An Evaluation of the COVID-19 Vaccine Management and Cold Chain Systems of the Five Cities in the National Capital Region of the Philippines

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Abstract

Several months since the rollout of COVID-19 vaccines, the Philippines still has a low immunization coverage. It is of high importance that the Cold Chain Systems (CCSs) where these vaccines are stored meet the required conditions to ensure the efficacy of each dose of vaccines. This study aims to evaluate and assess the knowledge level of Vaccine Cold Chain Handlers (VCCHs), implemented guidelines on COVID-19 vaccine handling, and the COVID-19 vaccine management in the National Capital Region (NCR). Furthermore, the study aims to evaluate and establish the relationship between the years in service and the educational attainment of VCCHs of the cities. The data were collected using a structured questionnaire based on the World Health Organization-Effective Vaccine Management (WHO-EVM) tool and the Centers for Disease Control and Prevention (CDC). The respondents were the VCCHs, responsible for storing and maintaining the vaccine at the lowest distribution points in the subject Local Government Units (LGUs). The data collected were analyzed and interpreted using Spearman's Rank Correlation and Fisher's Exact Test. The results showed that the independent variables, such as years in service, educational attainment, knowledge level of VCCHs, and implemented guidelines in COVID-19 vaccine handling have no significant relationship with the COVID-19 vaccine management and cold chain maintenance practice. However, the results could be influenced by the fact the study has a small sample size.

Keywords

Cold Chain Systems, Vaccine Handling, Vaccine Management, Vaccine Cold Chain Handlers, Lowest Distribution Points

1. Introduction

Vaccines have been one of the most efficient inventions and cost-effective public-health tools for saving lives and preventing diseases worldwide. Vaccination campaigns have saved billions of dollars in public healthcare costs and minimized hundreds of millions of people's deaths. These campaigns also made it possible to eradicate and near eliminate diseases such as smallpox and poliomyelitis that victimized hundreds to millions of people (DOH 2021).

In December 2019, a disease called COVID-19 caused by a novel coronavirus outbreak was first reported in Wuhan City, China. After thorough investigations, the WHO stated that the source of the virus, SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2), came from a zoonotic source (WHO 2020). On March 11, 2020, WHO declared that the world is in a pandemic. Weeks after recording the Philippines' first-ever local case of the *novel coronavirus 2019,* President Duterte officially signed Proclamation no. 922 on March 08, 2020, to declare a public health emergency with the country's continuous and rapid growth of COVID-19 cases. The NCR was then placed under a community quarantine to contain the virus's spread (Baclig 2021). According to WHO (2020), NCR became the epicenter of the COVID-19 virus in the country.

The researchers chose the NCR as the focus of their study; aside from being a highly populated region and the country's epicenter of COVID-19, it was also the government's priority for the COVID-19 vaccination rollout program during the time of the study. During the community quarantine, scientists and medical experts studied and developed vaccines to reduce infections. There were several COVID-19 vaccines in development using various technologies because it was not yet known which ones would be successful and safe (WHO 2020). The National Government and the Local Government Units (LGUs) and healthcare providers have prepared for the COVID-19 vaccine deployment and vaccination program implementation. However, proper vaccine supply chain management plays a vital role in ensuring that the vaccines to be administered meet the standard qualifications. WHO (2020) reported that almost 50% of vaccines are thrown away each year due to a lack of temperature regulation and infrastructure to maintain a continuous cold chain. This rate of spoilage could waste billions of vaccines on the scale of COVID-19, in which every dose counts for combatting the virus.

1.1. Objectives of the Study

Given the importance of the proper supply chain management of the COVID-19 vaccines, the study focused on factors in relation to VCCHs at the lowest distribution point and the implemented guidelines on COVID-19 vaccine handling, and their cold chain maintenance practice on COVID-19 vaccine management. The objectives of the study were to evaluate and assess the cold chain system of the cities in the National Capital Region in terms of the following: (1) Knowledge-level of the Vaccine Cold Chain Handlers; (2) Vaccine management practice of the cold chain handlers; (3) Availability of cold chain equipment in their facilities. The study also discussed the minimum standard and the key features of an adequate cold chain system and its management to maintain the efficacy of the COVID-19 vaccines. The collected data from the LGUs were interpreted and evaluated by the researchers using scoring criteria and statistical tools such as the Spearman's Rank Correlation and the Fisher's Exact Test. As a result, the researchers shall develop specification criteria for COVID-19 vaccine management in terms of cold chain system management.

The study also aimed to answer the following research questions:

a. Does the status of the knowledge of the vaccine cold chain handlers have a relationship with the COVID-19 vaccine management and cold chain maintenance practice?
b. Do the implemented guidelines for COVID-19 vaccine handling have a relationship with the COVID-19 vaccine management and cold chain maintenance practice?
c. Do the cities meet the minimum standard for COVID-19 vaccine management?

1.2 Scope and Limitations

This study covered five cities in the NCR that have agreed to participate in the study as respondents. The researchers focused on the NCR because it is the main priority for the current COVID-19 vaccination program. Subsequently, the researchers also considered the mathematical model of the Octa Research Group, a private polling, research, and consultation firm, that suggests that herd immunity in the NCR is more doable than the entire country. The study is focused on VCCHs as their respondents, as the structured questionnaire contained technical terms and required expertise. The study was conducted from January 2021 to October 2021; the data collected and used for the evaluation were from the five LGUs studied from August 2021 to October 2021.

The overall data obtained was based on a self-evaluation of each VCCHs to the structured-survey questionnaires provided. Hence, bias, dishonesty, and failure to remember could predispose the results of the study. The results could be influenced by the fact that the study was conducted at a specific time of year. The researchers had little knowledge of what occurred throughout the year, according to the same limitations from a study by Yakum et al. However, since non-parametric tests were used in this study, assumptions regarding the population are irrelevant to the study. Furthermore, the researchers utilized the EVM tool selecting only a few criteria to evaluate the LGUs. The study was not able to cover other criteria such as vaccine arrivals, transport, and infrastructure capacity, maintenance and repair of buildings and vehicles, disposal of immunization waste, and other criteria included in the EVM.

Listed below are the contributing impediments in the study:

a. Ethical

With the community quarantine being implemented at the time of the study, restrictions on travel, curfew, and health risks, among others, hindered the researchers from gathering information through a physical visit to the

LGU's offices, the conduct of face-to-face interviews, and on-site observations of the cold chain storage facilities.

b. Availability and Confidentiality of Data

The data in this study were collected from the LGUs of the five subject cities. The researchers also sent the questionnaires to all cities in NCR to gather more data. Moreover, certain cities implemented a Non-Disclosure Agreement with their employees, causing more restrictions to the researchers' study.

c. Study Sample Size

The different distribution centers in charge of handling COVID-19 vaccines in LGUs in NCR are the target of the study. Five out of the seventeen (17) LGUs of NCR responded to the researchers' questionnaire giving a response rate of 29.41% for this study.

2. Review of Related Literature

2.1 Literature Review

The COVID-19 vaccines are one of the strongest hopes in fighting the coronavirus and after a year living into the COVID-19 pandemic, several vaccines have been developed and are being distributed. However, the vaccination is taking much slower progress than expected. In North America, only 15 doses per 100 people were administered, while Asia and the Pacific are behind, with only 2 doses per 100 people being administered (Park et al. 2021). Several factors such as limited vaccine supply, limited funds and staff resources for the vaccination, vaccine hesitancy, and logistic challenges impede the progress for immunizing the majority of the population to effectively combat the pandemic (Park et al. 2021). In Southeast Asia, as of April 2021, the Philippines is among the Southeast Asian countries with the lowest COVID-19 vaccines administered, with 0.6 of the total population. Logistics support is a fundamental component of successful immunization campaigns. Such support leads to a more efficient rollout of vaccines while ensuring the quality of the immunization. Poor management of logistics systems results in high wastage rates, stock outs as well as higher program costs. WHO emphasized the three key areas for logistic support, which are: (1) vaccine management and monitoring, (2) cold chain management, and (3) immunization safety.

Proper storage and handling of vaccines are crucial factors in combating common-vaccine preventable diseases. However, storage and handling errors of the vaccines decrease the potency of the vaccines leading to a significant amount of financial loss and revaccination of patients. This further raises the problem of patients' loss of confidence in the vaccines as the vaccine they receive can be compromised (CDC, 2021). Vaccines are sensitive to different temperatures, some are sensitive to heat, while others are sensitive to freezing. Furthermore, some vaccines are also sensitive to light (Park et al. 2021). Finding and maintaining the right temperature during storage and handling is crucial to maintaining the efficacy of the vaccines.

According to Lin et al. (2020), exposure to a temperature beyond what is appropriate will diminish its potency to fight off diseases. The supply chain process for vaccines varies and is rigorous compared to over-the-counter drugs found in convenience and pharmaceutical stores. To preserve the effectiveness and efficacy of vaccines, these should be kept within their specified temperature range from production to use. Moreover, according to Ashok, Brison, and LeTallec (2017), the Cold Chain Systems (CCSs) are having difficulties in efficiently supporting the needs of national immunization programs in terms of ensuring the availability of safe, and potent vaccines. Such struggles result in 1) the risk of decreased potency for the vaccines, 2) poor availability of immunization supplies, and 3) inefficient management of limited financial and human resources. When problems in CCSs are addressed, this can expand the coverage of immunization programs as well as to further reduce the deaths caused by vaccine-preventable diseases. Moreover, this research also emphasized three key challenges that limit the performance of CCSs: 1) insufficient capacity for cold chain, 2) the lack of latest technology and *optimal* equipment, and 3) the inadequate temperature monitoring and maintenance systems.

According to WHO (2019), vaccine wastage refers to the total number of vaccines that are discarded, lost, damaged, or destroyed. Vaccines contribute a significant amount to the immunization program costs. Thus, it is important to ensure that the wastage is kept to a minimum. In connection, The WHO states that there is a global estimate of 50% in vaccine wastage. A significant part of the waste is due to a lack of temperature control and the logistics to maintain an unbroken cold chain. The high occurrence of wastage often increases demand in

purchasing. Which in turn, an excess in procurement happens and inflates the cost of vaccines. (Duttagupta et al. 2017).

In a news article published by Fulgar in Philippine Daily Inquirer (2021), he mentioned that a particular requirement referring to the term Deep Freeze is generally understood to mean that the efficacy of vaccines relies upon its storage facilities with appropriate temperatures. He also added that the procurement of vaccines and storage handling is by far one of the most demanding processes in vaccine management. Generally, a cold storage facility is sheltered in structural insulated panels. They are often made of six components, including cold room panels, cold room doors, cold room shelves, dry-aging cabinets, cooling devices, and PVC strip curtains. The WHO recommends three types of room setup depending on product volumes for cold storage facilities and usually runs a facility's cooling temperatures that customarily range between +15°C to -5°C. Hence its freezing temperatures run from 0°C to -40 °C.

According to Maglasang et al. (2018), there is still limited research on cold chain equipment capacity in the Philippines. Their research article focuses on assessing the current cold chain management of the rural health units in Northern Cebu, particularly in the towns of Consolacion and Liloan. The study consisted of 22 public health centers (PHCs), and the participants in the study were the person in charge of each health center that provided vaccination services. Out of 22 respondents, only 5 facilities store vaccines. The other 17 facilities claimed to offer vaccination services but lack the basic equipment essential for storing vaccines. It also stated that PHCs that do not store vaccines obtained the vaccines from another PHC. As a result, all facilities have cold boxes and ice packs for short-term vaccine storage and distribution across town. However, this practice can predispose vaccines to overheat and long-term exposure, resulting in damage and potency loss. Also, exposure to overheating is most common in developing countries as there is a frequent power outage. Aside from assessing cold chain capacity, the scope of the study also considered the knowledge of personnel in charge. It showed that some of the respondents were not aware that the person in charge should check the temperature in the refrigerator at least twice a day and that there is a proper place for the thermometer for accurate monitoring. Moreover, some respondents did not consider that an emergency plan was essential to prepare for emergencies such as power outages and disasters.

In the document paper of the United Nations Children's Fund (2016), each country in East Asia and the Pacific has a country profile for immunization. It summarizes the country's progress in immunization systems' key areas: coverage and equity, supply chain, and logistics management systems. This assessment helped the concerned teams deepen their understanding of immunization system performance, identify programmatic gaps, and sharpen the focus of their technical assistance. UNICEF and WHO conducted a nationwide Effective Vaccine Management (EVM) in the Philippines in the year 2017. EVM is a global effort of WHO that focuses on nine global criteria: 1) vaccine arrivals, 2) temperature management, 3) storage and transport capacity, 4) facility infrastructure and equipment, 5) maintenance, 6) stock management, 7) distribution of vaccines and dry goods, 8) vaccine management, and 9) waste management. The EVM composite scores of the Philippines are 49%, 57%, 79%, 69%, 69%, 50%, 39%, 61%, and 48% respectively. The EVM composite ranking represents the overall strength of a country's immunization supply chain. The results indicate that the Philippines' vaccine management does not meet the minimum acceptable score of 80% to be effective and reliable. The EVM assessment identified major bottlenecks for the EPI system. Aside from the EVM, the status of the immunization supply chain of the country in 2016 showed that there is no maintenance plan for the national cold chain equipment. Countries are encouraged to develop and incorporate continuous quality improvement strategies implemented into national health plans due to the EVM assessment (WHO 2018). Officials responsible for this must address supply bottlenecks to hasten access to allocated doses, reduce rollout delays, and reduce wastage of vaccines. Obtaining government support for supply chain investments is vital in implementing progressive and lasting improvements in the vaccine supply system.

A study by Mohammed et al. (2021) focused on the service points in Oromia Special Zone, Ethiopia assessing knowledge, attitude, and practice on vaccine cold chain management. The respondents were the vaccinators and vaccine handlers in public health facilities. The data were collected using a self-administered questionnaire and a structured checklist adapted from WHO. Moreover, the reliability of the questionnaire and checklist was also checked by Cronbach's alpha test. Data were analyzed using EpiData and SPSS Statistics with a total of 127 respondents. The results showed that more than half (53.5%) of the respondents had satisfactory knowledge. At the same time, less than half (45.7%) of the respondents had a positive attitude and good practice. Furthermore, the vaccines that required a shake test were correctly answered by 49 (38.6%) vaccinators and vaccine handlers. The socio-demographic characteristics of the respondents were also asked, such as age, years of experience, level of

education, salary, time of last training, and type of training received. The study's findings showed that none of the variables were found to have a statistically significant association with the level of attitude in cold chain management. However, only receiving training in cold chain management had a statistically significant association with the level of knowledge. Multiple studies mentioned in the paper also highlighted that increasing the amount of education will also increase cold chain management practice by 5.2. Hence, continuous training and efficient monitoring are necessary to achieve standard immunization.

In summary, vaccines play a crucial role in combating the COVID-19 virus. The immunization supply chain is a vital system in maintaining the efficacy of each dose of vaccines. The current state of the Philippine Healthcare Systems could improve by utilizing the EVM tool developed by WHO by applying changes that are aligned with the standards that they implemented. This tool provides the platform for assessing and monitoring the vaccine supply chain system at all levels to identify strengths and weaknesses and develop improvement strategies to strengthen the system. It could also help improve the immunization coverage rate, vaccine utilization rate and maintain the minimum vaccine wastage by evaluating the preparedness in Cold Chain Systems of healthcare facilities. With this, it will ensure that all vaccines distributed to recipients are effective while maintaining the efficacy of the vaccines, allowing the vaccination program to meet its objectives.

2. Research Paradigm

The conceptual framework in Figure 1 illustrates how the researchers conducted the study (Figure 1)

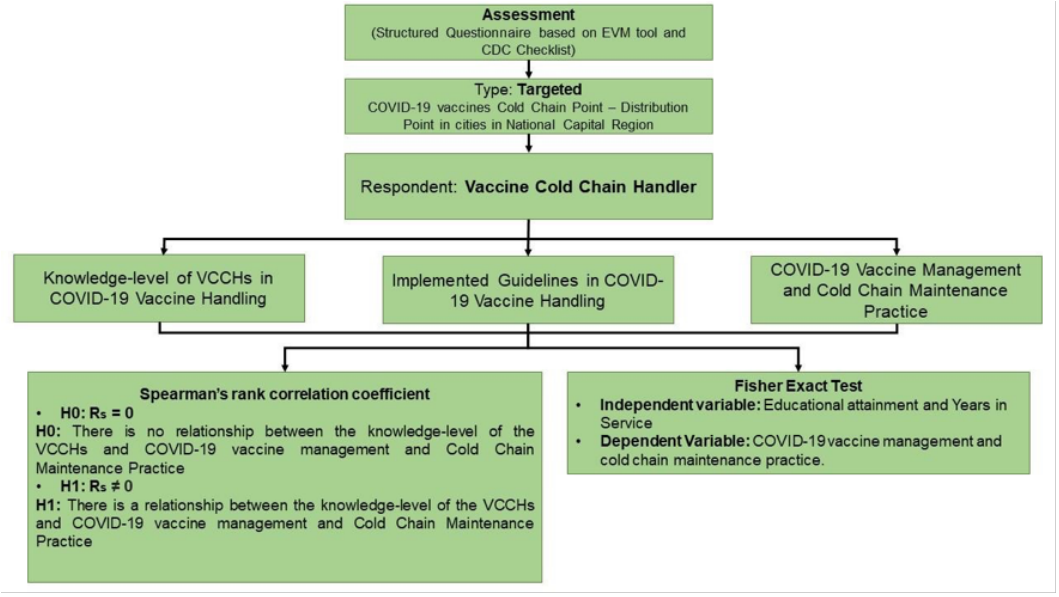

Figure 1. Conceptual Framework

The researchers dissected the EVM tool and CDC checklist to structuralize a questionnaire that focused solely on the CCSs and COVID-19 vaccine management. The gathered results were analyzed using the statistical tools of Spearman Rank Correlation and Fisher's Exact Test. At the end of the research, the researchers were expected to successfully evaluate the CCSs and COVID-19 vaccine management in terms of the availability of equipment in the facilities, knowledge level of the VCCHs, implemented guidelines for the COVID-19 vaccine handling, and COVID-19 vaccine management and cold chain maintenance practice. Furthermore, the study also tried to establish the relationship of educational attainment and number of years in service with the COVID-19 vaccine management and cold chain maintenance practice.

2. Methodology

In completing the study, the researchers adapted and customized a structured survey questionnaire based on the CDC checklist and WHO's EVM tool. The researchers prepared an online survey using Google Forms. A letter of request and the online survey were submitted to the Public Information Office and City Health Office of the

LGUs in the NCR via email. Informed consent was sought from all the VCCHs. The researchers also contacted each health office via phone to validate that the respondent was in charge of the vaccine handling. The data obtained from the respondents were processed using Statistical Package for the Social Sciences (SPSS) Statistics. Finally, the researchers analyzed and interpreted the data.

2. Results and Discussion

1.1 Data Analysis

Out of the 17 targeted LGUs' distribution cold chain points, only 29.41% (n=5) responded and agreed to the assessment in their respective LGUs. The five LGUs are Caloocan City, Malabon City, Navotas City, Pasig City, and Quezon City. Descriptive statistics in the form of percentages were used for the analysis. Fisher's Exact Test and Spearman Rank Correlation were used in analyzing the relationship among the variables.

1.2 Scoring Criteria

The questionnaire was divided into five sections: (1) Vaccine Cold Chain Handler's Basic information; (2) Facility-specific questions; (3) Assessment of the Knowledge-level of VCCHs; (4) Assessment of the Implemented Guidelines on COVID-19 vaccine handling; and (5) Assessment of the COVID-19 Vaccine Management and Cold Chain Maintenance Practice. The last three sections have their respective scoring criteria. The respondents were instructed to either answer "Yes" or "No." Each "Yes" was counted as one correct answer; likewise, each "No" answer was counted as zero, and the "Not Applicable" questions were removed from the total number of questions.

Table 1 presents the scoring criteria for assessing the knowledge level of the VCCHs, assessment of the implemented guidelines on COVID-19 vaccine handling, and assessment of the COVID-19 vaccine management and cold chain maintenance practice.

Table 1. Scoring Criteria

Criteria	Poor	Fair	Good	Excellent
Knowledge level of the VCCHs	0 - 4	5 - 9	10 - 13	14 above
Implemented Guidelines on Covid-19 Vaccine Handling	0 - 2	3 - 5	6 - 8	9 above
Vaccine Management and Cold Chain Practice	0 - 6	7 - 13	14 -19	20 above

1.3 Facility-Specific Equipment

The five respondents were asked five facility-specific questions before continuing to the remaining three sections of the questionnaire. This section was a requirement for the respondents to assess the type of equipment they are currently using in their respective LGUs. Table 2 shows the summary of the responses for the facility-specific section. Out of the five LGUs, four (or 80%) LGUs store the COVID-19 vaccines in cold rooms and freezer rooms (Table 2). Long-term cold boxes or refrigerators are utilized on all of the LGUs. The majority of the five LGUs also use freezers for the storage of the vaccines. Moreover, four out of five respondents also ensure that coolant-packs, like ice-packs, cool-packs, and Phase-Change Materials, are readily available at their facility in case of emergencies. Lastly, only two out of the five (or 40%) LGUs use standard passive containers such as cold boxes and vaccine carriers to store their vaccines since there are no active refrigerators in the facility.

Table 2. Scores for Facility Specific Questions

Facility-Specific	Availability (n=5)	
	Yes	No
Vaccines are stored in a cold room(s) and/or freezer room(s)	4	1
Vaccine is stored in refrigerators or long-term cold boxes	5	0

Facility-Specific	Availability (n=5)	
	Yes	No
Vaccines are stored in freezers	4	1
Coolant-packs, including ice-packs and/or cool-packs and/or PCM-packs (Phase-Change Materials) are prepared in the facility	4	1
Vaccines are kept in standard passive containers only (cold boxes and/or vaccine carriers). There is no active refrigeration	2	3

1.4 Vaccine Cold Chain Handlers' Demographics

The Table 3 below shows the years of service of the respondents as VCCHs in their respective LGUs. Three out of the five (or 60%) respondents serve for less than ten years, while the remaining serve as VCCHs for more than ten years during the pre-COVID.

Table 3. Number of Years in Service of the VCCHs

Number of Years in Service	Frequency	Percentage
10 years and below	3	60%
10 years and above	2	40%
Total	5	100%

On the other hand, Table 4 below presents the educational attainment of the respondents. The majority of the VCCHs are college graduates, while only one respondent is undergraduate. Moreover, three out of five respondents' professions are related to healthcare. In comparison, two out of five respondents' occupations are related to supply chain management.

Table 4. Educational Attainment of the VCCHs

Educational attainment	**Frequency**	**Percentage**
Undergraduate	1	20%
College Graduate	4	80%
Total	5	100%

The Table 5 below shows that years in service (Fisher = 1.875, p = 0.400) and education attainment (Fisher = 0.312, p = 1.000) have p-values greater than the significance level of 0.05. Thus, the researchers conclude that the number of years in service and educational attainment have no significant relationship to COVID-19 vaccine management and cold chain maintenance practice. Although the demographic profile of VCCHs was not significant in this study, a study in Ethiopia by Mohammed et al. (2021) found a statistically significant relationship between professional qualification and year of service of health professionals working in the immunization program. On top of that, inappropriate knowledge was also observed in older (17.4 years) and had a longer vaccination unit duration (7 years).

Table 5. Fisher's Exact Test

Demographic Profile	**Fisher Exact Test**	**P-value**	**Interpretation**

Number of Years in Service	1.875	0.4	Do not reject H0
Level of Education Attainment	0.312	1	Do not reject H0

1.5 Results of Spearman Rank Correlation

Table 6 shows a Spearman Rank = 0.707 with p-value = 0.182 and Spearman Rank = 0.158 with p-value = 0.8. Since the p-value is greater than the significance level of 0.05, the researchers failed to reject the null hypotheses. The researchers also concluded that there is no significant relationship between the knowledge of vaccine workers and implemented guidelines to COVID-19 vaccine management and cold chain maintenance practice.

Table 6. Spearman Rank Correlation

Variables	Spearman Rank	P-value	Interpretation
Knowledge and Vaccine Management	0.707	0.182	Do not reject H0
Implemented Guidelines and Vaccine Management	0.158	0.8	Do not reject H0

1.6 Composite Score for Each Criterion

Pasig City, Navotas City, Quezon City, and Malabon City have perfect results (100%) regarding the VCCHs' knowledge level about their respective Cold Chain Systems. On the other hand, Caloocan City achieved a 94% score for the knowledge level of their VCCHs. Despite not having a perfect score, Caloocan City still shows an excellent result in the assessment of the knowledge level of their VCCH in Cold Chain Systems. Having received training was one of the predictors of cold chain management expertise. According to a study conducted in the Oromia Special Zone, Ethiopia, professionals who received cold chain management training were about 3.04 times more likely to have satisfactory knowledge than those who did not receive proper training. In this study, all VCCHs received on-the-job classroom training in COVID-19 vaccine management.

As for the implemented guidelines on vaccine handling, the five cities have an excellent implementation and planned backup storage unit in the event of power failure or other unforeseen circumstances. According to a previous study in Cameroon's North West region, exposure to cold temperatures is more prevalent in developed countries, whereas exposure to overheating is most common in developing countries. Tropical temperatures, unreliable power supplies, and inadequate resources (material, financial, and human) are believed to be factors in vaccines being exposed to overheated temperature conditions frequently in developing countries.

In terms of vaccine management and cold chain maintenance practice, Navotas City and Quezon City have excellent COVID-19 vaccine management and cold chain maintenance practice, with scores of 21 (91.30%) out of 23 and 24 (100%) out of 24, respectively. One question was removed from the total score of Navotas City as it does not apply to their LGU. Then, Pasig City, Caloocan City, and Malabon City presented good results in COVID-19 vaccine management and cold chain maintenance practice with scores of 19 (79%), 16 (67%), 19 (79%), respectively. It is also noted that Navotas City does not make exceptions to the EEFO rule (Earliest Expiry, First Out). However, according to the WHO EVM tool assessor's guide, exceptions can be made if the later-dated stock shows a stage 2 exposure while the early-dated stock is still at stage 1. This allows the exception that the later-date stock with stage 2 exposures should be issued first.

Furthermore, three out of five cities, including Pasig City, Caloocan City, and Malabon City, do not use calibrated temperature monitoring devices with low-battery indicators, which are important in ensuring that correct temperatures are maintained all the time. Aside from these, Caloocan City only uses calibrated temperature monitoring devices to measure temperatures within +/- 0.5ºC and an active display to provide continuous monitoring information. The city does not use other types of calibrated temperature monitoring devices (TMD) with features. Moreover, all cities also successfully maintain their refrigerators' temperature within the range of +2 to +8ºC, aiming for +5ºC. On the other hand, only Caloocan City is not able to maintain their freezer's temperature within the required range of +50°C and -15°C (-58°F and +5°F). Also, four out of the

five cities do not keep extra containers of frozen water, ice packs, and ice-filled containers in the refrigerator to help maintain the cool temperature (table 7).

Table 7. Composite Score and Interpretation of Each Criterion

City	Knowledge-level of VCCHs	Implemented Guidelines on Vaccine Handling	Vaccine Management and Cold Chain Maintenance Practice
Pasig City	100% Met the minimum standard	90% Met the minimum standard	83.33% Met the minimum standard
Navotas City	100% Met the minimum standard	100% Met the minimum standard	91.30% Met the minimum standard
Quezon City	100% Met the minimum standard	100% Met the minimum standard	100% Met the minimum standard
Caloocan City	94% Met the minimum standard	100% Met the minimum standard	66.67% Failed to meet the minimum standard
Malabon City	100% Met the minimum standard	100% Met the minimum standard	79.17% Failed to meet the minimum standard

WHO recommends a minimum of 80% performance for each criterion to be considered “Effective” The two cities, Caloocan City with 66.67% and Malabon City with 79.17%, failed to meet the minimum standard for the criterion of vaccine management and cold chain maintenance practice, as seen in the Table 7 above. This result signified that the two cities’ vaccine management and cold chain maintenance practice are ineffective despite having met the standards for knowledge and implemented guidelines.

2. Conclusion, Recommendations, and Areas for Further Study

2.1. Conclusions

Based on the evaluation conducted, the researchers were able to identify some areas for improvement of the LGUs studied in the COVID-19 vaccine management and cold chain maintenance practice. In the final analysis, the researchers concluded that the five cities involved all met the WHO minimum performance score of 80% in terms of the knowledge level of the VCCHs in the COVID-19 cold chain system and the implemented guidelines in COVID-19 vaccine handling. On the other hand, in terms of the COVID-19 vaccine management and cold chain practice, both Caloocan City and Malabon City failed to meet the minimum performance score of 80% with scores of 66.67% and 79.17%, respectively. Pasig City and Navotas City successfully met the standard with 83.33% and 91.30%, respectively. Moreover, Quezon City met the standard for all three criteria with a perfect score of 100%. Using the Fisher’s Exact Test, the researchers also concluded no significant relationship among the demographic profile, specifically the number of years in service and educational attainment, and the COVID-19 vaccine management and cold chain maintenance practice. Using Spearman Rank Correlation, the same conclusion can also be drawn about the relationship between the knowledge of VCCHs and implemented guidelines in COVID-19 vaccine handling with regards to the COVID-19 vaccine management and cold chain maintenance practice of the five LGUs.

2.2. Recommendations

It is recommended that Caloocan City have more intensive vaccine management training that includes practical training about shake tests. This will help the VCCHs to understand how it is done and when necessary to do so. This will also help them reduce vaccine wastage in their LGUs and respective health centers. Pasig City and Navotas City should practice keeping complete manual temperature records at least twice a day for every cold chain equipment the facility uses. This will help them keep track of any temperature abnormalities that will affect the efficacy of the COVID-19 vaccine. Since Caloocan City failed the minimum standards for COVID-19 vaccine

management and cold chain maintenance practice, it is recommended to store their COVID-19 vaccines in large refrigerators and freezers with enough room to maintain and store the largest stock of vaccines. It is also recommended for the city to invest in calibrated temperature monitoring devices with other features such as an alarm system for out-of-range temperatures, low-battery indicator, digital data logger that indicates current, minimum, and maximum temperatures.

Likewise, it is recommended for Malabon City to invest in dormitory-style refrigeration units and calibrated temperature monitoring devices that include measuring temperatures within +/- 0.5ºC. This will help the VCCHs in monitoring the temperature and any alarming irregularities that may occur. For all five cities, it is recommended to keep extra water containers in the refrigerator to help maintain cool temperatures, especially during emergencies such as power outages. It is recommended that each facility in the lowest distribution points carefully consider storage and handling information for vaccines and comply with vaccine handlers' required training policies and procedures. It is suggested that all staff who handle or administer vaccines should be familiar with the facility's standard operating procedures (SOPs) for vaccines and their related practices. Following the CDC guidelines, the training should be completed as a part of onboarding for employees and an annual refresher for handlers involved in vaccine storage and handling activities.

A final recommendation is to develop a continuous improvement plan (CIP). The CIP will consist of two main parts: the strategic and operational plans. The strategic plan outlines the supply chain's vision, goals, and major strategies for the next five years. The operational plan outlines the activities, timelines, responsibilities, costs, and indicators for the coming year. There are four steps to the continuous improvement plan: assess, plan, implement, and monitor, which repeats in a cycle of continuous learning and innovation. 1) The assessment includes collecting and reviewing evidence to identify immunization supply chain (iSC) strengths, weaknesses, opportunities, and bottlenecks. 2) Planning includes creating a vision, strategy, and operational plan for iSC improvement. 3) Implementing includes disseminating the plan and ensuring the fund to put the plan in operation. 4) Monitoring the implementation progress toward outcomes. This plan could be consulted to the national Expanded Program on Immunization (EPI) team to improve further vaccine management that can help reveal the root causes of supply chain problems.

2.3 Areas for Further Study

Due to community restrictions in the NCR during the conduct of the study, the researchers were unable to conduct face-to-face interviews and physical observations in the lowest distribution point. Future researchers could target service points such as vaccination sites, private hospitals, and public health centers of a particular city or rural area if time permits. This would allow them to obtain a larger sample size by collecting the lists of health centers and targeting nurse vaccinators and anyone with experience in vaccine handling. By having a large sample size, parametric tests can be used as it assumes a normal distribution. With this, different statistical tools such as Multiple Regression, Pearson’s Correlation, and One-way ANOVA could be used to generalize the results of the population. Using these statistical tools is more powerful than nonparametric tests when assumptions are met. In addition, further improvements can be made in the survey questionnaire itself by checking the validity and reliability of each criterion. Possible additional questions per criterion may be added to measure what they are intended to measure fully. Furthermore, additional study variables on vaccine management are proposed to evaluate cold chain systems for future research. Some variables to be considered include, but are not limited to, availability of funds for cold chain maintenance, types of training on vaccine cold chain management, and cold chain EPI guidelines utilization.

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