75 (31.78)	57 (24.15)	56 (23.73)	2.55	1.18
Distance from sub-district health promoting hospital to district-level vaccine warehouse, and to service units in a village.	18 (7.63)	39 (16.52)	73 (30.93)	64 (27.12)	42 (17.80)	2.69	1.17
Utility system problems such as power outages	36 (15.25)	39 (16.53)	60 (25.42)	74 (31.36)	27 (11.44)	2.93	1.24
Number of service units such as community health service centers	10 (4.24)	31 (13.14)	71 (30.08)	53 (22.46)	71 (30.08)	2.39	1.17

In the in-depth interviews, practitioners had to design their work to overcome their challenging problems. For example, a high rate of vaccine loss such as the BCG vaccine was due to the vaccine requirement that it must be used within 2 hours after bringing it out of the cold-chain storage. However, a trip between villages takes more than 2 hours, so practitioners had to discard it and use a new unit (Figure 2).

"We are in a remote area where travelling between villages is challenging. There might be 2 - 3 children in one village for vaccination, then we have to spend 2 hours in mountain area to get to another village. The BCG vaccine cannot be used anymore, therefore we needs to bring a new one." (an officer in a backcountry area level 2)

Figure 2 Vaccination service units in backcountry area.

In urban or lowland area, it is convenient to transport vaccines from a host hospital to a sub-district health promoting hospital or a service unit. Usually, it takes about 10 - 30 minutes. However, it takes about 1 - 3 hours for backcountry or mountainous area. In rainy seasons, a car could not easily access to some areas, and a motorbike or walk by foot is used instead. Operating vaccines in highlands during rainy season is more difficult than any other season. Due to that reason, vaccination services are scheduled for every two months, instead of monthly (Figure 3).

Figure 3 Difficulty in traveling in backcountry area during rainly season.

In terms of vaccine storage and cold chain planning, in highland areas, electricity often goes out for more than 3 hours, or all day in some places. Preparing equipment for cold-chain system breakdown is crucial. However, following a guideline by transferring vaccines to a nearby sub- district health promoting hospital is challenging. It can take at least one hour to get to the destination, while it takes about 10 - 20 minutes in flat areas.

Discussions and Conclusion

Personnel responsible for vaccine cold-chain system management in primary care units in Chiang Mai province could operate their practices concordantly to the guidelines. However, by assessing their specific knowledge on vaccine and cold-chain management, there were many misconceptions leading to insufficient decisions to practice properly, especially in critical situations. Results of this study revealed that they needed additional knowledge related to the

properties of physicochemical properties of vaccines in relation to the storage and transportation.

Training should be a source of knowledge for practitioners that provides both technical and practical knowledge. In the past, the training sessions for vaccine and cold-chain systems were presented in a district meeting, but it often focused on practical knowledge, not technical or scientific knowledge behind the practice. As a result, personnel performed their job without a proper understanding of the importance of each process. When they faced with a prompt problem, they failed to solve the problem properly. Studies both in Thailand and abroad found that trained personnel are more knowledgeable than untrained personnel[12] and trained personnel were better able to administer the vaccines and cold-chain systems than untrained personnel.[17,18] Regular training for both technical and practical knowledge would result in correct implementation of the guidelines. In addition, supporting information with manuals, documents, posters for communication or providing a list of most frequently asked questions can help increase the knowledge and confidence of the practitioners.

In vaccine and cold-chain system management, only appropriate knowledge of personnel is inadequate. System supports concordantly with setting environmental context are needed. As presented in Figure 4, the study's finding summary, training, operational guidelines, budget, and equipment supports from the district vaccine depot which are flexible and tailored to the setting's contexts are essential for operating vaccine and cold-chain systems at primary care units.

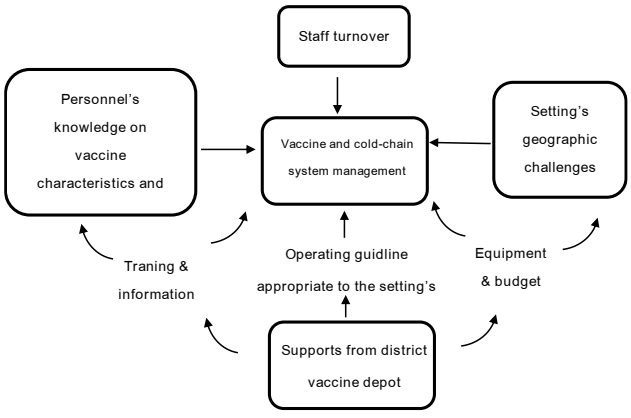

Figure 4 Situation of vaccine and cold-chain system management among public health personnel in primary care units at Chiang Mai province.

Data showed that vaccine management at district level provided great support for the practitioners at sub-district levels. It emphasizes an importance of not only practitioners' knowledge, but also systematic support for vaccine management from every level for manpower, budget and equipment in cold-chain system. Budget is needed for the purchase of equipment in the cold-chain system. Nowadays, availability of advances in technology for temperature monitoring in the cold-chain system should be considered. Appropriate equipment for specific functions should be provided. Small vaccine carriers are essential for carrying vaccines to out-of-area services. Large vaccine carriers are suitable for transferring large quantities of vaccines.[5,19] Styrofoam boxes are also an alternative to vaccine packaging for specific events where the budget is insufficient, but technical guidelines it should be added according to the guidelines.[5,19]

Monitoring for appropriate temperature is crucial, and a digital thermometer with an alarm when the temperature is outside the range of + 2 to + 8 degrees Celsius is recommended.[5,19] Data loggers and temperature tracking devices linked to mobile phone applications or operator watches are currently available. In budget allocation or support for vaccine operations, policy makers and supporting organization should always consider the geographic difference. Particularly, specific operations should be provided for high-altitude areas where travelling is difficult and power outages is frequent.

A self-administered survey may raise a social desirability bias. However, using both quantitative and qualitative data, it allowed researchers to validate research findings and to minimize the bias. This research provides insights of the situation of vaccine and cold-chain management from the primary care unit's perspective. However, perspective of district vaccine depot in the same issues is needed for understanding the whole picture. Therefore, further research should explore the situation at district-level vaccine depots, from pharmacist's perspective. Additional research on vaccine and cold-chain system management in geographically challenge area is worth exploring.

From the study results, various factors influence vaccine operations of the practitioners. Scientific knowledge behind the vaccine and cold-chain requirements is one important factor. Additionally, availability of supporting resources, including competent staff, technical training, budget and

equipment in the cold-chain system is essential. In providing supports, it should be relevant to the contexts of each district and sub-district.

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