ISSN 2409-2665
Journal of Logistics, Informatics and Service Science
Vol. 11 (2024) No. 10, pp. 173-198
DOI:10.33168/JLISS.2024.1010

Improving Medical Logistics Resilience in Earthquake Disasters: A Qualitative Case Study from Indonesia

Yeni Rimadeni[1,2], Hizir Sofyan[3]*, Safrizal Rahman[4], Setia Pramana[5], Muhammad Ikhwan[6]

[1] Graduate School of Mathematics and Applied Science, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia;

[2] Polytechnic of Health, Ministry of Health, Aceh 23231, Indonesia.;

[3] Department of Statistics, [3]Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia;

[4] Department of surgery sub division of Orthopedic and Traumatology, Faculty of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia;

[5] Department of Computational Statistics, Institute of Statistics, Jakarta 13330, Indonesia.;

[6]Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia;

hizir@usk.ac.id (Corresponding author)

Abstract. This qualitative case study examines the management practices and challenges of medical logistics following the 2016 Pidie Jaya earthquake in Indonesia. Through in-depth interviews, observations, and focus group discussions with key informants from the Pidie Jaya Health Office and Primary Health Care Pharmaceutical Installations, the study investigates 14 critical aspects of medical logistics preparedness and response. The findings indicate that while standard operating procedures are adhered to for routine medical logistics management, there is a lack of specific planning for earthquake scenarios. An innovative regional planning approach involving 18-month advance procurement has been effective in managing minor disasters. However, the study underscores the need for more comprehensive disaster-specific medical logistics planning, particularly for large-scale events like earthquakes. This paper contributes to the limited literature on optimizing medical logistics in disaster response within developing country contexts and provides practical insights for policymakers and practitioners. Despite this, the transferability of the findings may be constrained by the single case study design and the reliance on qualitative methods. Future research should explore the applicability of these lessons to other disaster contexts and use mixed-methods approaches to enhance the generalizability of the findings.

Keywords: medical logistic, disaster planning policy, pharmacy warehouse, qualitative method

1. Introduction

Indonesia is one of the countries located in the Pacific Ring of Fire, known for its high seismic activity(Cummins, 2017; Harris & Major, 2017; Irsyam et al., 2020; Tjipto Prastowo, 2022). Apart from earthquakes, Indonesia is also susceptible to other disasters such as tsunamis, volcanic eruptions, floods, landslides, tornadoes, fires, droughts, social conflicts, and pandemics(Amien et al., 1999; Briggs et al., 2006; Djalante et al., 2017; Djalante & Garschagen, 2017a, 2017b; Younger, 2019). These disasters result in loss of life, environmental damage, property losses, and psychological impacts. Aceh Province is one of the areas with significant earthquake potential. This is due to its geographical location near the convergence of the Indo-Australian and Eurasian plates, which is an active subduction zone. As a result, Aceh frequently experiences high seismic activity (Banyunegoro et al., 2019; Briggs et al., 2006; Farhan et al., 2024; Irwandi et al., 2021; Jena et al., 2020; Meltzner et al., 2006; Sufri et al., 2020).

In the past 17 years, the province of Aceh has experienced 5 significant earthquake events, including the mega-earthquake in Aceh in 2004 with a magnitude of 9.2 Mw that triggered a tsunami, twin earthquakes in 2012 with magnitudes of 8.1 and 8.6 Mw, as well as other earthquakes such as Geumpang-Mane in 2013, Bener Meriah in 2013, and Pidie Jaya in 2016(Farhan et al., 2024; Jena et al., 2020). These data indicate that Aceh faces a high risk of earthquake disasters(Agung & Indrajaya, 2020; Apriyadi et al., 2022). Mitigation efforts, preparedness, and drug management are crucially undertaken routinely as preparation to anticipate disasters. In the preparedness phase, drug needs planning (DNP) under normal conditions should consider the quantity and types of drugs appropriate to the supporting data and disaster risk information in the area(Bastos et al., 2014; Hu & Sheu, 2013; Sheu, 2014; Tavana et al., 2018). Past research has extensively discussed the challenges in medical logistics management for disaster response. For instance, Sheu (2014) developed an optimization model for the allocation of medical resources in emergency situations. Bastos et al. (2014) investigated the scheduling and delivery of pharmaceuticals during disasters. Hu and Sheu (2013) identified factors influencing the availability of medicines in disaster response. However, recent studies indicate that there are still gaps in understanding the integration of drug needs planning with local-level disaster risk information (Tavana et al., 2018). This study aims to fill this gap by analyzing drug needs planning under normal conditions in Aceh Province, one of the regions in Indonesia with high earthquake risk. A comprehensive understanding of this planning process is expected to enhance preparedness and effective response to disasters in the future.

During the emergency response phase, drug management aims to meet drug needs quickly within approximately 24 hours, taking into account the appropriate types of drugs according to the requirements. Emergency drug planning refers to data obtained from Rapid Health Assessment (RHA), which includes drug availability, human resources, warehouse conditions, facilities, infrastructure, and funding(Cherry & Trainer, 2008; Mkoka et al., 2014; Mulyasari et al., 2013). In the context of emergency preparedness planning or disaster planning, the Pharmacy Installation (PI) plays a crucial role in ensuring the availability of necessary medications and health supplies(Groenewold, 2006). Considering the frequency of disasters that occur, increased attention to this planning becomes highly important(March & Kornakova, 2017). In disaster situations, the provision of medications and health supplies becomes a vital element in delivering the necessary services. However, challenges arise when medications and health supplies are available but not managed effectively, which can impact the availability and effective distribution(Wiryanto et al., 2019). Therefore, the management of medications becomes highly crucial, especially in the context of providing medications and health supplies as a support during disasters. In this planning, medication buffers should be available at the district/city, provincial, and central levels(Alem et al., 2016; Yan et al., 2023). According to Minister of Health Regulation Number 72 of 2016 on the

Management of Pharmaceutical Preparations, Medical Devices, and Disposable Medical Materials, it is a cycle of activities that begins with selection, needs planning, procurement, receipt, storage, distribution, destruction and withdrawal, control, and administration required for pharmaceutical services activities (Hasan et al., 2023; Wang et al., 2019; Zheng et al., 2022).

The management of pharmaceutical preparations, medical devices, and disposable medical materials must be carried out multidisciplinarily, coordinated, and using effective processes to ensure quality control and cost control(Muzli et al., 2018; Tingkat et al., 2022). Pidie Jaya Regency, is a regency in Indonesia that has experienced the impact of earthquakes. A magnitude 6.5 earthquake struck Pidie Jaya on December 7, 2016. As a result, 103 people died, 267 people were severely injured, 127 people sustained minor injuries, 91,267 individuals were displaced, 2,357 houses were heavily damaged, 5,291 houses were moderately damaged, and 4,184 houses were lightly damaged. According to the report from the local government of Pidie Jaya Regency, the earthquake caused damage to a total of 17,673 residential units, with 2,414 being severely damaged. Additionally, 26 local government office buildings, 17 village office buildings, and 56 official residences were affected. Twenty-four military and police facilities, one regional hospital and its facilities, 11 primary health centers, 19 village health posts, and 31 paramedics' residences were also damaged. Educational facilities were not spared from the earthquake, with 31 preschools, 71 elementary schools, 21 junior high schools, 15 senior high schools, 63 mosques, 133 Islamic boarding schools, and 42 religious education institutions being affected. Furthermore, three bridges suffered severe damage, three kilometers of county roads were heavily damaged, one kilometer of village roads were moderately damaged, and four clean water facilities were heavily damaged. The earthquake in Pidie Jaya resulted in an estimated loss of around 2.94 trillion Indonesian rupiah, with estimated damages amounting to 2.79 trillion rupiah and losses estimated at 151.6 billion rupiah. The recovery needs for the Aceh earthquake were estimated to be around 2.4 trillion rupiah.

A model for the management of medications and health supplies, as well as the types of medications related to medication management in earthquake disaster situations in Pidie Jaya Regency, is needed. An analysis of the condition of medical logistics management at the Pharmacy Installation of Pidie Jaya Regency is crucial considering the series of earthquakes that frequently hit the area and result in significant impacts, including loss of life and extensive damage to buildings. These experiences highlight the need for increased preparedness and management in handling disaster impacts. By ensuring an adequate supply of medications and health supplies, the recovery of disaster victims can be accelerated and suffering reduced. Given the potential limitations of resources, such as human resources, budget, and healthcare infrastructure, such analysis is necessary to ensure the efficient utilization of available resources. Furthermore, evaluating the current condition will help identify necessary improvement measures to enhance disaster preparedness in the future, as well as strengthen healthcare systems and responses to occurring disasters. By achieving these objectives, this study aims to contribute valuable insights to the literature and improve medication and health supply management in earthquake disaster situations, ultimately enhancing the overall response and recovery efforts in Pidie Jaya Regency.

2. Theoretical Background

2.1. The earthquake in Indonesia.

The data on earthquakes in Indonesia reveals a high vulnerability to seismic activity due to its location at the convergence point of tectonic plates. Indonesia, as a country situated in the Pacific Ring of Fire, frequently experiences devastating earthquake disasters. These series of disasters are

caused by its position at the intersection of several active tectonic plates, resulting in intense seismic activity. The following table illustrates the series of earthquake disasters in Indonesia:

Table 1. The earthquake in Indonesia.

Year	Location	Magnitudo	Impact
2004	Aceh	9,1-9,3	Severe damage, tsunami, thousands of casualties
2006	Yogyakarta	6,3	Significant damage, thousands of casualties
2009	Padang	7,6	Severe damage, thousands of casualties
2010	Mentawai	7,7	Tsunami, hundreds of casualties
2016	Pidie jaya	6,5	Significant damage, thousands of casualties
2018	Sulawesi	7,5	Extensive damage, thousands of casualties
2019	Lombok	6,9	Significant damage, hundreds of casualties
2021	Sulawesi Barat	6,2	Severe damage, dozens of casualties

Several studies have been conducted to visualize earthquake data, including depth and magnitude, to support better decision-making(Nashih Uluwan Arif et al., n.d.) . There are specific areas, such as Mamuju, that often become the location of earthquakes, with a significant percentage of these earthquakes being of moderate to large magnitude and shallow depth. This emphasizes the need for effective seismic mitigation strategies(Erlangga et al., 2022). Recent earthquake events, such as the earthquake in Java in 2022, have caused significant damage. This event underscores the importance of utilizing data from various sensors to analyze land deformation and plan disaster responses. Through the exploration of earthquake records in Indonesia, including significant events such as the earthquakes in Yogyakarta and Palu, we can gain an understanding of seismic intensity and ground motion characteristics. Predictive analysis using methods such as the Gutenberg-Richter Method also aids in evaluating the vulnerability to earthquakes in regions like Aceh, considering historical seismicity data (Wally et al., 2023). Several studies have explored various aspects of earthquake data in Indonesia, providing a better understanding of earthquake patterns, potential triggers, fault patterns, and the importance of disaster mitigation strategies. One interesting study conducted by (Nugroho & Suryanto, 2011) focused on the timing of earthquakes in Indonesia in relation to tidal forces. This research found that a significant number of earthquakes with medium magnitudes, around 87%, occurred during the maximum tidal force period.

This correlation indicates the potential triggering of earthquakes in that region, where tidal forces generated by celestial bodies can influence stress distribution on faults and trigger earthquakes. Another study conducted by Badrul, (2015) investigated fault patterns in Sumatra, a region highly vulnerable to earthquakes due to complex tectonic plate interactions. This research aimed to identify and map faults in the region to better understand potential earthquake sources. By analyzing seismic data and geological features, this study successfully identified several active faults in Sumatra, contributing to a better understanding of earthquake hazards in the region. In West Papua, an area adjacent to tectonic plate boundaries and active faults, (Saputro & Momot, 2020) conducted a study to update the earthquake distribution map. This research aimed to improve the accuracy of earthquake hazard assessment in the region by analyzing historical earthquake data, geological surveys, and geodetic measurements. The updated earthquake distribution map provides valuable information for disaster management agencies, helping them prioritize areas more vulnerable to earthquakes and allocate resources appropriately. (Wally et al., 2023) emphasized the role of Geographic Information Systems (GIS) in earthquake-related disaster management, particularly in the context of high seismic

activity in Indonesia. This study highlights the benefits of using GIS technology in earthquake hazard mapping, risk assessment, and emergency planning.

2.2. Medical Logistics in Disaster

Medical logistics in disaster response plays a vital role in ensuring efficient medical interventions during crises. It involves strategic planning, organization, and proper allocation of resources to meet urgent medical needs. The World Health Organization (WHO) has developed guidelines for Emergency Medical Teams (EMTs) as part of efforts to provide comprehensive care in disaster situations(WHO, 2021). These EMTs are responsible for delivering emergency care at various levels, including outpatient emergency care, inpatient surgical care, and referrals to more comprehensive medical facilities. In an effort to enhance disaster response, the integration of drone technology and Geographic Information Systems (GIS) has been proposed for logistics systems(Thomas, 2018). The use of drones in medical logistics enables the quick delivery and installation of medical containers in hard-to-reach disaster locations. By leveraging GIS data, factors such as road conditions and hazard maps can be considered to select optimal routes and ensure timely delivery of medical logistics. This approach is expected to expedite the distribution and deployment of necessary medical resources in disaster-affected areas AbdelAziz et al., (2024; Negi & Negi, (2021). Additionally, studies on humanitarian logistics also focus on optimizing the location and number of Temporary Medical Centers (TMCs) during disasters.

This approach involves analyzing factors such as the presence of existing hospitals, casualty classifications, road conditions, and distance from the disaster area. By considering these variables, strategic locations for establishing Temporary Medical Centers can be determined, thus ensuring an effective and comprehensive emergency medical response in the disaster-affected area (Torani et al., 2019; Zuccaro et al., 2020). Studies conducted by several researchers have highlighted the importance of effective medical logistics in disaster response. Suhu et al., (2023) conducted research on earthquake response in South Halmahera. The study highlighted challenges in medical logistics, including delayed supplies, uneven distribution, and inadequate quantities. This research emphasized the need for careful planning and effective coordination to ensure timely and adequate medical logistics. Heryati, (2020) focused their research on non-medical logistics in mental hospitals in North Sulawesi. The study highlighted the need for proper storage and distribution systems to meet the needs of patients with mental disorders during disasters. This research demonstrated the importance of well-organized medical logistics to ensure adequate care for vulnerable populations.

Ampuh Hadiguna & Agus Wibowo, (2012)conducted research on disaster management and social assistance in Padang. The study emphasized the need for controlled logistics distribution during disasters. This research highlighted the importance of careful planning, effective coordination, and strict supervision in managing medical logistics. Collectively, these studies underscore the crucial role of efficient medical logistics in disaster response. By implementing appropriate strategies, good coordination, and organized logistics systems, it can ensure that the necessary medical resources are rapidly and accurately distributed to those in need during disaster situations.

2.3. Earthquake in Pidie Jaya

An earthquake occurred on Wednesday (12/6) at 05:03 WIB with a magnitude of 6.5 on the Richter scale, shaking Pidie Jaya and causing people to panic and run outside. The epicenter was on land at coordinates 5.19° N and 96.38° E with a depth of 10 km. The earthquake was felt in Pidie Jaya, Bireuen, and Pidie, reaching an intensity level of VIII on the MMI scale, causing significant damage to buildings. As of December 13, 2017, there were 89 recorded aftershocks on land and

offshore, classified as shallow earthquakes with a hypocenter less than 60 km below the surface. The impact was devastating, leaving deep scars and severe damage, resulting in 103 fatalities, 267 people with serious injuries, and 127 with minor injuries. More than 91,000 people were displaced as their homes became unsafe.

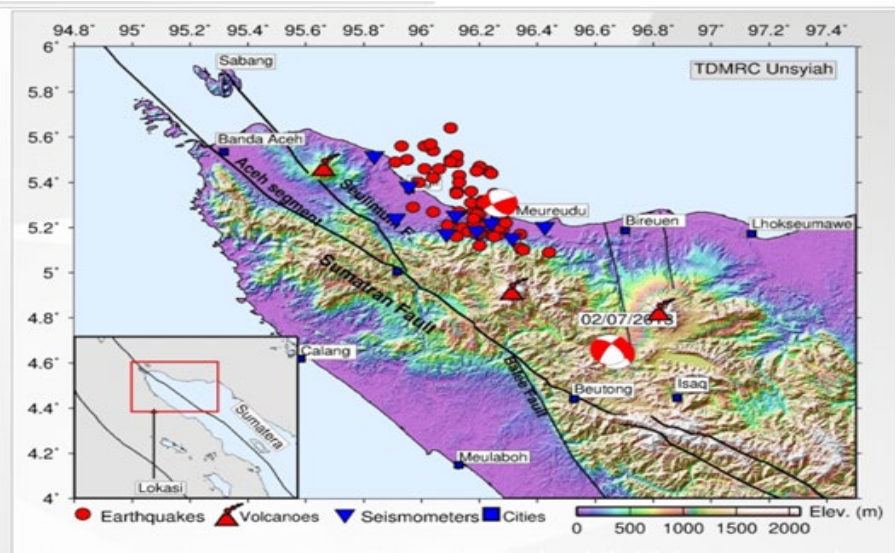

Figure 1. The epicenter of the Pidie Jaya earthquake (marked by a ball) and the aftershocks (marked by red circles), along with the locations where seismometer stations were installed (marked by blue triangles) to record the aftershocks of the December 7, 2016, Pidie Jaya earthquake.

The earthquake also affected Bireuen Regency, damaging two sub-districts: Samalanga and Simpang Mamplam. According to local reports on December 21, 2016, 2,608 houses were damaged (108 severely, 208 moderately, and 2,292 lightly). Additionally, 31 places of worship, one university,

29 educational facilities, one Koramil office, and one district hall were also damaged. The tremors, lasting 10-15 seconds, caused extensive damage in Pidie, with thousands of homes, shops, government offices, schools, as well as several mosques and bridges affected. A total of 2,325 homes in Pidie Regency were damaged, with 45 severely, 242 moderately, and 2,038 lightly. Furthermore, three bridges sustained severe damage, three kilometers of district roads were heavily damaged, one kilometer of village roads were moderately damaged, and four clean water facilities were severely damaged. Over 180 disaster management responders were involved in handling the earthquake. These included 25 local and provincial government agencies, 11 national government agencies and clusters, 9 other local governments providing response aid, 86 national NGOs and community organizations, 21 businesses, 11 universities, one regional organization, 13 international NGOs, four UN agencies, and two donor organizations.

3. Research Methodology

This research is a qualitative study using a case study approach to gain an in-depth understanding of the management of drug and health supplies at the Pharmaceutical Installation of the Pidie Jaya Health Office (PI PJHO) in Pidie Jaya District. The selection of Aceh Province as the case study site for this research is well-justified. As a region in Indonesia that is highly susceptible to natural disasters, particularly earthquakes due to its geographical location near active tectonic plate boundaries, Aceh Province represents a crucial context for examining medical logistics planning and preparedness for disaster response. The study's focus on analyzing drug needs planning under normal conditions in Aceh Province is a strategic approach to understanding how this critical aspect of medical logistics can be strengthened to enhance overall disaster preparedness and response effectiveness. The research was conducted between March and September 2023. Primary data collection involved in-depth interviews, observations, and Focus Group Discussions (FGDs). During observations, tools such as observation guides, mobile phones for photography, recording devices, and notebooks were utilized. Face-to-face and telephone interviews were conducted between the interviewers and respondents. The sampling strategy used to select the 15 interview respondents was a purposive sampling approach. This entails deliberately choosing participants who are likely to provide the most relevant and valuable information to address the research objectives.

Specifically, the 15 informants were selected from 15 Primary Health Care Pharmaceutical Installations (HCPI) under the PJHO Pharmaceutical Installation. This includes key personnel such as the Head of the Pharmaceutical Installation, who serves as the primary informant, as well as drug managers and managers of medical consumables at these 15 HCPI locations. The selection of interview respondents employed purposive sampling, encompassing 15 Primary Health Care Pharmaceutical Installations (HCPI) under PI PJHO, including Meureudu HCPI, Meurah Dua HCPI, Bandar Dua HCPI, Kuta Krueng HCPI, Blang Kuta HCPI, Masa Buya HCPI, Ulim HCPI, Trienggadeng HCPI, Pante Raja HCPI, Bandar Baru HCPI, Kuba HCPI, and Simpang 4 Nyong HCPI Secondary data was collected from reports, journals, and various relevant sources. This secondary data was used to access drug lists and information related to drug and health supply management from the PJHO Pharmaceutical Installation archives, as well as utilizing available information on relevant government websites. These sources provided initial insights into the drug inventory management conditions at PI PJHO. The data analysis process undertaken in this research involved meticulous recording and transcription of data collected through interviews, observations, and focus group discussions (FGDs). The data was then categorized based on themes relevant to the research objectives, such as medication inventory management, procurement processes, and challenges in managing healthcare supplies. Data coding was performed to identify patterns or trends within each category, followed by thematic analysis to uncover the key themes. To ensure the validity and reliability of the findings, data triangulation was carried out. This involved cross-

verifying information from various data sources (interviews, observations, and FGDs) as well as data types (primary and secondary). Triangulation helped to confirm the findings and provide a comprehensive understanding of the management practices at the PI PJHO Pharmacy. Furthermore, the analyzed data was evaluated and interpreted to develop a deeper understanding of the medication and healthcare supply management practices at the PI PJHO Pharmacy. These steps were taken to ensure the credibility and trustworthiness of the qualitative findings of this research. Data triangulation enabled cross-verification of information from diverse sources, while coding techniques and thematic analysis helped systematically identify patterns and themes emerging from the collected data. These efforts contributed to the trustworthiness and strong credibility of the research findings.

4. Results and discussion

4.1. Geographic condition of Pidie Jaya Regency.

The geographic condition of Pidie Jaya Regency is diverse, representing various terrains and landscapes within Aceh Province. It was formed as a subdivision of Pidie Regency, with its capital located in Meurendu. Positioned between 9603'16.62" to 96020'40.5" East Longitude and 5018'6.607" to 4056'42.1" North Latitude, it covers an area of 952.11 km². To the north, it is bordered by the Malacca Strait, while to the east, it shares boundaries with Biereun Regency. In the south and west, it is bordered by Pidie Regency. The population consists of 78,742 males and 79,655 females, totaling 158,364 individuals. Pidie Jaya Regency features a diverse geography, including coastal areas, lowlands, and highlands, divided into nine districts and 222 villages.

4.2. Characteristics of Respondents

The study involves a total of 15 participants. The informants include the Head of Pharmaceutical Installation (PI), who serves as the key informant, as well as drug managers and managers of Medical Consumables.

Table 2. Characteristics of respondents based on education and position

No	Initials of the Respondent	Gender	Education	Position
1	R1	Woman	Pharmacist	Head of PI
2	R2	Woman	Pharmacist	Drug Management and Medical Consumables Staff
3	R3	Woman	Pharmacist	Head of HCPI
4	R4	Woman	Pharmacist	Head of HCPI
5	R5	Woman	Pharmacist	Head of HCPI
6	R6	Woman	Pharmacist	Head of HCPI
7	R7	Woman	Pharmacist	Head of HCPI
8	R8	Woman	Pharmacist	Head of HCPI
9	R9	Woman	Pharmacist	Head of HCPI
10	R10	Woman	Pharmacist	Head of HCPI
11	R11	Woman	Pharmacist	Head of HCPI
12	R12	Woman	Pharmacist	Head of HCPI
13	R13	Woman	Pharmacist	Head of HCPI
14	R14	Woman	Pharmacist	Head of HCPI
15	R15	Man	Pharmacist	Head of HCPI

The management of drugs and pharmaceutical supplies is carried out within the scope of the Pharmaceutical Installation (PI) of PJHO. All drug management activities are conducted in the pharmacy warehouse of PJHO by human resources from HCPI. The PJHO Pharmacy Warehouse is located separately from the PJHO. The pharmacy warehouse is situated within the premises of the Pidie Jaya District Hospital (RSUD Pidie Jaya), but its management is distinct from the management of the pharmaceutical installation of RSUD Pidie Jaya.

4.3. Human Resources

The research findings regarding drug inventory management at the Pharmaceutical Warehouse of PJHO in Pidie Jaya District reveal several key findings. Firstly, all warehouse staff are involved in drug inventory management at the Pharmaceutical Warehouse, holding roles as warehouse supervisors, drug custodians, and medical consumables managers. Secondly, each staff member has distinct responsibilities in the drug inventory management process, where the drug management supervisor is accountable for planning medications and presenting the outcomes to the PI chairman for evaluation. Thirdly, the staff composition in the pharmaceutical warehouse is generally considered adequate, but there is a need for personnel capable of handling heavy items, such as liquids, given that the majority of warehouse employees are female. Lastly, efforts to enhance knowledge and skills related to drug inventory management are pursued through staff participation in training sessions or seminars related to pharmaceutical supplies. These findings provide valuable insights to improve and enhance efficiency in drug inventory management at the Pharmaceutical Warehouse of PJHO, which, in turn, can enhance healthcare services and responsiveness to community needs. Below is the participants' presentation regarding available human resources.

Table 3. Drug Inventory Management Overview

No.	Aspect	Details
1.	People involved in drug supply management	Most informants highlighted that individuals engaged in drug inventory management within the PJHO pharmacy warehouse are the warehouse personnel.
		"All warehouse staff are involved in managing the inventory." (R1)
		According to Informant R2, the core responsibilities of warehouse personnel include managing the warehouse, drug inventory, and medical consumables.
2.	Roles of officers	The roles of officers are delineated by their responsibilities in drug supply management. Informant R7, responsible for drug management, submits plans to the head of PI.
3.	Adequacy of staff composition	Informant R9 noted that the staff composition in the pharmaceutical warehouse is generally appropriate, though there's a need for additional personnel for heavy lifting tasks.
4.	Efforts in enhancing knowledge and skills	Informant R15 indicated efforts to enhance officers' knowledge and skills through training sessions or seminars focusing on pharmaceutical management issues.

4.4. Budget

At the PI Dinkes Pidie Jaya, the budget for drug inventory management is obtained through the Regional Revenue and Expenditure Budget (RREB). This budgeting process is overseen by a budgeting committee responsible for monitoring and controlling the funds used. The management of drug inventory funds is conducted through the List of Budget Implementation (LEBE) . The interview results from this study indicate that there are no perceived obstacles by the pharmaceutical warehouse regarding the budgeting of drug inventory management. Thus, overall, the budget for drug inventory management at the PI Dinkes Pidie Jaya is obtained from RREB, overseen by the budgeting committee, and managed through LEBE without any current hindrances in the budgeting process. This indicates that drug inventory management at the PI Dinkes Pidie Jaya has a sufficient and well-organized budget foundation, supported by adequate oversight processes.

Table 4 Analysis of Funding for Drug Inventory Management

No.	Aspect of Analysis
1.	Availability of Special Funds
	Information from informant R9 indicates the existence of special funds for drug inventory management at the PI PJHO.
2.	Source of Funds
	The budget used for the inventory management process is sourced from the regional revenue and expenditure budget (RREB) funds. Informant R8 mentions the existence of a budgeting committee whose funds come from RREB.
3.	Funds in the List of Entries of Budget Execution (LEBE)
	As per the statement of informant R1, the inventory management activities are listed within LEBE, specifying the allocated funds.
4.	Constraints in the Budgeting Process
	So far, no obstacles have been felt by the pharmaceutical warehouse regarding budgeting for drug inventory management, as per informant R1.

4.5. Facilities and Infrastructure

Conditions An analysis of the facilities and infrastructure in managing drug inventory at the Pharmaceutical Warehouse of PJHO in Pidie Jaya District reveals several aspects.

Table 5 below describes the conditions of facilities and infrastructure in managing drug inventory at the Pharmaceutical Warehouse of PJHO in Pidie Jaya District:

Aspect	Description
Main Facilities	Important facilities such as trolleys for goods, drug racks, and specialized storage cabinets for vaccines are available at the Pharmaceutical Warehouse of PJHO.
Availability and Suitability	The availability of facilities is considered sufficient and suitable for carrying out daily drug management processes.
Completeness and Quality	The completeness and quality of these facilities are maintained to ensure efficient and effective drug management processes.
Condition Assessment	The facility conditions in the pharmaceutical warehouse are adequate and rated as good, reflecting attention to infrastructure quality.

Information obtained from interviews indicates the presence of important facilities such as goods

trolleys, drug racks, and specialized storage cabinets for vaccines in the warehouse . This demonstrates efforts to provide the necessary infrastructure to support effective drug management activities. Furthermore, interview results affirm that overall, the availability of these facilities is considered sufficient and suitable for daily drug management processes. There is a need to ensure the completeness and quality of these facilities to ensure efficient and effective drug management processes. In the context of facilities and infrastructure conditions, informants indicate that the facilities in the pharmaceutical warehouse are adequate and even rated as good. This condition reflects attention to the quality of infrastructure used in drug management at the warehouse. There are no significant obstacles or constraints related to facilities and infrastructure in the drug inventory management process. The pharmaceutical warehouse has successfully met the infrastructure needs for drug management without significant issues. However, routine monitoring and maintenance of these facilities are still required to ensure the smoothness and effectiveness of drug management processes in the future.

4.6. Top of FormStandard Operating Procedures (SOP)

Based on the analysis provided, there are Standard Operating Procedures (SOP) already in place in the drug inventory management process at the pharmaceutical warehouse, as revealed by informant R8. The SOP development process involves the drug manager, the head of the Pharmacy Installation, service departments, and other staff. This indicates that drug inventory management at the Pidie Jaya Health Office involves various competent and experienced parties in developing effective guidelines. Furthermore, informants R10 and R15 stated that the implementation of drug management activities is considered effective and in line with existing SOPs. This indicates that the implementation team has followed established procedures well, allowing the drug inventory management process to proceed without significant obstacles. Informant R9 also mentioned that there are no obstacles hindering the implementation of drug inventory management procedures. Although the information provided does not offer detailed insights into effectiveness metrics, indicators of good implementation, and potential challenges, it can be concluded that drug inventory management at the pharmaceutical warehouse has been carried out in accordance with the existing SOPs.

Table 6 Analysis of Standard Operating Procedures (SOPs) in Drug Inventory Management

No.	Analysis Findings	Details
1.	SOP (Standard Operating Procedure)	There are SOPs implemented in drug inventory management, which help ensure a more directed process and yield satisfactory outputs (R8).
2.	SOP Development	SOP development involves each responsible person and the head of the Pharmacy Installation, as well as involving the head of the Pharmacy Installation, service departments, and other staff at the Pharmacy Installation (R8).
3.	Procedure Effectiveness	The implementation of drug management activities at the pharmaceutical warehouse is considered effective and in line with existing SOPs, although there are no further details regarding the effectiveness metrics used (R10).
4.	Good Implementation and Compliance with	The implementation of drug management activities has been based on and compliant with existing SOPs, although there is no additional information regarding indicators of

	Procedures	good implementation or compliance with procedures (R15).
5.	Constraints in Implementation	No obstacles are mentioned in the implementation of pharmaceutical supply logistics management procedures, although there are no details regarding potential challenges that may arise (R9).

4.7. Drug selection

The analysis of the pharmacy supplies determination process in the pharmacy warehouse is based on information provided by the informants. According to informant R8, the process begins with bottom-up planning, where the first users at the HC are responsible for determining pharmacy supplies, then followed by the logistics department in the pharmacy warehouse planning the pharmacy supplies to be ordered. Information from informant R5 indicates that determining pharmacy supplies is based on the monthly demand needs of each depot or unit, then planned by the pharmacy warehouse and forwarded to the head of the installation to order the planned pharmacy supplies. The drug selection process, as revealed by informant R1, begins at the start of the year based on usage from the previous two years, sometimes when drug stocks begin to deplete or run out. Barriers in the selection process, as conveyed by informant R4, occur when service users change, resulting in plans made for user A being used by user B. Lastly, information from informant R7 indicates that drug selection for disasters like earthquakes considers common cases such as cuts, open wounds, accidents, and emergency conditions as part of general drug selection. From the analysis, the pharmacy supplies determination process seems to involve several stages involving the first users, the logistics department, and the pharmacy warehouse, although there are barriers related to changes in service users and drug selection following standard needs and emergencies.

Table 7. Analysis Findings on Pharmacy Supply Determination

No.	Analysis Findings	Details
1.	Responsibility for Determining Pharmacy Supplies	Determining pharmacy supplies starts with the first users at the Health Centers (HC) who make requests, followed by the logistics department in the pharmacy warehouse planning which pharmacy supplies to order (R8).
2.	Method of Determining Pharmacy Supplies	Determining pharmacy supplies is based on the monthly demand needs of each depot or unit, submitted to the pharmacy warehouse for planning, and then forwarded to the head of the installation to order the planned pharmacy supplies (R5).
3.	Timing of Drug Selection	Drug selection begins at the beginning of the year based on usage from the previous two years, and sometimes when drug stocks begin to deplete or run out (R1).
4.	Barriers in the Selection Process	Barriers in the drug selection process occur when service users change, where plans made for user A are then used by user B (R4).
5.	Drug Selection for Disasters	Drug selection for disasters like earthquakes considers common cases such as cuts, open wounds, accidents, and emergency conditions as part of general drug selection (R7).

4.8. Drug Requirement Planning

Table 8 Analysis Findings on Medication Needs Planning

No.	Analysis Findings	Details
1.	Involvement in the Planning Process	Individuals in the pharmacy warehouse and the head of the PI are involved in the medication needs planning process (R15).
2.	Method of Medication Needs Planning	The method used is the consumption method, with the addition of using epidemiological methods in some cases (R6, R7).
3.	Timing of Determining Medication Needs	Medication needs planning is scheduled at the beginning of the year but depends on the existing requirements (R6).
4.	Effectiveness of Medication Needs Planning	Medication needs planning conducted by the pharmacy warehouse is considered quite effective (R9).
5.	Need for Medication in Disasters like Earthquakes	Medication for disasters like earthquakes has not been specifically budgeted for but is included in the selection of drugs for emergency installations (R14).
6.	Constraints in Medication Needs Planning	Annual budget changes are a constraint, and there are errors in the planning method sometimes resulting in errors in the ordered drug inventory (R11).

The analysis of the medication needs planning process at the PJHO Pharmacy Warehouse indicates several relevant points. First, the planning process begins by reviewing the previous month's drug usage at each Health Center, which is then summarized by warehouse personnel to create a medication inventory needs plan. The involvement of individuals in the pharmacy warehouse and the head of the PI in the planning process indicates strong cooperation in determining medication needs. The method of medication needs planning is based on drug consumption, but sometimes also employs epidemiological methods to obtain a more comprehensive picture.

Although planning is generally done at the beginning of the year, flexibility towards actual needs remains a consideration. The effectiveness of planning is deemed adequate according to informants. However, there are constraints such as annual budget changes and errors in the planning method that can lead to mistakes in the ordered drug inventory. The need for medication for disasters like earthquakes has been noted although not specifically allocated. This analysis indicates that while the medication planning process adheres to existing SOPs, there is still room for improvement, especially in budget management and validation of planning methods to avoid errors in the ordered drug inventory.

4.9. Procurement

Table 9 Drug Procurement Analysis

No.	Analysis Findings	Details
1.	Involvement and Responsibility	Individuals involved and responsible in the drug procurement process include the head of the PI, the head of the department as the Budget User (KPA), the Technical Implementing Officer, the Procurement Officer, and the

		procurement committee (R6).
2.	Types and Quantity of Drugs	The types and quantity of drugs stored in the PJHO Pharmacy Warehouse are based on the national formulary determined by the hospital. The preparation of medical consumables is adjusted to user needs, such as requests from Health Centers (R6).
3.	Drug Procurement Time	The drug procurement process is usually carried out at the beginning of the year. The use of the e-purchasing system sometimes takes a long time until July, so manual ordering is done with an estimated time of one week to three days depending on the distributor (R3).
4.	Constraints in the Procurement Process	Constraints that may occur in the drug procurement process include stock shortages at distributors, which may require finding another distributor or borrowing from the nearest hospital, especially for urgent medications (R2).

In the drug procurement process at the PJHO Pharmacy Warehouse, procurement is conducted through an online e-purchasing system using the Government Procurement Policy Agency website, as stated by informant R7. In its implementation, the head of the PI, the department head as the Budget User (KPA), the Technical Implementing Officer, the Procurement Officer, and the procurement committee are directly involved and responsible for the procurement process, as mentioned by informant R6. The types and quantity of drugs stored are determined based on the established formulary of the hospital, and the preparation of medical consumables is done according to user needs, as explained by informant R6. The drug procurement process is usually conducted at the beginning of the year, but the use of the e-purchasing system sometimes takes a long time, and manual ordering is done if possible, as disclosed by informant R3. Constraints in the drug procurement process include stock shortages at distributors, but efforts will be made to find another distributor or even borrow drugs from the nearest hospital if the medication is urgent, as revealed by informant R2.

4.10. Drug Reception

Table 10 Insights into Drug Reception Process

No.	Inquiry	Response
1.	Drug Reception Flow from Supplier	Goods from suppliers are received by the appointed receiving committee, then forwarded to the pharmacy warehouse section for recording and storage (R7).
2.	Special Committee for Receiving Drugs	PJHO forms a special committee tasked with receiving and inspecting incoming orders. This committee is called the Goods Reception and Inspection Committee (R2).
3.	Checking the Condition of Incoming Drugs	It is important to check the condition of incoming drugs, especially regarding expiration dates and damaged items. The informant emphasizes the need to inspect incoming drugs because there is a possibility of expired or damaged drugs (R9).
4.	Constraints in the Reception Process	Challenges in the reception process are related to the large quantity of incoming goods, which causes difficulties in organizing items on shelves due to limited storage space (R13).

In the drug reception process, attention should be paid to expiration dates and the availability of drug reception records, as mentioned by informant R3. The drug reception flow from the supplier begins with the receipt of goods by the receiving committee, which is then forwarded to the warehouse section for storage, as per informant R7. PJHO establishes a special committee responsible for receiving and inspecting the condition of incoming drug items, as mentioned by informant R2. Checking the condition of incoming drugs, especially regarding expiration or damage, is necessary, especially for long-term stock, as stated by informant R9. Challenges in the drug reception process may arise when items arrive in large quantities and there is no specific space to stack items before organizing them on shelves, as described by informant R13.

4.11. Storage

Table 11 Insights into Drug Storage Process

No.	Analysis Findings	Details
1.	Storage Process Conducted by Warehouse Staff	The storage process is carried out while considering the appropriate temperature for the drugs and arranging them alphabetically (R4).
2.	Personnel Involved in the Drug Storage Process	All warehouse staff are involved in the drug storage process. Drug management officers and medical consumables management officers are also involved in the storage preparation (R6).
3.	Methods Used in the Storage Process	The First In First Out (FIFO) and First Expired First Out (FEFO) principles are commonly used in drug storage at the pharmacy warehouse (R8).
4.	Factors Influencing the Drug Storage Process	Room temperature is a critical factor affecting the drug storage process and prevents rodents that may damage the drugs (R5).
5.	Condition of the Warehouse for Drug Storage	The warehouse condition is considered adequate, but there is a need for improved lighting and room cooling to meet expected standards (R6).
6.	Challenges in the Storage Process	The main challenges in the storage process include inadequate lighting and unstable room temperature (R5).

The drug storage process conducted by pharmacy warehouse staff at PJHO is based on appropriate temperature considerations and alphabetical arrangement, as mentioned by informant R4. In the drug storage process, all warehouse staff are involved, including drug management officers and medical consumables management officers, as explained by informant R6. The storage process employs the First In First Out (FIFO) and First Expired First Out (FEFO) principles, commonly used in drug storage at the pharmacy warehouse, according to informant R8. Room temperature significantly influences the drug storage process and prevents damage from rodents, as stated by informant R5. While the warehouse condition is deemed adequate, improvements in lighting and room cooling are necessary to meet expected standards, per informant R6. The primary challenges in the storage process include inadequate lighting and unstable room temperature, as reported by informant R5.

4.1 Distribution Process

Table 12. Drug Distribution Process at PJHO

No.	Distribution Process at PJHO	Details
1.	Process of drug distribution at PJHO	"...The drug distribution process is carried out with sand based on requests and previous usage basis..." (R12)
2.	Who is directly involved and responsible in the distribution process?	"The responsible pharmacist, warehouse manager, each pharmacist in the health centers" (R13)
3.	Facilities and infrastructure used in the drug distribution process	"We have stairs, because the shelves are high to take the drugs and there is also a tool for delivering goods to transport the drugs" (R12)
		Facilities and infrastructure used in the distribution of drug supplies include stairs to lower items from high shelves and a tool to push items to the vehicle.
4.	Challenges in the drug distribution process	"The number of male staff is limited, so if there are items coming in, they're overwhelmed" (R3)
		Because there are few male staff members, if a staff member is absent or has to leave for some reason, female warehouse staff have to prepare the items."

The distribution process at PJHO, relying on a method based on sand to meet demand-driven requests, involves key personnel like the responsible pharmacist, warehouse manager, and pharmacists from health centers, fostering a collaborative approach to inventory management and logistics. The infrastructure, including stairs and delivery tools, supports efficient movement of drugs from storage to transport vehicles. However, staffing limitations, particularly the shortage of male personnel, pose operational challenges, necessitating workforce diversification and contingency planning. Proactive strategies like process automation, workforce optimization, and infrastructure enhancement could bolster distribution efficiency, ensuring timely access to medications and strengthening healthcare delivery within the community.

4.12. Disposal Process

Table 13 Drug Disposal Procedures and Challenges

No.	Analysis Finding	Details
1.	Disposal process of expired or damaged drugs	"Currently, the drugs are withdrawn, so all expired or damaged drugs from each HC or local hospitals are collected by us. We then create some sort of report and wait until it is issued, the disposal is not just limited to this but involves other unit combinations as well..."(R9) All pharmaceutical stocks that are expired or damaged from each HCPI service unit or local hospitals are gathered at the pharmacy warehouse. Then, the pharmacy department creates a report addressed to the

		head of the goods issuing. Subsequently, the warehouse awaits the transfer process.
2.	Individuals involved and responsible	"Yes, individuals from the disposal department and the pharmacy department including myself, witnessed by the head of the department as well... if it involves narcotics, we need a witness from the POM Office too..."(R10) The informant mentions that those involved in the disposal process include staff from the pharmaceutical disposal department and the department head. In cases involving narcotics, a witness from the POM Office is required.
3.	Compliance with existing procedures	"Yes, it complies with the standard"(R11) The informant states that the removal process carried out so far complies with the established procedure, where the removal process must first be documented in a report signed by the head of the PI.
4.	Challenges with the disposal process	"The challenge is mainly waiting"(R11) Informant M mentions the challenge lies in having to wait for the transfer and disposal process.

The process of drug disposal at PJHO entails a systematic approach, as articulated by informant R9, who delineates the meticulous steps involved. Initially, drugs deemed expired or damaged are retrieved and consolidated from various healthcare facilities and local hospitals. Subsequently, the pharmacy department initiates the creation of a comprehensive report detailing the accumulated inventory. This report is then directed to the overseeing authority, typically the head of goods issuing. Moreover, R9 elucidates that the disposal protocol extends beyond mere documentation, incorporating a collaborative effort among diverse units. This underscores a holistic approach towards disposal management, ensuring the systematic eradication of pharmaceuticals in accordance with established regulations. Furthermore, the involvement of pertinent stakeholders in the disposal process, as highlighted by R10, reinforces accountability and procedural integrity. Notably, the inclusion of witnesses from regulatory bodies, such as the POM Office for narcotics disposal, underscores adherence to stringent protocols. However, despite adherence to procedural standards, informant R11 acknowledges a significant challenge: the inherent waiting period intrinsic to the disposal process. This delay underscores a potential area for optimization, suggesting avenues for streamlining disposal procedures to mitigate temporal constraints and enhance operational efficiency.

4.13. Removal

Table 14 Drug Disposal Procedures and Challenges

No.	Questions	Answers
1.	Process of Disposal	Expired or damaged drugs from each Healthcare Center (HC) or local hospital are withdrawn and centralized at the warehouse. A formal report is then generated by the pharmacy department and submitted to the head of goods issuing. Additionally, the disposal process extends beyond the warehouse, involving collaboration with other units (R9).
2.	Parties Involved and Responsibilities	The disposal process engages personnel from the disposal management division and the pharmacy

		department, including informant R9. The disposal proceedings are overseen by the department head. In instances involving narcotics, witnesses from the POM Office are necessary (R10).
3.	Compliance with Procedures	Compliance with established protocols is affirmed (R11). Disposal activities adhere to pre-established procedures, necessitating the creation of formal records signed by the PI chairman prior to implementation.
4.	Challenges in the Disposal Process	The predominant challenge cited involves procedural delays, primarily attributed to the waiting period inherent in the disposal process. Informant M identifies waiting as a key impediment to the timely execution of disposal and transfer activities (R11).

The analysis of the drug management process at the PJHO Pharmacy Warehouse reveals a well-coordinated series of steps, from drug selection to disposal. Drug selection is based on user demand and historical usage, while the procurement process involves various parties to ensure an adequate drug supply. Drug reception is carried out by a special committee that inspects the condition of the goods, although there are challenges regarding the quantity of incoming items. All staff members are involved in drug storage following the FIFO and FEFO principles, yet the warehouse conditions require more attention, especially regarding lighting and room temperature. Drug distribution is based on demand with the assistance of existing infrastructure, though staff shortages are a potential issue. The disposal of expired or damaged drugs is carried out with a formal record and strict procedures, although there are challenges regarding the execution timing. Overall, the drug management system at the PJHO Pharmacy Warehouse demonstrates compliance with procedures but requires improvement in several operational aspects to enhance efficiency and drug availability.

4.14. Inventory Control.

Table 15. Inventory Control Analysis at PJHO Pharmacy

No.	Analysis Questions	Responses
1.	Inventory Control Process at PJHO Pharmacy	"Yes. Control inventory based on stock, stock of goods. Goods that are taken out must be restocked. Every month, reports on usage, mutations, how much is used, and there is also stocktaking." (R14)
2.	Direct Involvement and Responsibility	"Every logistics department of HCPI and PJHO." (R4)
3.	Method in Drug Inventory Control Process	"There is no method used to control supplies, just looking at reports from each HCPI." (R2)
4.	Challenges in Inventory Control Process	"Sometimes it's slow to report. So if that happens, shortages of drugs are common... Yes, the solution is we have to go back to socialization and remind." (R3)

The inventory control process at PJHO Pharmacy involves monitoring stock levels, generating monthly reports, and restocking depleted items based on usage. Responsibility for inventory control is distributed among logistics departments at HCPI and PJHO, ensuring accountability. However, there is no specific method for control, relying on reports from each HCPI. Delays in reporting pose

a challenge, leading to occasional drug shortages. Solutions include reinforcing communication and emphasizing timely reporting. Overall, while proactive efforts are evident, standardizing methodologies and improving communication channels could enhance inventory management practices.

4.15. Recording and Reporting

Table 16 Recording and Reporting of Drug Inventory

No.	Process	Description
1.	Recording of incoming and outgoing drugs	Done routinely and systematically to generate monthly reports on the quantity and types of drugs circulating (R1).
2.	Challenges in drug recording	While there shouldn't be any barriers, errors in stock recording may occur (R1).
3.	Recording of expired and expired stocks	All activities are meticulously documented, including the expiry date, incoming and outgoing drugs, expired drugs, and damaged drugs (R2).

Analysis of the drug recording and reporting process reveals the practices implemented in pharmaceutical inventory management within the pharmacy system. The recording of incoming and outgoing drugs is performed routinely and systematically to generate monthly reports documenting the quantity and types of drugs in circulation. This practice is crucial for monitoring drug stock and ensuring timely availability. However, information from informants also indicates the potential for errors in drug inventory recording. This highlights challenges that need to be addressed to ensure the accuracy of records. Errors in drug inventory recording can lead to discrepancies between records and actual availability, adversely affecting decision-making regarding drug procurement and distribution. Therefore, it is important to identify and address issues that may arise in the drug inventory recording process, such as providing appropriate training for responsible personnel, implementing clear procedures, and utilizing technology to support accurate and efficient recording. In addition to drug stock recording, the process also meticulously records expired and damaged drugs. This practice includes documenting expiration dates, incoming and outgoing drugs, expired drugs, and damaged drugs. Accurate and systematic recording practices in this regard are crucial for monitoring drugs that are no longer usable or pose health risks, allowing appropriate action to be taken, such as disposal or replacement of expired or damaged drugs**.**

DISCUSSION

The findings highlight the importance of comprehensive disaster-specific medical logistics planning, particularly for large-scale events like earthquakes. This discussion was built constructively involving researchers and confirmed by R1 and R2. In general, the history of earthquake disasters does not change the inventory order. Respondents mentioned things that are part of the generally accepted and standardized SOP from the Ministry of Health (Franco & L, 2018) (Keim, 2021). Respondents also mentioned unique things in their area in addressing the deficiencies in the HCPI they were working with. So far, they state that the lesson learned during a disaster is only mental and physical readiness, for the system to work as it should (Davis-Reddy & Hilgart, 2021) (Sasaki et al., 2018) (Jiang, 2019) . Several respondents strongly agreed with careful planning starting from warehouse readiness at HCPI. The complaints submitted are not crucial complaints for disasters, but complaints that are corrected for daily services. Furthermore, the head of PI who has responsibility at the city center PJHO and HCPI stated important things that could apply not only to large-scale disasters, but cover other disaster scale. The summary can be listed in Table 17 as follows:

Table 17 Distribution of drug inventory management problems at HCPI of PJHO

No	Types of Issues	Settlement
1.	User inconsistency with the use of the preparation	Inform the user concerned to use the preparation that has been provided.
2.	In particular, the planning of drugs intended for disasters has not been carried out	There has been no specific completion but planning is carried out one year and a half or 18 (eighteen) months in the future.
3.	The stock of drugs ordered at distributors is empty	Place an order with another distributor. If the preparation needed is *cito*, the hospital will loan drugs to other hospitals.
4	Room temperature that does not meet the standards	The head of the pharmaceutical installation has made a request with regard to the addition of air conditioning that is considered to meet the standards
5.	There is a delay in the reporting of empty stocks	Pharmacy warehouse staff socialize, check and remind again of late reports if there are empty drugs

Discussions with R1 and R2, projections are carried out in a comprehensive manner. With the conditions experienced by PJHO in 2016 earthquake, inventory planning for 18 months each year is considered the most effective up to the 2023 fiscal year. Improving the resilience of medical logistics in earthquake disasters is crucial for efficient post-earthquake medical response. Disaster management may be feasible with new technologies based on the challenges identified. The study discovered that, due to a shortage of specialist nursing personnel in disaster- affected, undeveloped regions, the most essential strategy to deliver health care to large populations is to design effective health services that everyone can access equitably and fairly. The study (Sahebi et al., 2022) findings indicate that the average score for the feasibility of using telenursing in catastrophes is high. Thus, the quality of telenursing services under simulation settings is acceptable. Awareness of officers (Sahebi et al., 2022) skill levels is the first step in increasing their preparation as the most important members of the disaster health team. Disaster-related training is very important in the creation of educational policies in disaster nursing education. In addition to their ability to manage medicine warehouses, medical personnel involved in disaster response must be screened for mental health disorders before and after the disaster, as well as receive training in stress management, psychological resilience, and how to express feelings and emotions(Kaviani et al., 2022; Nejadshafiee et al., 2022). Various studies have proposed methods to enhance resilience, such as optimizing ambulance diversion between hospitals(Chen et al., 2022; Liang et al., 2023), designing seismic control devices for medical facilities(Wu & Chen, 2023), and assessing interdependent healthcare transportation systems for effective emergency response(Pei et al., 2022). A resilient system can significantly reduce recovery time and improve patient care by ensuring the availability of essential medical supplies and efficient resource allocation.

Explicitly considering the potential transferability of lessons learned from the Pidie Jaya case study to other disaster contexts can provide highly relevant and effective benefits. This can expand the impact of the research, enable organizations and governments to adopt proven effective practices, and drive collaboration and knowledge exchange among the disaster response community. By demonstrating how learnings from one context can be applied elsewhere, this research can become more relevant to policymakers and practitioners across various regions. Moreover, identifying

transferable lessons can help to enhance preparedness and response capabilities for diverse types of disasters, as well as avoid repeating the same mistakes at other disaster sites. Overall, a more explicit examination of transferability can increase the impact, relevance, and utility of this research, and support efforts to improve disaster preparedness and response effectiveness across various contexts.

5. Conclusion

This qualitative case study offers valuable insights into the medical logistics management practices and challenges in the aftermath of the 2016 Pidie Jaya earthquake in Indonesia. The findings highlight the importance of comprehensive disaster-specific medical logistics planning, particularly for large-scale events like earthquakes. While standard operating procedures are followed for routine medical logistics management, there is a need for more targeted planning and preparedness measures to ensure the timely and effective delivery of medical supplies and services in disaster situations. The study contributes to the limited literature on medical logistics optimization in disaster response in developing country contexts and provides practical recommendations for policymakers and practitioners. These include the development of disaster-specific medical logistics protocols, the strengthening of coordination and communication mechanisms between key stakeholders, and investment in infrastructure and capacity building for medical logistics management. However, the study has several limitations that should be acknowledged. The single case study design and reliance on qualitative methods limit the generalizability of the findings to other disaster contexts. The small sample size and potential biases introduced by the sampling strategy and data collection methods may also affect the validity and reliability of the results. Future research should build on the findings of this study by exploring the applicability of the identified lessons to other disaster contexts and employing mixed-methods approaches to enhance the generalizability and validity of the findings. More comparative studies are needed to examine the medical logistics management practices and challenges across different disaster types and geographical settings. In conclusion, this study provides a valuable starting point for understanding the complex challenges and opportunities for optimizing medical logistics in disaster response in developing country contexts. While there are limitations to the study design and methods, the findings offer important insights and recommendations that can inform future research and practice in this critical area of disaster management.

6. Research Limitations and Future Research Agenda

The research on optimizing medical logistics in disaster response, focused on the Pidie Jaya earthquake in Indonesia, has certain limitations. These include a limited sample size, a constrained research timeframe, data availability constraints, and resource limitations. To overcome these limitations, future research should consider conducting comparative studies across different disaster contexts, explore the potential of emerging technologies, develop decision support systems, examine stakeholder collaboration, and conduct evaluation and impact assessments. By addressing these limitations and pursuing the suggested future research agenda, a more comprehensive understanding of optimizing medical logistics in disaster response can be achieved, leading to more effective and efficient healthcare delivery during times of crisis.

Reference

AbdelAziz, N. M., Eldrandaly, K. A., Al-Saeed, S., Gamal, A., & Abdel-Basset, M. (2024). Application of GIS and IoT Technology based MCDM for Disaster Risk Management: Methods and Case Study.

Decision Making: Applications in Management and Engineering, *7*(1), 1–36. https://doi.org/10.31181/DMAME712024929

Agung, R., & Indrajaya, A. (2020). Penentuan Nilai Percepatan Tanah Maksimum Terhadap Mitigasi Gempabumi Kabupaten Pidie Jaya, Provinsi Aceh. *Jurnal Geografi : Media Informasi Pengembangan Dan Profesi Kegeografian*, *17*(1), 23–26. https://doi.org/10.15294/JG.V17I1.22372

Alem, D., Clark, A., & Moreno, A. (2016). Stochastic network models for logistics planning in disaster relief. *Eur J Oper Res*, *255*(1), 187–206. https://doi.org/10.1016/j.ejor.2016.04.041

Amien, I., Redjekiningrum, P., Kartiwa, B., & Estiningtyas, W. (1999). Simulated rice yields as affected by interannual climate variability and possible climate change in Java. *Climate Research*, *12*(2-3 SPEC. ISS. 6), 145–152. https://doi.org/10.3354/CR012145

Ampuh Hadiguna, R., & Agus Wibowo, D. (2012). Simulasi Sistim Logistik Bantuan Bencana Gempa–Tsunami: Studi Kasus di Kota Padang. *Jurnal Teknik Industri*, *13*(2), 116–125. https://doi.org/10.22219/JTIUMM.VOL13.NO2.116-125

Apriyadi, R. K., Kurniawan, W., Yulianto, S., Syamsunasir, S., Widana, I. D. K. K., Subiyanto, A., Bahar, F., & Kuncoro, D. C. (2022). Estimasi Ancaman Gempabumi dan Tsunami di Kabupaten Pidie Jaya Aceh untuk Mendukung Keamanan Nasional. *PENDIPA Journal of Science Education*, *6*(1), 1–7. https://doi.org/10.33369/PENDIPA.6.1.1-7

Badrul, M. (2015). *Penggunaan data gempa dan data geologi untuk menganalisa pola-pola sesar di daratan Pulau Sumatra*.

Banyunegoro, V. H., Alatas, Z. A., Jihad, A., Eridawati, & Muksin, U. (2019). Probabilistic Seismic Hazard Analysis for Aceh Region. *IOP Conference Series: Earth and Environmental Science*, *273*(1), 012015. https://doi.org/10.1088/1755-1315/273/1/012015

Bastos, M. A. G., Campos, V. B. G., & Bandeira, R. A. de M. (2014). Logistic Processes in a Post-disaster Relief Operation. *Procedia - Social and Behavioral Sciences*, *111*, 1175–1184. https://doi.org/10.1016/J.SBSPRO.2014.01.152

Briggs, R. W., Sieh, K., Meltzner, A. J., Natawidjaja, D., Galetzka, J., Suwargadi, B., Hsu, Y. J., Simons, M., Hananto, N., Suprihanto, I., Prayudi, D., Avouac, J. P., Prawirodirdjo, L., & Bock, Y. (2006). Deformation and slip along the Sunda megathrust in the great 2005 Nias-Simeulue earthquake. *Science*, *311*(5769), 1897–1901. https://doi.org/10.1126/SCIENCE.1122602

Chen, W., Wu, M., Zhang, L., & Gardoni, P. (2022). Multi-objective optimization for enhancing hospital network resilience under earthquakes. *International Journal of Disaster Risk Reduction*, *82*, 103281–103281. https://doi.org/10.1016/J.IJDRR.2022.103281

Cherry, R. A., & Trainer, M. (2008). The current crisis in emergency care and the impact on disaster preparedness. *BMC Emergency Medicine*, *8*(1), 1–7. https://doi.org/10.1186/1471-227X-8-7/FIGURES/2

Cummins, P. R. (2017). Geohazards in Indonesia: Earth science for disaster risk reduction - introduction. *Geological Society Special Publication*, *441*(1), 1–7. https://doi.org/10.1144/SP441.11/ASSET/BB605A5E-2681-4C15-8CCA-C6B3F62BDF1D/ASSETS/GRAPHIC/SP441-1992F02.JPEG

Davis-Reddy, C., & Hilgart, A. (2021). Toward an Interoperable National Hazards Events Database for South Africa. *Frontiers in Climate*, *3*(March), 1–9. https://doi.org/10.3389/fclim.2021.591020

Djalante, R., & Garschagen, M. (2017a). *A Review of Disaster Trend and Disaster Risk Governance in Indonesia: 1900–2015*. 21–56. https://doi.org/10.1007/978-3-319-54466-3_2

Djalante, R., & Garschagen, M. (2017b). *A Review of Disaster Trend and Disaster Risk Governance in Indonesia: 1900–2015*. 21–56. https://doi.org/10.1007/978-3-319-54466-3_2/COVER

Djalante, R., Garschagen, M., Thomalla, F., & Shaw, R. (Eds.). (2017). *Disaster Risk Reduction in Indonesia*. https://doi.org/10.1007/978-3-319-54466-3

Erlangga, W., Teguh, M., Mushthofa, M., Trianggoro Saputro, I., & Setiadi, G. (2022). Sebaran gempa utama berdasarkan magnitudo dan kedalaman di wilayah mamuju dan sekitarnya. *Teknisia: Jurnal Ilmiah Fakultas Teknik Sipil Dan Perencanaan Universitas Islam Indonesia Yogyakarta*, *27*(2), 122–131. https://doi.org/10.20885/TEKNISIA.VOL27.ISS2.ART6

Farhan, A., Nasution, A. I., & Akhyar. (2024). Earthquake disaster map using GIS analysis: a case study of Bener Meriah-Aceh, Indonesia. *Arabian Journal of Geosciences 2024 17:1*, *17*(1), 1–15. https://doi.org/10.1007/S12517-023-11850-Y

Franco, C., & L, E. R. (2018). *A Mathematical Model Under Uncertainty for Optimizing Medicine Logistics in Hospitals*. *1*, 53–60. https://doi.org/10.1007/978-3-030-00353-1

Groenewold, M. R. (2006). Enhancing Local Health Department Disaster Response Capacity with Rapid Community Needs Assessments: Validation of a Computerized Program for Binary Attribute Cluster Sampling. *Prehospital and Disaster Medicine*, *21*(1), 32–39. https://doi.org/10.1017/S1049023X00003290

Harris, R., & Major, J. (2017). Waves of destruction in the East Indies: The Wichmann catalogue of earthquakes and tsunami in the Indonesian region from 1538 to 1877. *Geological Society Special Publication*, *441*(1), 9–46. https://doi.org/10.1144/SP441.2

Hasan, M., Saidi, T., Afifuddin, M., & Setiawan, B. (2023). The assessment and strengthening proposal of building structure after the Pidie Jaya earthquake in December 2016. *Journal of King Saud University - Engineering Sciences*, *35*(1), 12–23. https://doi.org/10.1016/J.JKSUES.2021.02.007

Heryati, S. (2020). PERAN PEMERINTAH DAERAH DALAM PENANGGULANGAN BENCANA. *Jurnal Pemerintahan Dan Keamanan Publik (JP Dan KP)*, 139–146. https://doi.org/10.33701/JPKP.V2I2.1088

Hu, Z. H., & Sheu, J. B. (2013). Post-disaster debris reverse logistics management under psychological cost minimization. *Transportation Research Part B: Methodological*, *55*, 118–141. https://doi.org/10.1016/J.TRB.2013.05.010

Irsyam, M., Cummins, P. R., Asrurifak, M., Faizal, L., Natawidjaja, D. H., Widiyantoro, S., Meilano, I., Triyoso, W., Rudiyanto, A., Hidayati, S., Ridwan, M., Hanifa, N. R., & Syahbana, A. J. (2020). Development of the 2017 national seismic hazard maps of Indonesia. *Https://Doi.Org/10.1177/8755293020951206*, *36*(1_suppl), 112–136. https://doi.org/10.1177/8755293020951206

Irwandi, I., Muksin, U., Asrillah, Simanjuntak, A. V. H., & Asrurifak. (2021). Probabilistic seismic hazard map analysis for Aceh Tenggara district and microzonation for Kutacane city. *IOP Conference Series: Earth and Environmental Science*, *630*(1), 012001. https://doi.org/10.1088/1755-1315/630/1/012001

Jena, R., Pradhan, B., Beydoun, G., Nizamuddin, Ardiansyah, Sofyan, H., & Affan, M. (2020). Integrated model for earthquake risk assessment using neural network and analytic hierarchy process: Aceh province, Indonesia. *Geoscience Frontiers*, *11*(2), 613–634. https://doi.org/10.1016/J.GSF.2019.07.006

Jiang, Y. (2019). *Emergency Logistics in a Large-Scale Disaster Context : Achievements and Challenges*. https://doi.org/10.3390/ijerph16050779

Kaviani, F., Aliakbari, F., Sheikhbardsiri, H., & Arbon, P. (2022). Nursing Students' Competency to Attend Disaster Situations: A Study in Western Iran. *Disaster Medicine and Public Health Preparedness*, *16*(5), 2044–2048. https://doi.org/10.1017/DMP.2021.263

Keim, M. (2021). *Disaster Planning*. Cambridge University Press. https://doi.org/10.1017/9781009004213

Liang, B., Tao, Q., Gao, W., Ren, Q., & Yao, X. (2023). Integrated the Medical Procedure Analyze Seismic Resilience of Healthcare System: A Critical Review from the Resilience of Healthcare System vs. Medical Demand Perspective. *Advances in Civil Engineering*, *2023*, 1–21. https://doi.org/10.1155/2023/4468383

March, A., & Kornakova, M. (2017). *Urban Planning for Disaster Recovery*.

Meltzner, A. J., Sieh, K., Abrams, M., Agnew, D. C., Hudnut, K. W., Avouac, J.-P., Natawidjaja, D. H., Meltzner, C. :, Sieh, K., Abrams, M., Agnew, D. C., Hudnut, K. W., Avouac, J.-P., & Natawidjaja, D. H. (2006). Uplift and subsidence associated with the great Aceh-Andaman earthquake of 2004. *Journal of Geophysical Research: Solid Earth*, *111*(B2), 2407. https://doi.org/10.1029/2005JB003891

Mkoka, D. A., Goicolea, I., Kiwara, A., Mwangu, M., & Hurtig, A. K. (2014). Availability of drugs and medical supplies for emergency obstetric care: Experience of health facility managers in a rural District of Tanzania. *BMC Pregnancy and Childbirth*, *14*(1), 1–10. https://doi.org/10.1186/1471-2393-14-108/TABLES/3

Mulyasari, F., Inoue, S., Prashar, S., Isayama, K., Basu, M., Srivastava, N., & Shaw, R. (2013). Disaster preparedness: Looking through the lens of hospitals in Japan. *International Journal of Disaster Risk Science*, *4*(2), 89–100. https://doi.org/10.1007/S13753-013-0010-1/METRICS

Muzli, M., Muksin, U., Nugraha, A. D., Bradley, K. E., Widiyantoro, S., Erbas, K., Jousset, P., Rohadi, S., Nurdin, I., & Wei, S. (2018). The 2016 Mw 6.5 Pidie Jaya, Aceh, North Sumatra, earthquake: Reactivation of an unidentified sinistral fault in a region of distributed deformation. *Seismological Research Letters*, *89*(5), 1761–1772. https://doi.org/10.1785/0220180068

Nashih Uluwan Arif, L., Ridho Barakbah, A., Sudarsono, A., & Edelani, R. (n.d.). *Big Data Environment for Realtime Earthquake Data Acquisition and Visualization*.

Negi, S., & Negi, G. (2021). Framework to manage humanitarian logistics in disaster relief supply chain management in India. *International Journal of Emergency Services*, *10*(1), 40–76. https://doi.org/10.1108/IJES-02-2020-0005/FULL/XML

Nejadshafiee, M., Nekoei-Moghadam, M., Bahaadinbeigy, K., Khankeh, H., & Sheikhbardsiri, H. (2022). Providing telenursing care for victims: a simulated study for introducing of possibility nursing interventions in disasters. *BMC Medical Informatics and Decision Making*, *22*(1), 1–9. https://doi.org/10.1186/S12911-022-01792-Y/TABLES/2

Nugroho, K. P., & Suryanto, Dr. rer. nat. W. (2011). *Studi Awal Pengaruh Gaya Pasang Surut sebagai Pemicu Gempa Bumi: Studi Kasus Gempa Bumi M.6,4 DI Indonesia antara Tahun 2001-2010*.

Pei, S. S., Zhai, C. H., Wang, Z. Q., Liu, K. Z., & Hu, J. (2022). Resilience assessment of the interdependent transportation–healthcare system during emergency response. *Structure and Infrastructure Engineering*, 1–15. https://doi.org/10.1080/15732479.2022.2136719

Sahebi, A., Golitaleb, M., Moayedi, S., Torres, M., & Sheikhbardsiri, H. (2022). Prevalence of workplace violence against health care workers in hospital and pre-hospital settings: An umbrella review of meta-analyses. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/FPUBH.2022.895818

Saputro, I. T., & Momot, H. (2020). *PEMUTAKHIRAN PETA SEBARAN GEMPA BUMI BERDASARKAN MAGNITUDO DAN KEDALAMAN DI WILAYAH PROVINSI PAPUA BARAT PADA*

50 TAHUN TERAKHIR. https://doi.org/10.24127/TP.V10I1.1315

Sasaki, D., Moriyama, K., & Ono, Y. (2018). Hiddencommonfactorsindisaster loss statistics: A case study analyzing the data of Nepal. *Journal of Disaster Research*, *13*(6), 1032–1038. https://doi.org/10.20965/jdr.2018.p1032

Sheu, J. B. (2014). Post-disaster relief–service centralized logistics distribution with survivor resilience maximization. *Transportation Research Part B: Methodological*, *68*, 288–314. https://doi.org/10.1016/J.TRB.2014.06.016

Sufri, S., Dwirahmadi, F., Phung, D., & Rutherford, S. (2020). Progress in the early warning system in Aceh province, Indonesia since the 2004 earthquake-tsunami. *Environmental Hazards*, *19*(5), 463–487. https://doi.org/10.1080/17477891.2019.1653816

Suhu, B. La, Ibrahim, A. H., Jafar, A., & Wance, M. (2023). Kinerja Pegawai dalam Pelayanan Logistik Pasca Bencana Pada Kantor BPPD Kabupaten Halmahera Selatan. *Journal of Government Science Studies*, *2*(2), 110–123. https://doi.org/10.30598/JGSSVOL2ISSUE2PAGE110-123

Tavana, M., Abtahi, A. R., Di Caprio, D., Hashemi, R., & Yousefi-Zenouz, R. (2018). An integrated location-inventory-routing humanitarian supply chain network with pre- and post-disaster management considerations. *Socio-Economic Planning Sciences*, *64*, 21–37. https://doi.org/10.1016/J.SEPS.2017.12.004

Thomas, D. S. K. (2018). The Role of Geographic Information Science & Technology in Disaster Management. *Handbooks of Sociology and Social Research*, 311–330. https://doi.org/10.1007/978-3-319-63254-4_16

Tingkat, K., Sosial, K., Masyarakat, T., Bencana, T., Kecamatan, D., Pasca, T., Bumi, G., Jaya, P., Maulidin, R., Indra, I., & Abubakar, Y. (2022). Kajian Tingkat Kerentanan Sosial Terhadap Masyarakat Terdampak Bencana di Kecamatan Trienggadeng Pasca Gempa Bumi Pidie Jaya 2016. *JIPI (Jurnal IPA Dan Pembelajaran IPA)*, *6*(4), 341–355. https://doi.org/10.24815/jipi.v6i4.28353

Tjipto Prastowo, G. P. A. H. R. (2022). *Magnitude-rupture area scaling derived from global earthquakes of moderate to large sizes: Implications for seismic hazards in Indonesia*.

Torani, S., Majd, P., Maroufi, S., Dowlati, M., & Sheikhi, R. (2019). The importance of education on disasters and emergencies: A review article. *Journal of Education and Health Promotion*, *8*(1). https://doi.org/10.4103/JEHP.JEHP_262_18

Wally, I., Wattimanela, H. J., & Lesnussa, Y. A. (2023). Analysis of earthquake activity level in several districts in the Province of Aceh with using the Guttenberg-Richter method approach. *Nucleation and Atmospheric Aerosols*, *2588*. https://doi.org/10.1063/5.0112463

Wang, J., Yuan, B., Li, Z., & Wang, Z. (2019). Evaluation of public health emergency management in China: A systematic review. *International Journal of Environmental Research and Public Health*, *16*(18). https://doi.org/10.3390/IJERPH16183478

WHO. (2021). Classification and minimum standards for emergency medical teams. *World Health Organization*, 148. http://apps.who.int/bookorders.

Wiryanto, W., Tanjung, H., & Rumonda, R. (2019). Implementation of Standards for Managing Pharmaceutical, Medical Devices and Disposable Medical Materials in Community Pharmacy in Medan City. *Open Access Macedonian Journal of Medical Sciences*, *7*(22), 3769. https://doi.org/10.3889/OAMJMS.2019.532

Wu, Y., & Chen, S. (2023). Traffic resilience modeling for post-earthquake emergency medical response and planning considering disrupted infrastructure and dislocated residents. *International Journal of Disaster Risk Reduction*, *93*, 103754–103754.

https://doi.org/10.1016/J.IJDRR.2023.103754

Yan, Y., Di, X., & Zhang, Y. (2023). Optimization-driven distribution of relief materials in emergency disasters. *Complex and Intelligent Systems*, *9*(3), 2249–2256. https://doi.org/10.1007/S40747-021-00290-4/TABLES/3

Younger, J. S. (2019). Factors, Including Disasters, Affecting Sustainable Development-Focus on Indonesia. *ICSECC 2019 - International Conference on Sustainable Engineering and Creative Computing: New Idea, New Innovation, Proceedings*, 1–8. https://doi.org/10.1109/ICSECC.2019.8907189

Zheng, J., Bao, F., Shen, Z., & Xu, C. (2022). Data-Driven Dynamic Adjustment and Optimization Model of Emergency Logistics Network in Public Health. *Risk Management and Healthcare Policy*, *15*, 151. https://doi.org/10.2147/RMHP.S350275

Zuccaro, G., Leone, M. F., & Martucci, C. (2020). Future research and innovation priorities in the field of natural hazards, disaster risk reduction, disaster risk management and climate change adaptation: a shared vision from the ESPREssO project. *International Journal of Disaster Risk Reduction*, *51*. https://doi.org/10.1016/J.IJDRR.2020.101783