# Assessing Hospital Logistics Preparedness During the Outbreak of Covid-19 : A Study of Thai Public Hospitals in Remote Areas

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**Abstract**

The hospital logistics operation is not about transportation; it's an entire operation that efficiently links two primary hospital operations, *clinical* and *non-clinical services*, aiming at the highest patient safety with a minimum total cost. The system is more complicated than it might seem, especially for Thai public hospitals in remote areas because of its location constraint. This paper aimed to assess the internal hospital logistics preparedness of 15 Thai public hospitals in remote locations of border cities in Thailand by using the World Health Organization's hospital readiness checklist for the COVID-19 guidebook. In-depth interviews and onsite operation observations were conducted at the hospitals during the rapid rise of the Omicron variant in Thailand. The result found a low preparedness score in five out of eight dimensions, including logistics coordination, IT, inventory management, forecasting, purchasing, storage area, transportation, and essential support services. Details of how the hospital prepared in each dimension are also discussed. The major contribution of this paper is exploring the challenges of public hospital internal logistics operations when implementing the recommended action by WHO, which received less attention from researchers compared to the study of hospitals in urban areas.

**Keywords:** Hospital logistics; Public hospital; Management; Covid pandemic; Remote area

## Introduction

Hospitals are vital as community centers in response to the COVID-19 pandemic. Abdi et al. (2022) COVID-19 pandemic poses hospitals with extraordinary clinical and management challenges, resulting in an inevitable need to adjust their operational processes to maintain regular service and handle new surging demands caused by the pandemic. The system enabling hospitals to make such effective rearrangements between clinical services and other management is called the hospital logistics system.

Hospital logistics is a set of design, planning, and execution activities that enable purchasing, inventory management, and replenishment of goods and services surrounding medical services to patients (Landry and Beaulieu 2002). It's labor intensive with non-standard

processes (because it depends on individual health conditions) and a lack of relevant information. Due to these characteristics, the hospital logistics system's major challenge is ensuring resource availability at any treatment place (Đapić et al. 2015). In short, the hospital logistics system helps ensure that its clinical services are always available for patients by efficiently managing all related hospital operations.

Supeekit et al. (2015) state that there are two primary services in the hospital where patients seek diagnosis and treatment; clinical care services can be considered a core treatment process by medical professionals, including doctors, nurses, and lab staff. At the same time, non-clinical services are derived from clinical care services, including clinical related such as medicines and medical supplies management, sterile and patient food services, etc. And pure non-clinical areas such as purchasing management, information technology, etc.

Thailand is a developing country with a population of 70 million in 2022 and a GDP per capita of around 7,000$. The Universal Cover Scheme (UCS) was introduced in 2002 as a primary social health insurance program covering approximately 75% of the total population, making most services free of charge at public hospitals (Paek et al. 2016). The country borders four countries: Myanmar, Laos, Cambodia, and Malaysia. More than 30 permanent border checkpoints are located in the urban areas of big border towns. However, another 50 temporary border checkpoints still exist in remote rural areas of small towns. Public hospitals in remote small towns play vital roles during the COVID-19 pandemic in providing medical services to their people and controlling the spread of disease within border areas. However, the constraints of being a hospital in a rural area of remote small towns make it even more challenging to manage its logistics system, including traveling distance, smaller population size, and lack of medical staff. Etc.

Therefore, this paper aims to assess hospital logistics preparedness when public hospitals provide unplanned services to surged COVID-19 patients in rural, remote areas to understand their challenges regarding their hospital logistics operations. This paper used an exploratory approach by comparing the logistics operations of case study hospitals with guidelines recommended by the World Health Organization.

To the best of our knowledge, only a few research studies specifically seek to improve the logistics operations of public hospitals in rural areas of Thailand, even though Ariyaarpakamol (2019) has examined and academically confirmed the existence of rural-urban inequality in Thailand due to the superior welfare of urban households. Thus, the result of this paper can be used as an initiation of an attempt to help reduce the gap between the rural-urban quality of life and the ability to prepare for a better response to a future pandemic.

## Research Objectives

Kritchanchai (2012) was among the first papers to highlight the inefficiency of Thai public hospitals' logistics operations. Later, Kritchanchai et al. (2019) found public hospitals in Thailand are still relying on manual information exchange processes, causing slow and inaccurate data exchange in the supply chain; Kalaya et al (2023) extended the studies into the hospital operations in a remote area during a pandemic and found inefficiency in medicine forecasting and inventory planning were caused from its irregular demand pattern which differs from the city hospital, lead to the main research objectives of this paper, which is 1) to find if logistics system of the small public hospital in a remote area are prepared for a pandemic or not? 2) is to explore insightful hospital logistics operations data to supplement understanding of the preparedness assessment result since their resources are way inferior compared to the city hospital but play a vital role in the border area.

To answer such questions is more complicated than it might seem. Hospital logistics systems are embedded in entire hospital operations, making it even more challenging to scope which operations we should assess. So, this paper needs to find a framework to evaluate if

hospitals are well prepared. It should be a kind of standard for hospital logistics operations with specific instructions, enabling this paper to assess if selected case studies of Thai public hospitals can operate as per the standard instructions or recommendations.

Currently, the finalized national standard of Thai public hospitals for hospital logistics preparation for the COVID-19 pandemic does not exist yet, so we have reviewed further into an international standard and found a standard developed by World Health Organization (WHO) that is capable of being our framework for assessment since it covering both scopes of operations to be included in the framework, as same as providing detail of recommended action for a hospital to follow, which allow us to compare with the current operations of selected hospitals. Suppose they are currently operated as per the recommended procedure. In that case, we can rationally assess that the hospital logistics system of Thai public hospitals in remote areas is well prepared for a pandemic even though they have fewer resources than a city hospital. The details of the framework are explained in the next session.

Although several papers have also assessed hospital preparedness using WHO's guidelines (Dhamanti et al., 2022; Sanders et al., 2021). But to the best of our knowledge, only a limited paper provided insightful information on the operational challenges that public hospitals in remote areas faced when preparing for services during the pandemic, especially their location context, which makes their challenge and needs differ from the city hospital. Hence, this paper will also explore insightful operations data to supplement understanding of the preparedness assessment result, which is beneficial information for improving hospital pandemic preparedness levels in the future.

## Literature Review

As mentioned in previous sections, the framework for hospital preparedness assessment in this paper was adapted from the World Health Organization (2020) guidebook called Hospital Readiness Checklist for COVID-19, which consisted of 11 major functions that guide hospitals to plan when preparing for the COVID-19 pandemic— including the preparation of; incident management system, communication, continuity of essential health services, surge capacity human resources, logistics, essential support services, infection prevention control, case management, surveillance system, and laboratory services.

This paper will emphasize only the function of hospital logistics preparation in the guidebook, which aims to ensure the continuity of hospital services and the availability of essential equipment, including supplies and pharmaceuticals, and since our target hospitals are all located in remote areas where their logistics operations might be different compared to those hospitals in urban areas. The WHO's provided a checklist and recommended actions covering the operation management in 8 areas; logistics coordination, IT, inventory management, forecasting, purchasing, storage area, transportation, and essential support services. The indicators used in this paper and the recommended action from the WHO guidebook are shown in **Table** 1. Details and related research in each indicator are as follows;

**Logistics coordination:** In the recommended action of the guidebook, the hospital is recommended to designate a unit that will be responsible for integrated work within the hospital, such as a designated logistics team that will monitor and provide automatic stock fulfillment for all hospital units, intra-hospital transport for stretched and wheelchair patients, or provide medicine and medical supplies to home isolation patients. Several papers also reported the critical role of the logistics coordination team in hospital logistics operations (Moons et al., 2019; Lourenco Garcia et al., 2020; Trenada Alvarez et al., 2023).

**Table** 1 WHO's Indicators for Assessing Hospital Logistics Preparedness

| Functions | Recommended Action by WHO (2020) |
|---|---|
| ***Logistics Coordination*** | |
| 1. Well-functioning hospital logistics operation center | *Designate a staff or department to provide pharmaceuticals and medical supplies for cases treated at a treatment site, including coordinating and managing related activities.* |
| ***IT*** | |
| 2. An effective data-sharing system within hospital operations | *Maintain an updated inventory of all equipment, supplies, and pharmaceuticals. Establish a shortage alert and reordering mechanism.* |
| 3. The real-time tracking system of the use rate | *Able to track the use rate at the point of use* |
| ***Inventory management*** | |
| 4. Inventory management policy | *Ensure there is a policy for hospital inventory management.* |
| 5. Effective inventory management procedure | *Ensure a timely use of stockpiled items to avoid loss due to expiration.* |
| ***Forecasting*** | |
| 6. Effective forecasting procedure | *Estimate the consumption of essential equipment, supplies, and pharmaceuticals.* |
| ***Purchasing*** | |
| 7. Emergency purchase system | *The hospital uses an effective purchasing system to ensure prompt delivery even during the pandemic.* |
| ***Storage*** | |
| 8. Effective storage management | *Ensure effective operations in a storage area to guarantee the availability of essential items under their storage condition.* |
| ***Transportation*** | |
| 9. Effective management of intra-hospital transport | *Ensure an effective transport system for patients and supplies within the hospital.* |
| 10. Effective management of inter-hospital transport | *Coordinate with inter-hospital networks and establish a transportation system to ensure continual patient transfer.* |
| ***Essential support services*** | |
| 11. Effective linen and laundry management | *Ensure a mechanism for the prompt and adequate services of patients' clothes.* |
| 12. Effective hospital food production system | *Ensure a mechanism for the prompt and adequate service of inpatient meals.* |

**IT:** In the recommended action, hospitals should be able to maintain an updated inventory of all equipment, supplies, and pharmaceuticals. Establish a shortage alert and reordering mechanism. Several papers developed an approach for hospitals to achieve the ability to maintain a real-time update of all inventory during a pandemic crisis. Neve and Schmidth (2022) developed a system that increases inventory accuracy by capturing the hospital's point of use. Redondo et al. (2023) proposed a tool for assisting hospital managers with the availability of hospital resources to ensure adequate access to services for admitted COVID-19 patients.

**Inventory management:** In the recommended action of the guidebook, hospitals should have a clear inventory policy to ensure the timely use of inventory to avoid loss from expiration. Hospital inventory management during the pandemic period received attention from hospital researchers seeking the same goals as the WHO suggested (Rojas et al., 2021; Tsiligianni et al., 2023)

**Forecasting:** In the recommended action of the guidebook, hospitals were advised to estimate the consumption of essential equipment, supplies, and pharmaceuticals. Many researchers seek to find a more accurate way for hospitals to forecast various products, including; pharmaceuticals demand (Kalaya et al., 2019), medical supplies demand (Gonzatto

Junior et al., 2022), or even a demand for emergency department hourly occupancy rate (Cheng et al., 2021)

**Purchasing:** In the recommended action of the guidebook, hospitals were suggested to use an effective purchasing system to ensure prompt delivery even during the pandemic. There are a number of papers that attempt to develop a more effective purchasing system for hospitals when coping with COVID-19; (Araujo et al., 2023; Montás et al., 2022)

**Storage:** According to the recommended action of the guidebook, hospitals must ensure effective operations from the inbound, storage, and outbound operations of the storage area to guarantee the availability of essential items under their storage condition. (Rocha and Rego, 2023; Alharthy et al., 2021)

**Transportation:** In the recommended action of the guidebook, hospitals must ensure an effective transport system for patients and supplies in both intra-hospitals and inter-hospitals. For inter-hospital, hospital logistics researchers apply various tools to reduce patient transfer time (Costa and de Campos Vieira Abib, 2023). For intra-hospital transport, researchers attempt to develop a more efficient transport system within the hospital using a variety of research tools (Knight et al., 2015; Meephu et al., 2023).

**Essential support services:** In the recommended action of the guidebook, hospitals must ensure a mechanism for the prompt and adequate provision of essential support services, which, in this paper, focuses on two major services: clothing and hospital food for admitted patients. For the hospital clothing management system, hospital researchers attempt to develop a prompt and adequate service with minimum cost (Ndhaief et al., 2019), while researchers in the area of hospital food system attempt to develop a fast delivery and minimize operation cost (Hasachoo et al., 2023; Abderrabi et al., 2020)

## Research Methodology

### Study Participants and Procedure

This paper focused on the Thai public rural-remote district hospitals in the border area (also known as community hospitals) with a bed capacity between 10-120 beds with only 2-8 full-time doctors (WHO, 2015). Still, having a vital role as a healthcare gatekeeper between Thailand and neighboring countries, especially during the COVID-19 pandemic crisis, and hence, purposively selected 15 public community hospitals in the rural districts from 5 border cities in the upper north of Thailand.

Firstly, the research team communicates with the hospitals through an official email, issues a formal letter containing research details, and asks permission to conduct this research. Then, let them select representatives who know the details of hospital logistics operations from the predetermined questions that were attached to the official letter and are willing to participate in the interview. They could be hospital directors, heads of departments, operation supervisors, or front-line staff like nurses and admin staff. When representatives were selected, the research team communicated with them through authorized hospital contact details to verify their positions and voluntary participation.

### Data Collection and Analysis

The indicators used in this paper will be assessed using a 3-point Likert scale. The hospital will be scored 3, which indicates a high preparedness level if the hospital is already operating the WHO's recommended action; a 2-score show moderate preparedness and will be given if a hospital partially implements WHO's recommended action. Lastly, a 1-score shows low preparedness and will be given if the hospital has not yet implemented it. This paper aims not only to find the final preparedness score but also to explore the insightful information on day-to-day operations faced by hospitals when operating as per WHO's recommended action.

Therefore, two data sources will be collected to get insightful information and to validate the obtained data to ensure the repeatability of the result.

Firstly, the data were collected from January to December 2022, when Thailand's Omicron variant rapidly rose nationwide, from in-depth interviews using a semi-structured questionnaire covering eight areas of hospital operations as in **Table** 1, with the selected representatives of the sample hospitals. The interviews were conducted onsite, face-to-face, at the hospital, and took about 120 minutes per hospital. Secondly, the onsite observation at each department with selected representatives was also conducted to validate and confirm the assessment result from the first step, which took another 60-120 minutes per hospital. Lastly, the assessment results obtained from the interview will be cross-checked to see if they match with data obtained from onsite hospital observation as per data validation. Due to the dynamic nature of hospital operations, the results in the next section only provide a snapshot assessment during the pandemic. An evaluation in the post-pandemic might give a different result and suggest a direction for future research.

## Research Results

### Overall Hospital Logistics Preparedness Level

The characteristics of 15 sample hospitals that participated in this research are shown in **Table** 2. On average, most of them have a bed capacity of less than 30, with only 1-5 full-time doctors providing medical services to more than 300 outpatients per day. The average preparedness scores are shown in **Table** 3, followed by the qualitative data from in-depth interviews for insightful information on each indicator. The details are as follows;

**Table 2** Hospital characteristics

| Characteristics | No.of Hospitals (%) |
|---|---|
| Bed Capacity | |
| 10-30 Beds | 8 (53%) |
| 31-60 Beds | 4 (27%) |
| 61-120 Beds | 3 (20%) |
| Number of full-time doctors | |
| 1 – 5 | 8 (53%) |
| 6 - 10 | 3 (20%) |
| > 11 | 4 (27%) |
| The daily average number of outpatients | |
| 100-200 | 6 (40%) |
| 201-300 | 1 (7%) |
| > 300 | 8 (53%) |

### Logistics Coordination

The result found that the hierarchy of emergency operations centers existed in all hospitals during the pandemic, but none of the hospitals had designated personnel responsible for logistics coordination prior to what was being ordered. Nurses and pharmacists who are extremely busy with surged patients still need to manage their own stock, from monitoring and requesting to the central warehouse if their sub-stock needs to be refilled, walking and getting stuff from the central warehouse, and even delivering to the treatment side themselves. These operations are perceived as a no-man-land operation; hence, the user must manage it themselves even though many public hospitals in big cities designated these activities to logistics teams so that medical professionals can spend their valuable time with rapidly raised patients instead of spending it with non-medical activities. This is because the government

allocates budgets, and hospitals' permanent job positions are proportionate to the size of the population in their service area, and of course, population sizes in remote locations are much smaller compared to those hospitals in urban areas. Therefore, having a specific person for logistics activities in small rural hospitals is almost impossible.

The absence of this recommended action causes hospitals to risk a shortage of medical supplies since they might not have enough time to monitor and manage the stock level. This also led to an overstock and expiration problem since we found that users are replenished double the quantity needed to avoid the risk of shortage, also known as the bullwhip effect.

**IT**

This paper found all hospitals using software enabling real-time data sharing among front-office services, including patients' medical records and prescriptions from the medical examination room to pharmacy departments, which should give them a high preparedness score. However, most hospitals (12 of 15) have no back-office software and still use manual paper-based procedures; therefore, they are unable to maintain updated inventory data as recommended by WHO.

Whenever hospital units want to take stock from a central warehouse to refill their sub-stock, they must write a request form and send the hard copy to the responsible person for approval. All hospitals still have no system that automatically notifies of the shortage or reorders points. They must still check the manual stock card at the central warehouse to update inventory data. The lack of back-office software creates the risk of stockout, especially during the pandemic, since front-office operations cannot see the availability of medicines and supplies but can still order them via software.

Another critical IT function missing in all hospitals is tracking the real use rate at the point of use, including supplies and pharmaceuticals. Currently, all hospitals use the same procedure, which only records the use rate based on the user's request to the central warehouse, but not an accurate use rate from patients. For example, nurses might request 30 saline bags on day 1, lasting the entire month. The system will then report the use rate of saline as one bag per day at the end of the month, which might not always be true since they did not know the exact details that the nurse uses with the patient, it might be one bag per day on average as current system reported, or it could be ten bags on the first day, and the rest are still in the ward stock.

All sample hospitals say finding an IT staff capable of customizing back office software and willing to live in rural and remote towns is very challenging. Three hospitals that already use the back office software face the same challenge since the software they purchase is developed based on general-size hospitals, not small-rural-remote areas like them. However, they found it difficult to modify the software to match their hospital operation since their IT staff could not do that. They can only wait for the software developer, who, on average, only visits them once every two months due to transportation difficulties.

**Inventory management**

All hospitals were found to have the same inventory policy. The central warehouse serves as a storage area for all items of all users; then, it will be sent to a user's sub-warehouse upon request by the user, e.g., ward and clinic. This paper found all hospitals attempted to use the "max-min" inventory policy logic in central and sub-warehouse warehouses but still not yet effectively prepared as WHO's suggested.

Theoretically, the max-min system is the system that predetermines the maximum quantity of inventory to be stocked, as same as the minimum quantity of inventory left in the sub-warehouse that will alert the user to request the central warehouse for a replenishment back to the maximum level, based on the daily actual use rate. This inventory policy should enable hospitals to achieve WHO's recommended action since inventory data will continuously be updated, guaranteeing timely inventory use in both central and sub-warehouses. However, we

found 13 out of 15 hospitals have no mechanisms for identifying the optimal max-min quantity. They used staff self-estimation based on the inaccurate use rate. The hospital management team will approve any quantity the user has requested as long as it has been pre-approved by the supervisor of the user's department, even if sometimes the quantity requested is higher than the predetermined *max* value of its department, which finally leads to an inability to fulfilled WHO's suggestion on ensuring the timely use of inventory to avoid loss from expiration.

**Table 3** Overall preparedness regarding hospital logistics systems of 15 Thai public hospitals

| Functions | Number of hospitals | | | Average Score (Meaning) |
|---|---|---|---|---|
| | Not-prepared | Partially-prepared | Completed | |
| ***Logistics coordination*** | | | | **1.2** |
| 1. Well-functioning hospital logistics operation center | 12 | 3 | 0 | (low) |
| ***IT*** | | | | |
| 2. An effective data-sharing system within hospital operations | 0 | 12 | 3 | **1.7** (low) |
| 3. The real-time tracking system of the use rate | 13 | 2 | 0 | |
| ***Inventory management*** | | | | |
| 4. Inventory management policy | 4 | 10 | 1 | **1.5** |
| 5. Effective inventory management procedure | 13 | 2 | 0 | (low) |
| ***Forecasting*** | | | | **1.3** |
| 6. Effective forecasting procedure | 10 | 5 | 0 | (low) |
| ***Purchasing*** | | | | **1** |
| 7. Emergency purchase system | 15 | 0 | 0 | (low) |
| ***Storage*** | | | | **1** |
| 8. Effective storage management | 15 | 0 | 0 | (low) |
| ***Transportation*** | | | | |
| 9. Effective management of within-hospital transport | 10 | 2 | 3 | **2.3** (Moderate) |
| 10. Effective management of inter-hospital transport | 0 | 0 | 15 | |
| ***Essential support services*** | | | | |
| 11. Effective linen and laundry management | 0 | 15 | 0 | **2** |
| 12. Effective hospital food production system | 0 | 15 | 0 | (Moderate) |

**Forecasting**

The result found that none of the hospitals required conducting demand forecasting, and most hospitals only found using staff self-experience to decide how much should be ordered in the next month. But even if they wanted to forecast, the use rate recorded in the system is not the actual demand and hence will result in low accuracy estimation.

**Purchasing**

The result found that all hospitals follow the same purchasing procedure the Ministry of Health issued. The average lead time from the day the user makes a purchasing request until it is available at the hospital is 15 days. And no emergency purchase channel is available.

The interesting constraint from the context of being a public hospital in a remote rural area in the border city is that the purchasing procedure of all public hospitals requires an "open tender" procedure. But half of the hospitals say many sellers are not interested in bidding at their hospital because some items only use one or two pieces per year, e.g., Foley catheter or cardiac catheter, since they are the primary care hospital and the most complicated case will be

transferred to the big hospital in the city center. Sometimes, they must go to the city center, with an average of 6 hours for a round trip, and buy themselves since no seller joins the open tender process.

Another ineffective procedure in purchasing operations is deciding on purchasing quantity. All hospitals were willing to buy in any amount the user requested and pre-approved by its department supervisor. Most users preferred to purchase more than they needed, known as just-in-case buffers, which might equal the amount that can last two months. It's exceptionally not cost-effective.

**Storage**

The result found all hospitals have the same storage working procedure. A central warehouse staff member is responsible for sorting items that have already been approved and putting them onto the shelf in the storage area. Also accountable for assembling things as requested for the user to pick up at the stage area of the central warehouse. Some hospitals have no full-time warehouse staff, making the central warehouse only a shared space, allowing all users to store things. Therefore, users needed to manage everything themselves in the shared space.

The problem that all hospitals have in common is not about infrastructure or technology for controlling the temperature; they heavily rely only on the warehouse staff, not the system. For example, only warehouse staff know the exact storage area of all items, including shelf and row numbers, and the timely sequence for pickup. Also, the problem with updating stock records is that all hospitals still use manual stock cards in front of the item on the shelf. The staff must write on the stock card whenever they take in or out from the shelf. When two problems are combined, it's almost impossible for other staff, e.g., nurses and pharmacists, to get the items if warehouse staff is away, e.g., taking a week off due to COVID-19 infection, and hence unable to guarantee the availability of essential items under their storage condition as per suggested.

**Transportation**

We found the preparedness score of inter-hospital transportation systems is higher than within-hospital transportation systems because the inter-hospital network involves predetermined external parties, including its network hospitals, the local municipality, and the provincial public health office. Etc. Therefore, when there is a demand for inter-hospital patient transfer, all parties operate on the same predetermined operation procedure, including transportation service.

However, within-hospital transport was found to be ineffective. All hospitals only employ a full-time driver who is responsible for driving either an ambulance or a vehicle like a van. But for the case of transferring a wheelchair patient from the triage center to the cohort ward, no service is available, not even a channel for hospital staff to request wheelchair escort staff, or take a saline bag from the central warehouse to the ward or causing users like nurses to pick themselves up. And since time is valuable, especially during pandemic periods, instead of only requesting enough saline for day-to-day operations, users often order more than they need so they don't have to waste their time getting items from the central warehouse again, causing misunderstandings in the recorded data as higher use rate, purchasing staff will then increase the purchasing lot size prior to the updated use rate.

**Essential Support Services**

For the clothing services: All hospitals had prompt and adequate clothing services, including laundry and delivery. However, ineffective operations make their operation costs higher than they should be. This is because the challenge faced by all hospitals is the inability to check and count the used clothes, e.g., patient uniforms, patient blankets, and operation room bed sheets, from the ward due to the Infection Prevention and Control (IC) requirement. Since

they cannot confirm the exact quantity received, making effective return operations for cleaned clothes back to the users is very challenging. Half of the hospitals required users to write a request form before getting cleaned clothes in any quantity as pre-approved by their supervisor at the linen department. We found this mechanism forced them to purchase too many clothes since they have to guarantee that clothes are always available whenever a user requests. Some hospitals had a more efficient system by implementing a max-min system at the ward, and users were responsible for requesting the number of cleaned clothes equal to the gap between their current stock and max level.

For patient food service: We found hospitals have different ways of operating to guarantee the prompt services of patients' food, including fully self-operated, partially self-operated, and fully outsourced. Six hospitals fully self-operated in providing meals to admitted patients, from purchasing daily raw materials, cooking, serving at the bedside, collecting, and washing the used trays. Five hospitals were partially self-operated by outsourcing all meals for home isolation patients to a third-party kitchen. Two hospitals fully outsourced the kitchen operations to a third-party company while the food department is only responsible for controlling the quality of food nutrition and serving at the patient's bedside.

Another challenge faced in the production and operation of hospital food is uncertainty in demand. A hospital meal demand did not come from an admitted patient's desire but was medically indicated by a medical professional. For example, during a daily bedside diagnosis, if a doctor believes that a patient's health requires a low-purine diet, then a "gout diet" will be assigned instead of a "regular diet". But no matter what type of diet it is, the production needs to be started ahead of the decision made by doctors since they have to plan for raw materials purchase, as same as worker scheduling, in advance for a week. This paper found that being in a hospital in a remote area makes it even more challenging to estimate the demand for this type of therapeutic diet, e.g., a "Chronic kidney disease diet" or a "Sodium restricted diet" hardly occurs. Still, food departments must guarantee prompt and adequate service if they do.

## Conclusion and Knowledge from Research

This study creates new knowledge contributions by adding new insights into public hospital pandemic logistics preparedness by assessing the hospital logistics preparedness of 15 Thai public hospitals in remote areas of the border city, using the indicators from WHO's guidebook called Hospital Readiness Checklist for COVID-19. The major contribution of this paper is exploring the operations challenges faced when implementing the recommended action by WHO, which received less attention from researchers compared to the study of hospitals in urban areas. The key findings in this paper can be discussed as follows;

Firstly, this paper found that the logistics systems of Thai public hospitals in remote areas were not as well-prepared as WHO suggested. A preparedness score of 6 out of 8 functions was assessed as low preparedness, including logistics coordination, IT, inventory management, forecasting, purchasing, and storage area. The rural location constraints were causing operation challenges when case study hospitals prepared their hospital logistics operations.

Secondly, this paper found the hospital logistics operation in all case study hospitals was found to be no-man-land operations. Even though administration staff was at the central warehouse, nurses were still assigned to monitor and refill the medical supplies to the sub-warehouse at their ward or clinic, despite being swamped servicing rapidly rising patients. Pharmacists were also assigned to deliver the pre-arranged medicines to home isolation patients even though the hospital drivers were available. The purchasing staff will start the purchasing process for warehouse fulfillment only if they receive the purchasing request from clinical

users, even though it puts more risk of a shortage since clinical users' time for inventory management is limited due to the surge of patients. Due to the lack of a designated main person responsible, this kind of no-man-land operation creates an ineffective hospital system from both cost and service-level perspectives.

Thirdly, this paper found that the working culture and perception of being a staff member in a state-owned public hospital led to a cost-ineffective system. Currently, the average purchasing lot size for stock replenishment at the central warehouse for most hospitals will cover the demand for two months, while the lot size for user refilling from the central warehouse to their sub-stock is an average of two weeks. A simple reduction in purchasing lot size from two months to one month at the central warehouse and from two weeks to every week for sub-stock refilling will lower the inventory-related cost and system efficiency for the entire hospital. However, all hospitals are primarily concerned about the risk of a shortage from a smaller lot-size purchase, even though the recorded data shows a minimum chance of a deficit, enabling them to lower the cost. This is because the government fully financially supports all case study hospitals, and maximizing social welfare was a perceived primary objective for all hospitals, not profit maximization, and hence no motivation for staff to lower the operation cost through improving the work process.

## Discussions

Firstly, the result is that logistics operations of hospitals in remote areas were found to be not well-prepared as WHO suggested, not only happening in developing countries like Thailand, a case study of this paper. However, it was also found in other developed countries; Carpenter et al. (2021) found a low preparedness score under pharmacists' training and protective equipment domain in rural areas of the United States due to the transportation difficulties resulting from its isolated geography. Hence, we suggest policymakers stop making one-size-fits-all hospital logistics-related policies for urban and rural hospitals when preparing their pandemic response plan. A data-driven policy that is more effective when preparing for pandemic response (McLaren, 2022) based on location constraints is suggested.

Secondly, the finding of missing designated persons in hospital logistics activities is in the same direction as the previous work of Moons et al. (2019), who reported the importance of a designated hospital logistics team in reducing hospital operational costs and inefficiencies through improved collaboration and integration among the internal hospital supply chain. So, researchers would suggest a future study on developing designated logistics personnel in Thai public hospitals for better internal operations.

Lastly, the lack of cost-effectiveness perception of hospital staff is also found in many countries where for-profit hospitals provide a higher service quality than non-profit hospitals (Picone et al., 2002; Shen, 2002; Jensen et al., 2009).

## Suggestions

We would suggest a future research direction on developing a strategy for improving hospital logistics systems by continuing on a previous framework developed by Kritchanchai et al. (2018), together with the findings in this paper, into a strategy specifically designed for small public hospitals in remote areas.

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