

# **Humanitarian Supply Chain Management Challenges in COVID-19 Vaccine Distribution: A Study Case From Bandung Indonesia**

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## **Abstract**

COVID-19 significantly impacted health, economic, social, and industrial activities. This condition requires a practical solution, namely vaccination. Every geographical area has its challenge in administering the vaccine to the population. This study presents a lesson learned from a major city in Indonesia: Bandung. We aim to analyze what critical challenges need to be managed in the humanitarian supply chain management process to distribute the vaccine in Bandung City. We used the analytical hierarchy process method with experts from the health center, law enforcement, and COVID-19 vaccination officials. The study shows that the most critical challenge comes from social, environmental, and technical criteria. Further validation is carried out from the general public's perspective using questionnaires.

## **Keywords**

Humanitarian Supply Chain Management, Vaccine, Distribution, COVID-19, Analytical Hierarchy Process

## **1. Introduction**

By the end of 2022, the COVID-19 pandemic has infected 666 million people, with total deaths of 6.6 million worldwide (WHO 2022). Indonesia has reported 6,73 million infections and 161 thousand deaths, with Jakarta, as the capital city, contributing the highest number of infections and deaths (Indonesia 2022). Bandung, a metropolitan city in Indonesia, with a population of only a quarter compared to Jakarta, contributed the second highest number of infections and deaths. In January 2023, the city of Bandung confirmed 112,270 cases and 1,485 death concerning COVID-19 (Bandung 2022). Figure 1 shows the number of instances in Bandung from 2020-2022. The pandemic has primarily impacted Bandung's health, economy, social, and industrial sectors (Bandung 2022). In this situation, the supply chain management of every humanitarian aid becomes critical in providing the goods timely, in the right amount, and to the right target. Therefore, the humanitarian supply chain management in managing the aids is needed during and after the pandemic.

The vaccine is the key to surviving the COVID-19 pandemic (Fontanet and Cauchemez 2021). The first vaccine was approved in December 2020, and other vaccines have been developed and administered since then. To resist infection, a population must distribute at least 80% of the vaccine to the people. On the other hand, supplying vaccines becomes complex as humanitarian factors are also involved. The chain from the manufacturer to the customer continues even when the vaccines arrive at the customer side and how the government administers vaccines to the people (Alam, et al. 2021).

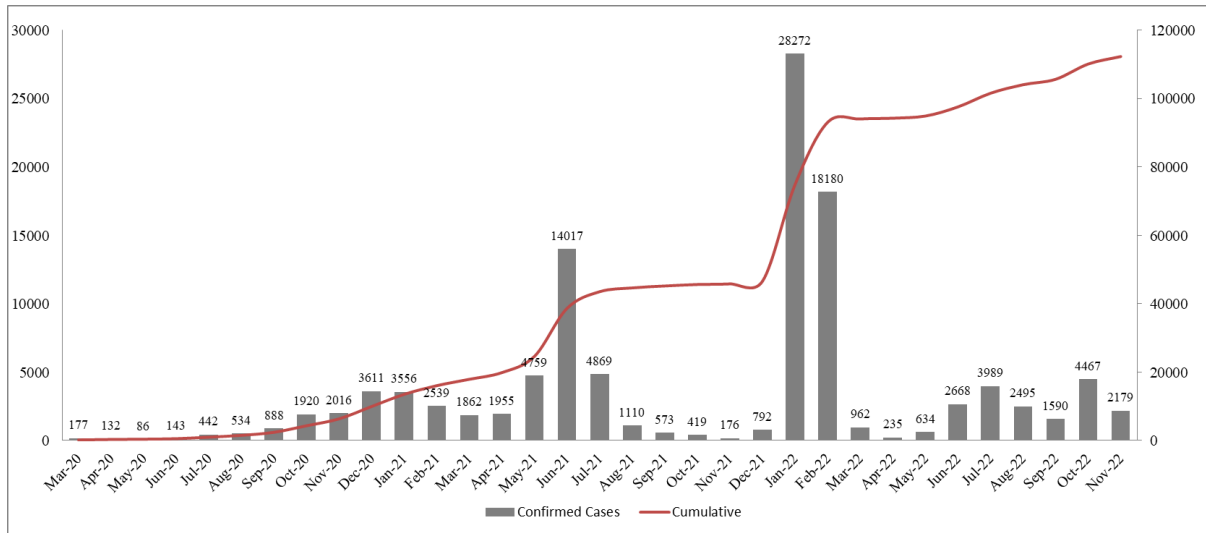


Figure 1. Confirmed COVID-19 Cases in Bandung

Bandung is a metropolitan city with great access to the capital and main ports. The focus of humanitarian logistics in Bandung is basic groceries, relief funds for personal and small business businesses, employee subsidies, and vaccine administration. Vaccine procurement and distribution should be relatively straightforward, however, in 2022 the vaccination administration rate is considered low and under the target. Figure 2 shows the vaccine administration achievement in early 2023, where only 93% received the first and 86% received the second dose of vaccine. The third dose has only achieved 46.53% of the general citizen and 9% of teenagers. Based on data availability and importance, in this study we will focus on the vaccine distribution in within 2021-2022.

This research intends to analyze the main challenges of COVID-19 vaccine distribution and administration in Bandung, Indonesia. This research is essential as scientists predicted that more similar disasters would come. Therefore, every country and culture must learn how to defend itself from disasters. Moreover, the study and method are extendable to other regions or countries with similar characteristics.

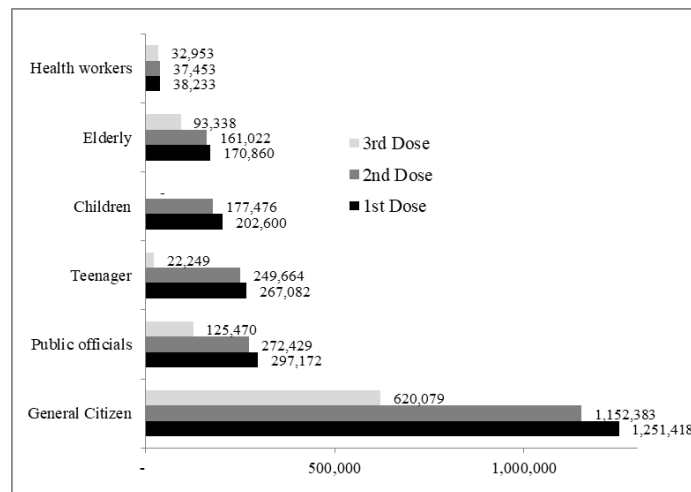


Figure 2. Cumulative Vaccine Administration in Bandung December 2022

## **1.1 Objectives**

There are two main objectives of this research. First, this research intends to identify the critical challenges in distributing and administering the COVID-19 vaccine by selecting several criteria in Bandung, Indonesia. Second, as the result serves as feedbacks, we can formulate a lesson learned and strategic suggestion for society, mainly in big cities, to protect the population from the same situation.

The organization of this paper is as follows. Section 2 serves as the literature review on the humanitarian supply chain management, vaccine distribution, and the analytical hierarchy process as the qualitative evaluation method to identify the critical challenge. Next, we present the methods and data collection in sections 3 and 4. The result and identified main challenges will be elaborated in section 5, along with the conclusion in section 6.

## **2. Literature Review**

The COVID-19 pandemic can be categorized as a disaster, as the United Nations International Strategy for Disaster Reduction (UNISDR) defines a disaster as a severe disruption of the functioning of a community involving human, material, and economic losses which exceeds the ability of the affected community to cope using its resources (UNISDR 2022). Humanitarian supply chain management (HSCM) is critical in handling disasters (Tomasini, and Van Wassenhove 2009). HSCM's primary role is coordinating all components of goods and services to the victim, including food, logistics, medical equipment, and service (Abidi et.al. 2014). Since the COVID-19 pandemic happened, the distribution chain has been interrupted as countries closed their borders and people became victims of the pandemic. The HSCM plays a critical role in managing these disruptions, as it is not only addressing the logistical problem but also the coordination between supply chain actors

There are three successive stages in the HSCM (Cozzolino 2010):

- The response phase is right after the disaster.
- The recovery phase after the disaster.
- The preparedness phase to prevent the next disaster.

The vaccine distribution is categorized as the last stage, the preparedness phase, which includes collaboration, coordination, resource planning, and knowledge management.

Several qualitative studies on vaccine distribution have been identified in the literature. According to a study in India, vaccine distribution has five main challenges: organizational, social, technical, environmental, and availability (Karuppiyah et al. 2021). Sharma et al. (2020) used the step-by-step weight ratio analysis method to analyze significant factors influencing aid management during the Covid-19 pandemic in the Indian context. Sahebi et al. (2017) used the best-worst fuzzy method to analyze obstacles to sustainable humanitarian supply chain management. Agarwal (2020) uses a combination of the Fuzzy Stepwise Weight Assessment Ratio Analysis and the Fuzzy Weighted Aggregated Sum Product Assessment to analyze barriers in sustainable humanitarian supply chain management. Koppiyahraj Karuppiyah et al. (2021) use a combination of the Analytic Hierarchical Process to examine challenges in humanitarian supply chain management and select the best strategy for this activity.

## **3. Methods**

In this research, we use the analytical hierarchical process (Saaty1994) to find the main challenges of vaccine distribution and administration in Bandung. The method sorts criteria for the best aggregate decision based on the pair-wise comparison matrices as data. Furthermore, it is relatively easy to use even with an extensive data set.

This study aims to find the main challenging criteria among many possible measures. The initial criteria and sub-criteria are adopted from the literature (KaruppiyahV 2021). Second, we performed interviews and group discussions with 28 experts from the health center, law enforcement, and COVID-19 vaccination officials to validate the criteria. Third, we calculate the weights of each criterion and sub-criteria. After the experts validated all criteria, we asked them to fill in the pair-wise comparison for each sub-criteria. Fourth, we analyzed the consistency ratio to ensure the experts' answers were reliable. Finally, we analyze the main challenge with the AHP. Finally, we analyze the main challenge with the AHP.

There are five acknowledged criteria in vaccine distribution: organizational, social, technical, environmental, and availability.

- Organizational

There are multiple organizations involved in vaccine distribution. Figure 3 shows the distribution actors. However, information misalignment should be improved in establishing coordination among members of the supply chain network. Also, in the event of a pandemic, there may be a need for more organizations and agencies that can handle vaccination efficiently. Furthermore, the lack of warehouses and inadequate capabilities of health facilities may hinder the flow of vaccine movement.

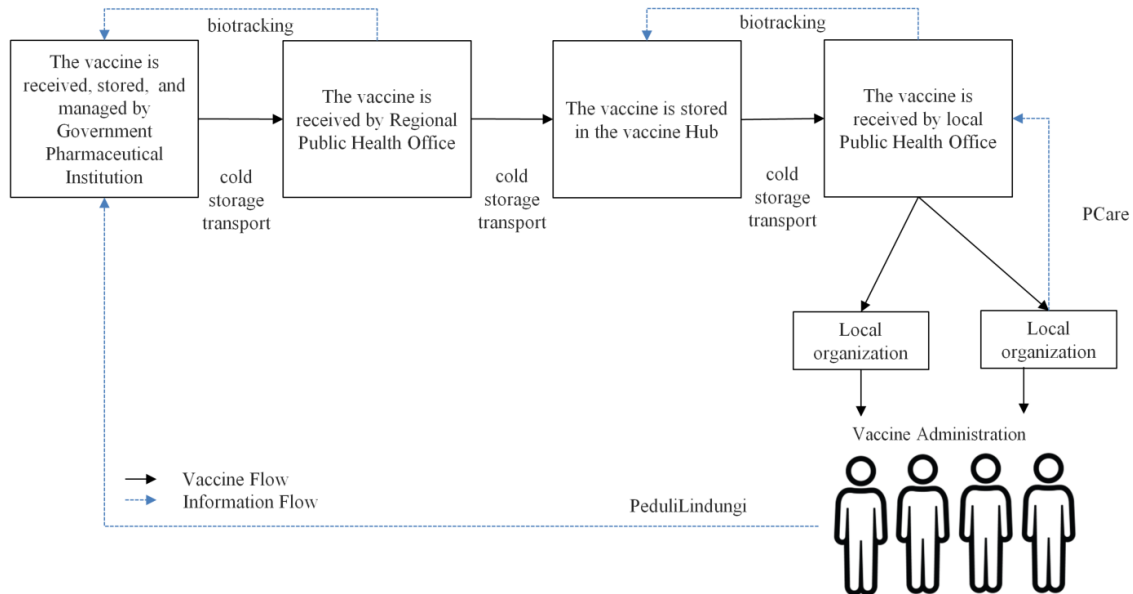


Figure 3. COVID-19 Distribution Flow

- Social**

Everyone in the population is affected by the pandemic, so every society needs to evaluate its social aspects. Also, as there is no pre-knowledge about the pandemic, the lack of public knowledge about the importance of vaccines as an intervention for the transmission of the COVID-19 virus has raised concerns about vaccines, thus preventing people from getting vaccinated. The local conditions of a region or country affect the efficiency of the supply chain network, especially in the case of the Covid-19 vaccine. Lastly, misleading information or wrong campaigns about the vaccine's side effect may cause panic among the public.
- Technical**

The vaccine supply chain incorporates manufacturing, storage, distribution, and a complex information system. The increase in demand adds to the pressure on the manufacturing unit, requiring a long waiting time in the vaccine supply process. The insufficient number of seaports, roads, and airports limits the import and distribution of relief materials. Apart from that, there are several obstacles to transportation flow, namely congestion, and restrictions on mobilization. Differences in data information occur due to system damage (errors) and information misalignment in digital applications supporting vaccination, namely *PCare* and *PeduliLindungi*.
- Environmental**

In developing countries, communities have limitations in finding information with the digitalization implemented, especially the elderly. In addition, differences in language, culture, and community character are obstacles to vaccine distribution and implementation. Another problem comes from the difficulty in calculating the exact number of the affected population due to the large number of new cases that have appeared. Also, the emergence of new clusters quickly creates new vaccine demand and makes it difficult to distribute the vaccine.
- Availability**

Availability challenge comes in many forms. The availability of the actors involved, such as medical personnel involved in the vaccination process, can be one of the obstacles. The availability of the vaccination tools that is caused by the shortage or damage to vaccine tools such as syringes, cold storage/storage tools) can hinder the

implementation of vaccination. The imbalance between the number of vaccines and the population can also challenge vaccine distribution.

#### 4. Data Collection

The data was collected from two interview sessions and forum group discussions with 28 experts consisting of 10 government health officials, ten public health center officials, one law enforcement representative, 5 district officials, and two pharmaceutical officials.

The first interview session was to analyze the main challenges of COVID-19 vaccine distribution and validate those challenges. We adopted the main challenges from literature as our main criteria. Once those criteria are validated, the experts will give their judgment in the form of a pairwise comparison table for our analysis. Therefore, the second session was intended for the experts to fill in the pairwise comparison on the selected criteria. Table 1 is the result of the selected criteria and sub-criteria to decide the main challenges in vaccine distribution and administration.

Table 1. Selected Criteria and Sub-Criteria of Vaccine Distribution and Administration

Criteria	Validated Sub-criteria
<i>Organizational</i>	Lack of organizational coordination
	Lack of organizations and agencies as vaccination providers
	Facility location problem
<i>Social</i>	Lack of vaccine awareness in society
	The influence of social conditions, culture, and customs
	Rumor spreading/false knowledge
<i>Technical</i>	Long waiting times for vaccine supplies
	Inadequate transport infrastructure
	Information and data fallacy from the digital application provider side (PCare, PeduliLindungi)
<i>Environmental</i>	The inability to access information digitally
	Communication barriers regarding understanding the importance of vaccination
	Uncertainty in demand for vaccines
	The appearance of new COVID-19 clusters
<i>Availability</i>	Lack of medical personnel involved
	Lack of availability of vaccine tools (syringe, cold storage/storage equipment)
	Lack of vaccine availability

Table 2 shows the example of a pair-wise comparison between sub-criteria in the first criterion, organizational. The notation S1 represents the first sub-criteria, “lack of organizational coordination,” S2 represents the second sub-criteria, “lack of organizations and agencies as vaccination providers,” and S3 represents the third sub-criteria, “facility location problem.” The experts answered one if both sub-criteria is equally important, while nine is if one criterion is highly more important than the other.

Table 2. Example of Pair-wise Comparison Between Criteria 1 Sub-Criteria S1, S2, S3 from Expert #1-Expert #9

<b>Expert 1</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>Expert 2</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>Expert 3</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>
<b>S1</b>	1	5	3	<b>S1</b>	1	6	3	<b>S1</b>	1	5	4
<b>S2</b>	0.200	1	1	<b>S2</b>	0.167	1	2	<b>S2</b>	0.200	1	2
<b>S3</b>	0.333	1	1	<b>S3</b>	0.333	0.500	1	<b>S3</b>	0.250	0.500	1
<b>Expert 4</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>Expert 5</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>Expert 6</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>
<b>S1</b>	1	2	1	<b>S1</b>	1	4	1	<b>S1</b>	1	4	5
<b>S2</b>	1	1	1	<b>S2</b>	1	1	2	<b>S2</b>	0.250	1	2
<b>S3</b>	1	1	1	<b>S3</b>	1	0.500	1	<b>S3</b>	0.200	0.500	1
<b>Expert 7</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>Expert 8</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>Expert 9</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>

S1	1	2	1	S1	1	4	6	S1	1	6	1
S2	1	1	1	S2	0.250	1	1	S2	0.167	1	2
S3	1	1	1	S3	0.167	1	1	S3	1	0.500	1

## 5. Results and Discussion

We presented the result of our calculation in Table 3. The sub-criteria with the highest weight is **spreading rumors/false knowledge**, with a weight of 12.02%, and the second sub-criteria with the most weight is the **lack of awareness in society**, with a weight of 10.14%. These two sub-criteria are critical challenges that arise in the main criterion, namely social, where this is due to the formation of trust in the community towards information that cannot be proven factually and the lack of public will in responding to the importance of vaccines as an intervention in the transmission of the Covid-19 virus which in turn will eventually cause concern in the population. Furthermore, the third sub-criteria with the highest weight is the **lack of involved medical personnel**, with a weight of 7.34%, which proves that the limited number of medical personnel involved in implementing and taking vaccines can hinder vaccine achievements in the city of Bandung. The fourth sub-criteria, which is a critical challenge in the vaccine supply chain with a weight value of 7.33%, is **information and data errors from the side of digital application providers (PCare, PeduliLindungi)**, which proves that there are still frequent errors regarding the input of public data information using the PCare digital application and CareProtect. Furthermore, the **lack of vaccine availability** is the last sub-criteria, which is a critical challenge with a weight of 6.88%. The value proves an imbalance between the number of vaccines available and vaccine recipients based on the target recipient's vaccine needs.

Table 3. Global Priority on Main Challenges of Vaccine Distribution

Global Priority	Sub-criteria	Weight	Criteria
1	Rumor spreading/false knowledge	0.120	Social
2	Lack of vaccine awareness in society	0.101	Social
3	Lack of medical personnel involved	0.0734	Availability
4	Information and data fallacy from the digital application provider side (PCare, PeduliLindungi)	0.0733	Technical
5	Lack of vaccine availability	0.069	Availability
6	Facility location problem	0.061	Organizational
7	Lack of organizational coordination	0.060	Organizational
8	The inability to access information digitally	0.060	Environmental
9	Lack of availability of vaccine tools (syringe, cold storage/storage equipment)	0.059	Availability
10	Long waiting times for vaccine supplies	0.058	Technical
11	The influence of social conditions, culture, and customs	0.056	Social
12	Communication barriers regarding understanding the importance of vaccination	0.051	Environmental
13	Lack of organizations and agencies as vaccination providers	0.048	Organizational
14	Inadequate transport infrastructure	0.042	Technical
15	The appearance of new COVID-19 clusters	0.038	Environmental
16	Uncertainty in demand for vaccines	0.031	Environmental

As the two highest criteria come from social factors, the main challenges of vaccine administration in Bandung are social. This result encourages the government to take further actions in handling social problems such as rumor spreading and the lack of awareness in society. Possible ways to address these issues are through targeted education and awareness campaigns. These campaigns can be designed to provide accurate information about the safety and efficacy of vaccines, as well as address common misconceptions and concerns. Also, being a country with a religious foundation and strong community bonds, community leaders, religious figures, and local organizations can be engaged to help promote vaccination and build trust within their communities. Another critical strategy could be to increase the accessibility and convenience of vaccination, such as by setting up mobile vaccination clinics in underserved areas or providing transportation assistance for those who have difficulty getting to a vaccination site. By addressing these social challenges, the government can help increase vaccination rates and protect the community's health.

Furthermore, to ensure the above analysis's result, we surveyed Bandung's citizens to verify the main challenges. Six main questions were designed to ask the following questions and answers.

- (1) Which of the five main criteria significantly impacts vaccine distribution and administration?  
In summary, 55% of the respondents selected “social” as the main challenge, and 15 selected technical as the main challenge.
- (2) Which among the three sub-criteria of the first criteria has the most significant impact on vaccine distribution and administration?  
In summary, 50% of the respondents selected “the lack of organizational coordination” as the main challenge, and 32.5% “the lack of organizations and agencies as vaccination providers” as the main challenges.
- (3) Which among the three sub-criteria of the second criterion has the most significant impact on vaccine distribution and administration?  
In summary, 48 % of the respondents selected “rumor spreading/false knowledge” as the main challenge, and 37% chose “the lack of vaccine awareness in society” as the main challenge.
- (4) Which among the three sub-criteria of the third criteria has the most significant impact on vaccine distribution and administration?  
In summary, 43 % of the respondents selected “information and data fallacy from the digital application provider side” as the main challenges, and 40% chose the “long waiting times for vaccine supplies” as the main challenges.
- (5) Which among the four sub-criteria of the fourth criteria has the most significant impact on vaccine distribution and administration?  
In summary, 48 % of the respondents selected “communication barriers regarding understanding the importance of vaccination” as the main challenge, and 30% chose the “inability to access information digitally” as the main challenge.
- (6) Which among the three sub-criteria of the fifth criteria has the most significant impact on vaccine distribution and administration?  
In summary, 55 % of the respondents selected “the lack of vaccine availability” as the main challenge, and 23% chose “the lack of availability of vaccine tools” as the main challenge.

## **6. Conclusion**

In this study, we have identified the main challenges of COVID-19 in Bandung, Indonesia. The five main criteria are organizational, social, technical, environmental, and availability. The expert analysis and confirmation survey re-confirmed our conclusion that the main challenges of COVID-19 vaccine distribution and administration are the rumor spreading/false knowledge, the lack of vaccine awareness in society, and the lack of medical personnel involved. We can also conclude that the humanitarian supply chain context in the case of vaccine administration needs more attention as the social aspect is part of the supply and demand. This study can be extended to other cities of countries to find the main challenges in COVID-19 vaccine distribution and administration.

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## **Biographies**

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