The Effectiveness of Covid-19 Vaccine Supply Chain in Indonesia and Hungary

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Abstract

The Covid-19 pandemic has brought the importance of the supply chain of vaccines from the movement restrictions that have been imposed everywhere. Vaccination is simply one step in the fight against Covid-19. The procurement of the Covid-19 vaccine is a critical step in promoting herd immunity and reducing viral transmission. The implementation of any immunization program is seen as a problematic element as it depends on the vaccine supply chain. To achieve a specific percentage of the population vaccinated according to the vaccination program, it requires the timeliness of the vaccines delivered, since it has become a race for public health and economic recovery. As a result, prior to vaccinating the population, governments should establish a countrywide distribution plan based on careful observation of numerous factors to ensure the success and efficiency of the vaccination campaign, therefore, securing the distribution channel is a crucial step towards a successful vaccination program. This article compares the vaccine supply chain in Indonesia and Hungary. Needless to say, that both countries are not comparable in size, population, GDP, and many other aspects. However, the comparison is limited only on the supply chain mechanism to see its effectiveness. It is expected that the distribution of the vaccine in Hungary is simpler than Indonesia. This article is essentially about explanatory research, taking sources from existing literature and databases. The expected results explain the success and barrier factors affecting the streamlined distribution of COVID-19 vaccines in Indonesia and Hungary, and what we can learn from examples of these two countries.

Keywords
Covid-19, vaccine supply chain, effectiveness, Indonesia, Hungary.

1. Introduction
COVID-19 is the official name for the coronavirus disease 2019. It is caused by the SARS-CoV-2 coronavirus, which had not previously been identified in humans. More than 200 million cases have been confirmed worldwide, and the disease has claimed around 4.3 million lives. The pandemic continues to put health systems under severe strain, but regulators have approved safe treatments, and countries have launched their vaccination programs. The disease, which was found in Wuhan, China, in December 2019, has caused several cases of Viral Pneumonia of Unknown Etiology (VPUE). The source of the disease might have come from patients who have been working in the Huanan Seafood Wholesale Market, a place famous as a selling hub of animals (Ali et al., 2020). On March 11, 2020, WHO declared this type of disease called COVID-19 as a pandemic (Ducharme, 2020). Pandemic is a term for the global disease situation. The virus that has been spread over the world possesses high attack rates and explosiveness, high severity,

high infectiousness, and novel (Morens et al. 2009). One of the ways to prevent the outbreak is through vaccination programs. Vaccines work to reduce illness and hospitalizations among the target populations, simultaneously reducing transmission from those immunized to other groups (Schuchat 2011).

Vaccination and immunization are two vital activities required to prevent the spread of viruses. The challenges faced by distributing these COVID-19 vaccines include capacity, packaging, and security. Delivering vaccines requires enough capacity to maintain just in the time supply chain to minimize the need for local storage. Packaging involves more than ten suppliers to complete the readiness of increasing demand. If one of the suppliers lacks its product, it will affect the production process of vaccines. Security is important to prevent theft or tampering of the vaccines at every touchpoint (Hart 2021).

1.1 Objectives

In this article, the authors would like to observe the different supply chain mechanisms of vaccines between Hungary and Indonesia. The two countries cannot be comparable in several aspects such as size, population, GDP, infrastructure, technology, supply chain, and other aspects. By area, Hungary has 93,030 km2, and Indonesia has 1,904,569 km2. By population, Hungary has approximately 10 million citizens, and Indonesia has 272 million citizens. In addition, Hungary's GDP per capita is nearly three times higher than in Indonesia in 2020 (The World Bank, 2020). Geographically, Indonesia is an archipelago country. Governing the islands is a challenge with the intervening presence of the sea, thus creating coordination and communication issues (Cribb and Ford 2009) that affect the supply chain. Meanwhile, Hungary as a landlocked country has its own challenges. Despite technological developments, it continues to have structural challenges in accessing world markets (Faye et al. 2007). As a result, the different geographical features influence the behavior in terms of the logistic distribution. These considerations will give different theoretical impacts in the analysis.

Table 1 provides the latest data summarizing the vaccination progress for Indonesia and Hungary until December 2021. In this case, Hungary has 63.36% of its population fully vaccinated, compared to Indonesia, with 59.77% of the population. However, due to the large population in Indonesia, the vaccination progress is quite slow.

Table 1. Comparison of Vaccination Progress in Indonesia and Hungary until December 2021.

TERMS	INDONESIA	HUNGARY
% of population fully vaccinated	59.77%	63.36%
Doses administered	389,329,305	16,488,911
People fully vaccinated	161,761,633	6,190,140

Table 2 showed developments until April 2022, where there is an increase for the percentage of those fully vaccinated in Indonesia (64.1%). However, during the same period, Hungary managed to give a booster dose for 41.7% of the population, compared to Indonesia, which managed to give a booster dose to only 8.5% of the population.

Table 2. Number of COVID-19 Vaccine Doses Administered in Indonesia and Hungary as per April 4, 2022.

TERMS	INDONESIA	HUNGARY
% booster dose	8.5%	41.7%
% fully vaccinated	64.1%	63.3%
% given 1st dose	72.7%	65.5%

Based on these facts, it shows that Hungary has the upper hand in the vaccination strategy, possibly contributed by the supply chain process. In this case, the authors came up with the research question on the success and barrier factors of the vaccine supply chain mechanism in Indonesia and Hungary.

2. Literature Review

2.1 Key Issues of Manufacturing and Distributing Vaccines

Due to the COVID-19 pandemic, immunization drives have become more challenging. Restriction on movement during the pandemic is the root of the problem, making the situation more difficult for vaccine manufacturers to deliver the vaccines on time, conduct timely checks and monitor the efficacy of the vaccines' vials. All of those should

be in line with the key principles in vaccine distribution, namely human well-being, equal respect, global equity, national equity, reciprocity, and legitimacy (WHO 2020). According to findings by the OECD (2021) report, no country was able to produce all items required to combat the virus. This issue emphasized the significant degree of trade interdependence among nations. In addition, an article from OECD (2021) related to manufacturing and distributing vaccines, mentioned vital issues as follows:

a. All countries require vaccines, but not all are able to produce them.

Vaccine manufacturing is a highly specialized industry. As a result, the trade will be critical in facilitating access to COVID-19 vaccinations, particularly for developing countries. Developing countries have the feasibility to produce vaccines, but sometimes they have a lack of vaccine production cost (Munira et al. 2019). In addition, several manufactures across the world successfully developed vaccines in less than 12 months, which was an extraordinary achievement (Wouters et al. 2021).

b. A big bulk of vaccines are manufactured, distributed, and delivered along with the ingredients that support the final product.

The industry has tasks to manufacture and supply billions of COVID-19 vaccines, starting from zero. Manufacturers that have the capacity to produce not only the COVID-19 vaccine but also other vaccines in the production process (Kahla, 2021). Other ingredients needed for the final vaccine production, such as vials to transport vaccines, syringes to administer, cold boxes to transport, dry ice to keep vaccines cold, and freezers to preserve vaccines, should be prepared at the same time (OECD 2021).

c. COVID-19 vaccine manufacturing is likely to be locally confined, although demand is global.

This pandemic is a test of the world's ability to respond rapidly and fairly to a major global health crisis. The majority of the distribution went to developed countries where most of the manufacturers are located. The emergence of the Delta variant, which has a greater fatality rate, is becoming more prevalent in developing countries such as Africa, Latin America, Asia, and other areas where a large portion of the population is still unprotected (Zaidi 2021).

2.2 COVID-19 Situation in Indonesia

Since WHO stated the COVID-19 pandemic on March 11, 2020, the first cases have already been found in Indonesia on March 6, 2020. The infection might have come from a Japanese citizen living in Malaysia who travelled to Indonesia (Tosepu et al., 2020). Social distancing was announced by the government two weeks after the first case was confirmed, and regulation on the large scale of social distancing that restricts non-essential population mobility was enacted in April 2020 (Ariawan and Jusril 2020). Indonesia has a dense population (272 million citizens), and this situation has made the speed of the spread of COVID-19 faster, despite restrictions. As of June 23, 2021, Indonesia's government has documented 47,896 instances of COVID- 19 in all of the country's provinces, with 2,535 deaths (OCHA, 2020). The situation became worse during the month of Ramadan, followed by Eid holidays, where millions leave Jakarta and other major Indonesian cities to go home to celebrate the event (Surer 2020).

By the end of July 2021, the situation became worse due to the outbreak of the Delta variant (Griffiths, 2021). Although the Delta variety has been connected to a COVID-19 revival in Nepal, Southeast Asia, and elsewhere, its expansion in the United Kingdom has provided scientists with a clear picture of the harm it poses. Delta appears to be 60 percent more contagious than the already contagious Alpha variant (Callaway, 2020). Indonesia is listed as the first rank for daily new cases of COVID-19 by around 41.000 cases at the end of July 2021 (John Hopkins 2022). Indonesia became the new epicenter of the Delta variant spread after India (Widadio 2021).

It can be seen from figure 1 that active cases in Indonesia increased significantly in mid-2021. The trend became lower after the peak, but in the months of January-February 2022, the Omicron variant spread and active cases reached another peak before gradually decreasing in March. Until April 2022, Indonesia has 5,900,124 confirmed cases and 152,423 deaths (John Hopkins 2022).

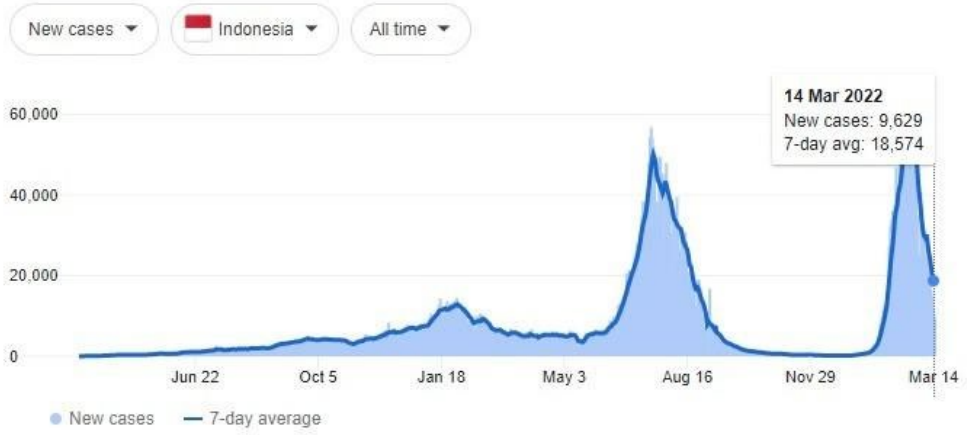

Figure 1. Indonesia Active Cases of COVID-19 until March 14, 2022.

Indonesia started the COVID-19 vaccination program in January 2021 with a target of 181.5 million vaccinations to achieve herd immunity. The Indonesian government has ordered COVID-19 vaccines from several firms and from the COVID-19 Vaccine Worldwide Access (COVAX) Facility, a global initiative created to ensure that every country in the world has fair and equal access to the vaccine. Indonesia is part of COVAX's Advanced Market Commitment (AMC) category, which ensures that 20 percent of the country's at-risk population will have access to inexpensive and high-quality COVID-19 vaccinations by the end of 2021 (UNICEF 2020). There are 5 types of vaccines that have been approved to be used in Indonesia, namely, Moderna, Pfizer, AstraZeneca, Sinopharm, and Sinovac (Vaccine Tracker 2022). Recently, as per March 2022, there are 11 types of Covid-19 vaccines approved by the Indonesian government as shown in table 3.

Table 3. Vaccines Approved for Use in Indonesia as per March 2022.

No	Type	Manufacturer
1	COVOVAX	Serum Institute of India
2	Zifivax	Anhui Zhifei Longcom
3	Spikevax	Moderna
4	Comirnaty	Pfizer/BioNTech
5	Convidecia	CanSino
6	Sputnik V	Gamaleya
7	Janssen (Johnson & Johnson)	Ad26.COV2.S
8	Vaxzevria	Oxford/AstraZeneca
9	KCONVAC	Minhai Biotechnology Co.
10	Covilo	Sinopharm
11	CoronaVac	Sinovac

Local governments will have logistical problems in distributing COVID-19 vaccinations from Jakarta to more than 10,000 health facilities across Indonesia, some of them located in rural areas with limited transportation, infrastructure, and resources. To guarantee that adequate vaccinations are provided when and where they are needed, effective coordination at both the national and subnational levels will be critical (UNICEF, 2020).

2.3 COVID-19 Situation in Hungary

The first case of COVID-19 in Hungary has been announced in March 2020. The case infected two Iranian students residing in Hungary, and they were directly being hospitalized in Budapest's St. László Hospital (Hungary Today, 2020a). Due to the increase of COVID-19 cases at the beginning of the outbreak, the government started to announce a curfew from March 28 to April 11, 2020. Restrictions were extended several times with rules implemented across cities. For example, grocery shops and pharmacies will be open to people above 65 years between 9 and 12 every day. Non-essential shops remained closed. People were required to wear masks indoors and outdoors, and social gatherings

were prohibited (Hungary Today 2020).

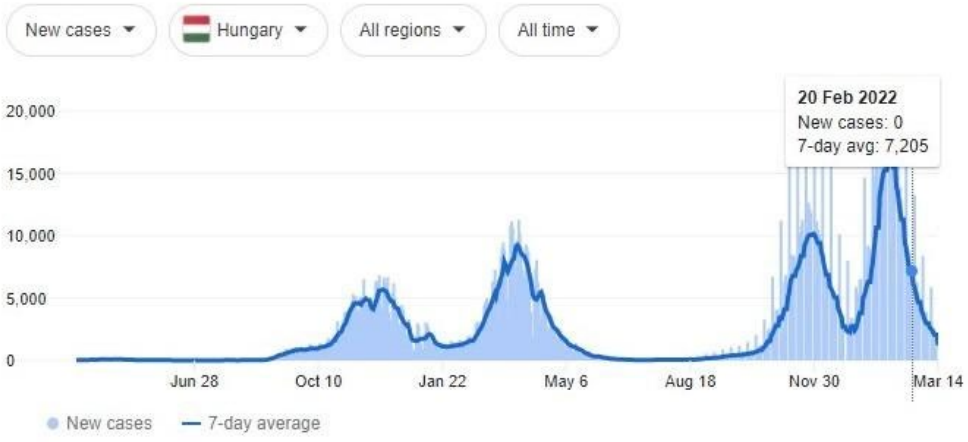

Figure 2. Hungary Active Cases of COVID-19 up to Feb 20, 2022.

Most of the restrictions were lifted, such as no masks for both indoor and outdoor, except in hospitals and in the premises of social institutions. The number of participants allowed in social gatherings increased from 50 to 100 for family events and 200 to 400 for weddings, no more social distancing in the store, etc. (Cseresnyés 2021). The ease of restriction indicated that the third wave has been slowing down in Hungary. However, 14 Delta variant cases were registered on July 22, 2021, and one Gamma variant was registered on the same day (Hungary Today, 2022). This leads to plans to administer a third dose of COVID-19 vaccines in August 2021 (Cseresnyés 2021). Figure 2 presents the situation in Hungary on February 2022. Until April 2022, Hungary has 1,814,362 confirmed cases and 44,653 deaths (John Hopkins 2022).

Hungary approved various types of vaccines to be administered to the population, namely Moderna, Pfizer, CanSino, Sputnik, Janssen, AstraZeneca, Covishield, and Sinopharm (Vaccine Tracker 2022). As per March 2022, shown in table 4 below, there are 9 types of Covid-19 vaccines approved by the Hungarian government.

Table 4. Vaccines Approved for Use in Hungary as per March 2022.

No	Type	Manufacturer
1	Nuvaxovid	Novavax
2	Spikevax	Moderna
3	Comirnaty	Pfizer/BioNTech
4	Convidecia	CanSino
5	Sputnik V	Gamaleya
6	Janssen (Johnson & Johnson)	Ad26.COV2.S
7	Vaxzevria	Oxford/AstraZeneca
8	Covishield (Oxford/AstraZeneca formulation)	Serum Institute of India
9	Covilo	Sinopharm

In Hungary, like in other European nations, the number of new coronavirus infections is quickly increasing, owing mostly to the Delta type, which accounts for 90% of transmissions and it happens until nowadays March 2022 (Cseresnyés, 2021). This delta variant situation became a fourth and fifth wave in Hungary. Since March 7, 2022, most coronavirus-related actions have been phased out by the government, which has lifted mask restrictions. The special legislative decree will stay in place to allow the government to respond quickly if the country is hit by a sixth wave of the pandemic (About Hungary 2022). The demand for vaccines during the pandemic is naturally higher than the supply. Some of the challenges faced in vaccine development is to ensure the availability of vaccines; to produce enough vaccines, and to preserve supply chain capacity (Forman et al., 2021). In the beginning of the outbreak in 2020, Hungary took proactive steps in ordering vaccines. Hungary had pre-orders for 3,270,000 doses of vaccine from

AstraZeneca, for 4,360,000 from Janssen, and for 4,439,000 from Pfizer (Budapest Business Journal, 2020). Figure 3 shows that Pfizer is the most widely administered type of vaccine in Hungary. It is interesting to note that after Pfizer, Sinopharm and Sputnik V vaccines are in the second and third place. The analysis section will discuss some of the drawbacks of Hungary's vaccine policy.

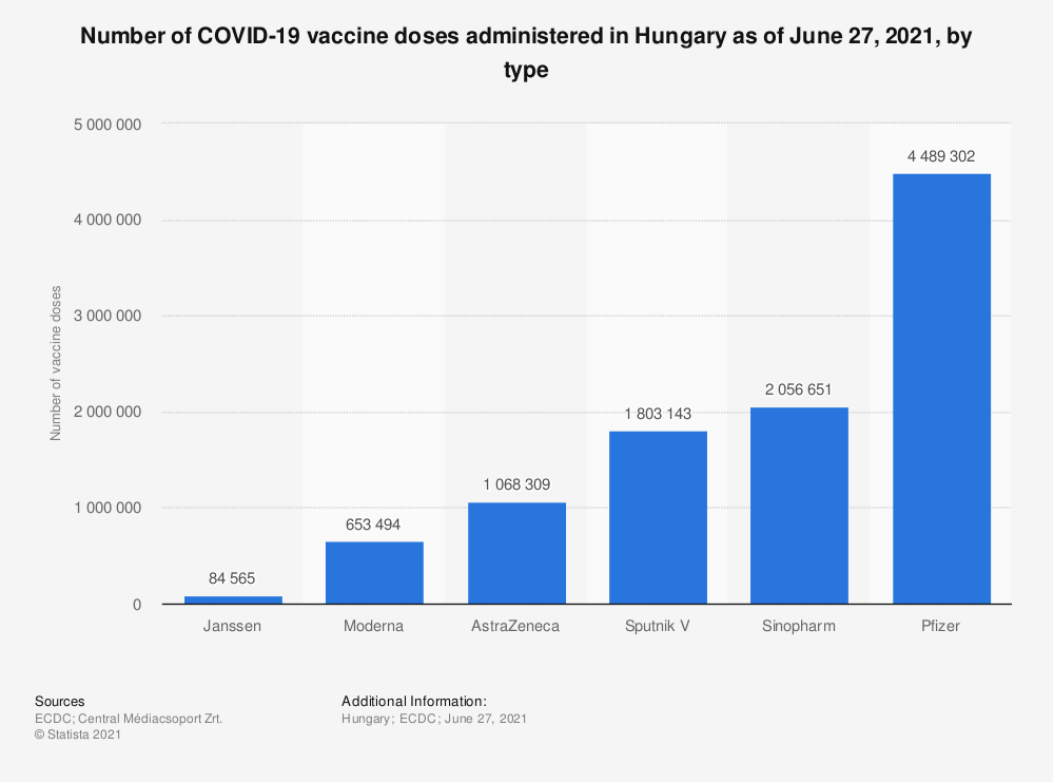

Figure 3. Number of COVID-19 vaccine doses administered in Hungary, by type.

Thus, the literature review summarizes the Covid-19 situation in Indonesia and Hungary with respect to the latest developments in 2021, and how each country responded to the pandemic.

3. Methods

This study is an exploratory study, and as explained in Sekaran and Bougie (2013): "an exploratory study is undertaken when not much is known about the situation at hand, or no information is available on how similar problems or research issues have been solved in the past." In other words, an exploratory study is to look at a phenomenon that has never been investigated before. Therefore, an exploratory study is necessary when some facts are known, but more information is required to build a theoretical framework. Based on the preliminary work conducted, the study will reach a decision in the conclusion if further research is not needed, or requires more comprehensive investigation (Sekaran and Bougie 2013). The literature review section highlights the findings to get information from some capable websites or newspaper sites in each country. For example, the authors used COVID-19 supply chain as the main keyword and specific keywords that have been used in a specific country for Indonesia and Hungary. To support the literature findings, the European Union (EU) area and formal websites from Indonesia were used to identify the results.

The suitable literature collection was created by looking at the title, content, and keywords of articles that addressed the COVID-19 supply chain scenario in each country. At the same time, the authors applied a similar filter to the period from March 2020, when WHO first announced the COVID-19 pandemic, to the end of July 2021. This article observes the supply chain mechanism of COVID-19 vaccines in Hungary and Indonesia. Since there is a lack of recent resources, authors decided to include all types of information such as articles, papers, reviews, government announcements, etc. All authors are responsible for the validity and verification.

The supply chain of vaccines starts with the price or costs of the vaccine, starting from the whole supply chain from Research and Development (R&D) until distribution and administration of the vaccines to the population. There are two main costs that need to be considered: the cost of research and development (R&D), and the cost of manufacturing. A vaccine's R&D costs can be hard to quantify as they include the cost of unsuccessful candidates and profits foregone (Lee and McGlone 2010). Looking to medications and other treatments included, only 0.01-0.02% of compounds screened are ultimately FDA-approved for sale in U.S. vaccine markets, where competing producers with high fixed, sunk costs face relatively concentrated demand. This tends to lead to exit of all but one or very few producers per vaccine. Detailed evidence of exits and shortages in the flu vaccine market demonstrates the importance of high fixed costs, demand uncertainty, and dynamic quality competition. A comparison of vaccine suppliers in four industrialized countries compared with the United States shows that smaller foreign markets often have more and different vaccine suppliers. High, country-specific fixed costs, along with price and volume uncertainties, are likely deterrents to these potential suppliers entering the US market. (Light et al. 2009). Startup manufacturing, clinical studies and regulatory processes all have an impact on R&D costs. Most research facilities are vaccine-specific and there is often a considerable lag time between production and sales. R&D has historically had high sunk costs. The cost of R&D for innovative vaccines may be higher than for established vaccines. New and technologically advanced vaccines frequently have higher production costs and are more likely to be on the market for shorter periods of time, as combination vaccines may swiftly replace them (Coleman et al. 2005).

Manufacturing is a large part of the vaccine cost structure. Costs associated with administration, quality control, depreciation, and other fixed costs account for 60% of the total vaccine manufacturing cost (Danzon et al. 2005). The manufacturing cost can be very high if the manufacturer does not have operational facilities in place. This production cost is influenced by vaccine type, time, unaccountable obstacles, and other simultaneous product development and production (Lee and McGlone 2010). Therefore, the price of the vaccine often entails high sunk costs and high fixed costs with low marginal cost per dose. Governments, bilateral and multilateral organizations, non-governmental organizations (NGOs), and private firms are sponsoring vaccine R&D and have signed contracts with vaccine makers prior to vaccine licensure in the instance of the COVID-19 vaccine. This increases incentives in producing the vaccines and lowers the risk of capital loss (Cornish 2020).

Several laboratories developing vaccines against COVID-19 are partnering with vaccine manufacturers to ease the transition from development to production (e.g., the Oxford University and Astra-Zeneca partnership and the NIH-Moderna partnership). Such partnerships allow phases II and III of clinical trials to occur while simultaneously building up production capacity, leading to a quicker rollout if the vaccine is approved.

The price of vaccine supplies is only one component of vaccination costs. Labor, cold chain storage, transportation, capital, and other recurring expenditures. The examples of recurring expenditures are program administration, training, social mobilization, waste management, and monitoring and evaluation are all included in vaccine rollout costs (Sim et al. 2021). These expenses are referred to as immunization delivery expenses. Globally, delivery expenses account for roughly half of all immunization program costs. The cost of delivery varies by area, ranging from $0.18 to $11.31 per dose given, depending on accessibility and infrastructure in each country (Sim et al., 2021). Governments must use existing delivery infrastructure and integrate partnerships at all levels to reduce delivery costs and promote efficient and equitable access to COVID-19 vaccinations. The most significant problem facing the deployment of COVID-19 vaccinations is that, unlike most vaccines, these vaccines will target adults, a larger and more challenging population to efficiently target. Most nations lack the health-care infrastructure and protocols needed to routinely provide immunizations to people, especially in hard-to-reach places far from healthcare facilities. Furthermore, even during a public health emergency, heightened vaccination hesitancy and lack of vaccine confidence will slow the progress to vaccinate large populations. Consequently, this leads to high wastage rates and additional efforts to engage the society in the vaccination program.

Different COVID-19 vaccines may have different requirements for storage and delivery and procuring highly specialized equipment may be necessary. For instance, the biotechnology used for the mRNA vaccine developed by Pfizer requires storage at -70 degrees Celsius, much colder than vaccines routinely used for childhood immunization (Simmons-Duffin 2020). Extreme cold chain requirements do not necessarily preclude low- and middle-income countries from using such a vaccine. However, countries without this infrastructure may opt to wait for a product with less stringent cold chain requirements.

4. Data Collection

4.1 COVID-19 Vaccine Supply Chain in Hungary

On the supply side, pharmaceutical and equipment manufacturers in Hungary are increasing their capacity to satisfy the rising demand for vaccine ingredients and packaging. The supply of ingredients and packaging are in terms of international supply networks and the government's interest in national self-sufficiency. The Hungarian government has expressed an interest in developing a national vaccine production capacity. On the consumer side, it's unclear whether persons who receive non-European Medicines Agency (EMA)-approved vaccines will be restricted in their ability to travel and work inside the EU, whilst those who can show a "vaccine certificate" will be permitted greater domestic freedoms.

With both home-grown enterprises (some, such as Richter Gedeon, internationally recognized) and local operations of multinationals, such as Teva, Sanofi-Aventis, Egis-Servier, and GSK, Hungary has long played a role in worldwide supply chains and has a strong presence in pharmaceutical and medical equipment and supplies. As supply chains are restructured, it results in the development of local capacity in sectors like vaccines, as well as foreign corporations setting up or acquiring enterprises in Hungary. Table 5 presents the distribution of COVID-19 vaccines in Hungary according to type.

Table 5. Distribution of COVID-19 Vaccines in Hungary.

No	Name of vaccine	Percentage
1	Comirnaty/BioNtech	44,2%
2	Beijing CNBG/Sinopharm	20.3%
3	Vaxzevria (previously called AstraZeneca)	10.5%
4	Sputnik V	17.8%
5	Moderna	6.4%
6	Janssen/Johnson & Johnson	0.8%

Every organization needs to rapidly build an agile capability of carriers to cover all destinations to manage the distribution of vaccines (Fleming, 2021). Shippers had to quickly identify and go-live with multiple new carriers who specialize in specific geographic locations, and who themselves needed updated documentation and labeling to support the delivery of vaccines. This includes back- up carriers ready to go in case of carrier capacity issues, or if the first choice did not perform as required. It is not an option to throw away vaccines because they were spoiled in transit due to delays or an inability to effectively manage extreme cold temperatures (as low as -70˚C). To gain approval for shipping with a new carrier, it is necessary to prove that the labels and electronic data produced are compliant with the specifications required by the carrier. In international shipping, each carrier has its own quirks when it comes to data, and the verification of data is critical, especially if this is the first time that vaccines are being shipped. If the data is incorrect, errors and delays may cause an increase in time and cost. Figure 4 is an overall description of the supply chain of vaccines in Hungary.

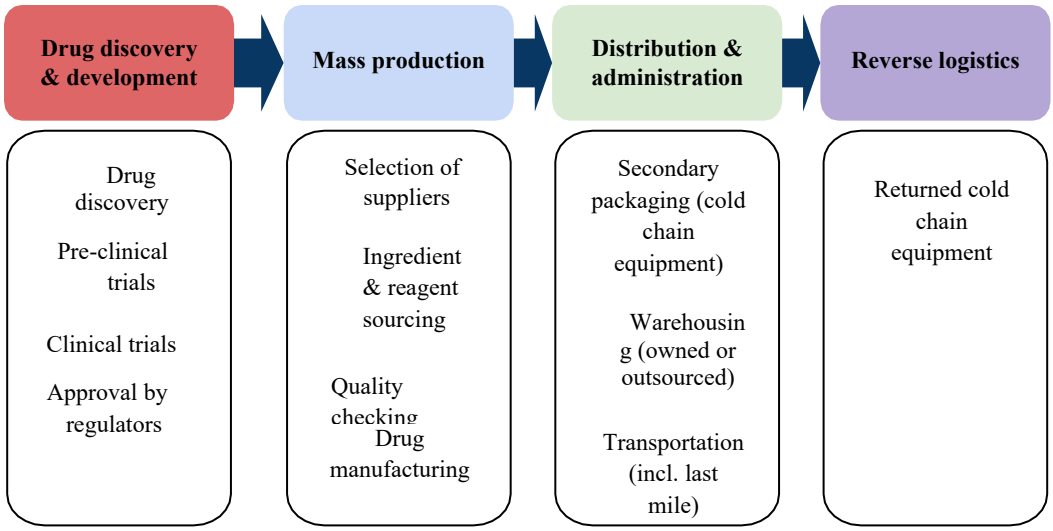

Figure 4. The COVID-19 Vaccine Supply Chain in Hungary.

After testing the data, the next step is to check that the physical label meets all requirements. To ensure that vaccines can be shipped as a matter of urgency, this process was reviewed with various vaccine producers. The objective is to make sure that millions of shipments are ready and labeled with carrier compliant information to enter the supply chain as soon as regulatory approval is given. Another important part is complete, real-time visibility of shipments from the point of departure to final delivery. This can be achieved through the Business Intelligence function of a Transportation Management System (TMS) designed for shipping parcels globally and where necessary, partnering with internet-of-things (IoT) providers. Having the information of the exact whereabouts of any shipment and the possibility of any delays, help the supply chain leaders who are coordinating the distribution of the vaccines to proactively manage shipments in transit, in order to avoid vaccine degradation.

4.2 COVID-19 Vaccine Supply Chain in Indonesia

The Indonesian government has been proactive in vaccine procurements to inoculate its 272 million people. Like many Southeast Asian countries, Indonesia relied heavily on the Chinese Sinovac vaccine, but has also secured shipments of vaccines from Moderna and AstraZeneca.

The process of distributing the COVID-19 vaccine covers 34 provinces in Indonesia (Bio Farma 2021). As of December 2021, the total number of COVID-19 vaccine doses distributed had reached 272 million. Bio Farma, a company that carries out the duties of the Indonesian government as a provider of COVID-19 vaccines, continues to maintain the supply of COVID-19 vaccines in Indonesia. Bio Farma has the responsibility for vaccine distribution, based on the allocation and request from the Ministry of Health. Table 6 summarizes the type of vaccine and doses distributed by Bio Farma in Indonesia as of December 2021.

Table 6. Distribution of COVID-19 Vaccines in Indonesia.

No	Name of vaccine	Doses (in approx. units)
1	Covid-19 Bio Farma	122,400,000
2	CoronaVac 1 dose	3,000,000
3	CoronaVac 2 dose	50,000,000
4	Moderna	8,000,000
5	Sinopharm (from UAE)	749,502
6	CoronaVac 1 dose (from Covax)	10,700,000
7	CoronaVac 2 dose (from China)	1,900,000
8	CoronaVac B2B 2 dose	31,400,000
9	Sinopharm (from China)	200,000

10	AstraZeneca (B2B)	37,200,000
11	Janssen	497,395
12	Pfizer (Covax)	5,370,000

The standard Indonesian operating procedure for the distribution of vaccines at polymer health institutions utilizes FEFO (First Expiry First Out), which means issuing or using the first expired vaccines (Prakoso, 2021). If the Vaccine Vial Monitor (VVM) shows C or D, the vaccination should be refused, and the distribution activities of each vaccine (place of delivery, vaccine type, quantity, batch number and expiration date) should be recorded. Vaccine carriers or coolers must be used to dispense vaccines. The central government through certain business entities assigned or appointed in accordance with the provisions of the legislation, distributes vaccines, enabling equipment, and other logistics to the provincial health offices (Yuniarto, 2021). The provincial health office then distributes vaccines and supporting equipment to the district/city health offices. Furthermore, the district/city health offices distribute it to *Puskesmas* (public health center) and other health service facilities in its area (see figure 5).

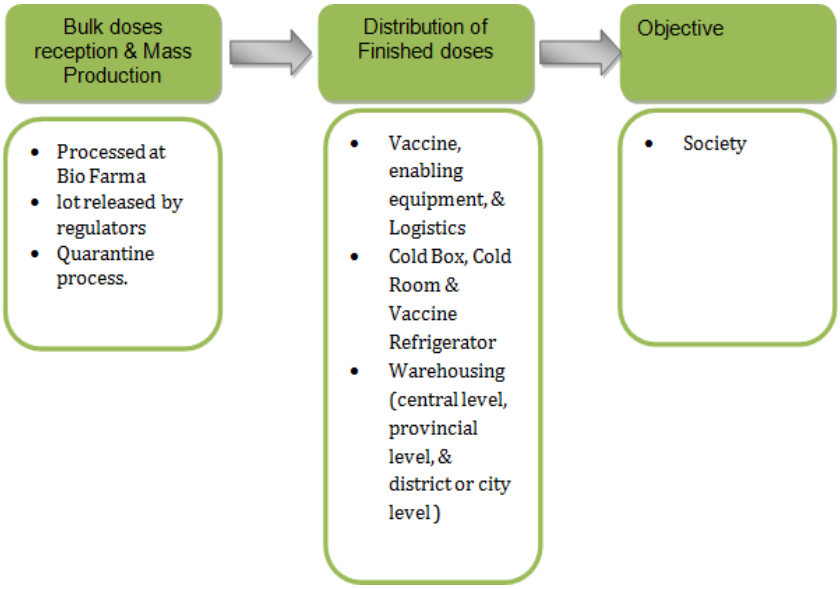

Figure 5. The COVID-19 Vaccine Supply Chain in Indonesia.

The distribution of vaccines, enabling equipment, and other logistics must be carried out and managed according to established procedures to ensure good quality. Distribution from the central level to the provincial level is carried out by air or by land using special refrigerated vehicles, cold boxes, or other means of transporting vaccines according to the type of COVID-19 vaccine. Meanwhile, the distribution of supporting equipment and other logistics is carried out using other standard carriers in accordance with the provisions. During the distribution process, vaccines are stored in cold rooms, vaccine refrigerators, and other vaccine storage areas that match the type of COVID-19 vaccine at the recommended temperature. Supporting equipment and other logistics, such as disposable syringes, safety boxes, alcohol swabs, are stored in a designated space in the pharmacy installation.

The next step is the distribution from the provincial level to the district or city level, carried out using special refrigerated vehicles, cold boxes, vaccine carriers or other means of transportation of vaccines according to the type of COVID-19 vaccine. Equipment and other logistics use standard carriers in accordance with the provisions. From the district or city level, vaccines, supporting equipment, and other logistics are distributed to health centers, clinics, hospitals, or vaccination service posts that have been designated as COVID-19 vaccination services. Distribution is done by using a box car or mobile health center car. At the time of distribution, the vaccine is placed in a cold box or vaccine carrier. The vaccine is stored in a vaccine refrigerator or vaccine storage area according to the type of COVID-19 vaccine.

Bio Farma uses a trace and track system in the COVID-19 vaccine distribution. The use of this system is useful in

digitally tracing the availability of vaccines and their quality for recipients. Bio Farma sets a temperature sensor on a refrigerated truck that can be read during the trip to maintain the vaccine temperature. As an example, for the Sinovac vaccine, the temperature is maintained between 2-8° Celsius. For location monitoring, Bio Farma completes a GPS system on each refrigerated truck carrying vaccines to ensure that vaccine distribution reaches its destination and minimizes chaos in the distribution process (Indonesia Baik 2021). The vaccine distribution safety measures also include vaccine counterfeit prevention to prevent unexpected actions during the vaccine distribution process. Bio Farma applies a vaccine identification system code in the form of a 2D barcode, which contains information on production data, expiration date, and the unique serial number on each vaccine (Indonesia Baik 2021).

5. Results and Discussion

5.1 Barrier Factors of COVID-19 Vaccines Distribution

One of the barrier factors that hinder the continuity of COVID-19 vaccines is policy and regulation. In the case of a pandemic situation, each country enforces its own rules but mainly countries attempt to close borders to limit the flow of people. For example, a spike in COVID-19 cases led Hungary to close its borders to non- residents in September 2020. The border closure regulations impacted the challenge of the logistic system due to the long queue at the borders. The surrounding countries of Hungary showed a red area which also experienced a spike for the active cases (Euronews 2020).

In the case of Indonesia, the distribution of COVID-19 vaccines requires continuous supervision from the central government and local government. The challenge that requires consideration in the vaccine program is the implementation in the regions of Indonesia. Vaccine distribution is carried out in stages, starting from the central, provincial, district, and city levels. To ensure the safety of vaccine products, supporting equipment, and logistics, the central government has assigned Bio Farma or other business entities by statutory regulations. In the event of a vacancy or shortage of vaccine stock, the Minister of Health may relocate the COVID-19 vaccine from another area. The Minister of Health can directly supply vaccinations to the district/city level, health service centers, and even vaccination service posts. The objective is to speed up the vaccination process and preserve vaccine safety, quality, and efficacy (Budianto 2021).

The Food and Drug Supervisory Agency (BPOM) admits that the distribution of the COVID-19 vaccine throughout Indonesia requires a big effort. Considering that Indonesia is an archipelago country and of course a big effort is needed to be able to distribute vaccines to the point of injection. It is also related to the availability of the cool box as a medium to manage the quality of COVID-19 vaccines. The vaccine is a product that is susceptible to damage if the temperature of distribution and storage does not meet the requirements (Susilo 2021). Therefore, the Indonesian government tried to engage cold chain industry players to be involved in the vaccine distribution process. There were 14 ARPI members currently involved in the distribution of this COVID-19 vaccine (Andi 2021). The number of cool boxes needed is still very high, and this situation is a part of the barrier factor for the success of COVID-19 supply chain management.

5.2 Success Factors of COVID-19 Vaccines Distribution

The success of vaccination campaigns will be strongly influenced by the extent to which people trust the effectiveness and safety of the vaccines, the competence and reliability of the system that delivers them, and the principles that guide the underlying government decisions and actions (OECD 2021).

To achieve vaccine fairness, expanding the geographic distribution of vaccine manufacturing capacity is crucial (Zaidi 2021). It is not a coincidence that countries with domestic capacity received the majority of COVID-19 vaccines while those without the capacity have to wait. Vaccine producers in underdeveloped countries (commonly known as Developing Countries Vaccine Manufacturers or DCVM) are generally more responsive to focusing on neglected diseases than large multinational businesses, especially when those diseases are still endemic in their country or region. For example, Bio Farma in Indonesia is now the sole developer or source of several oral polio vaccines used around the world, even as large multinational vaccine companies have stopped making them.

Hungary is among Europe's most vaccinated countries, even though it is not among the wealthier countries in Europe. Hungary's success in the distribution of COVID-19 vaccines is due to the infrastructure of the supply chain in Europe and Hungary. The Hungarian government is also proactive in procuring vaccines. It has been receiving a variety of vaccines from both the East and West politically. Hungary was the first EU country to purchase Sputnik V and

Sinopharm vaccines. In fact, Hungary has approved more vaccines than any other nation. The country's immunization campaign seems bold and even forward-thinking at the start of 2021. Hungary did not wait for EMA approval, but decided on the policy to speed up the vaccination program and put the country ahead from the rest of Europe. The European Medicines Agency (EMA), which is responsible for the evaluation and supervision of medicinal products within the EU, has approved only four vaccines: Pfizer/BioNTech, Moderna, AstraZeneca, and Johnson & Johnson. Citizens and residents of the EU who received those vaccines are exempt from testing or quarantine when travelling to other EU countries. However, it is not the case for Hungarians who were vaccinated with Sinopharm and Sputnik V vaccines (Rutai, 2021). While Sinopharm does not have EMA approval, it has been granted emergency use by the World Health Organization (WHO), meaning some European countries, including Austria and Spain, will accept it. Sputnik V has neither EMA nor WHO approval, which means that in the EU, for example, only Hungary, Slovakia, Cyprus, and Greece, will accept it as proof of immunization. Despite initiating a rolling examination in March, the EMA is not expected to make a judgment on Sputnik's license until the first quarter of 2022, according to reports. Following the conflict between Russia and Ukraine, it may affect the approval of the Sputnik V vaccine from EMA and WHO. While the EMA has never started an assessment of the Chinese vaccine, the WHO's emergency authorization for Sinopharm has opened up more choices, including travel to the United States and the United Kingdom.

The vaccine rollout in Indonesia is also considered to be fast, but the infrastructure (lack of cold chain), the huge population and the dispersed locations made it difficult to deliver vaccines in a timely manner. So instead of relying on the supply chain from abroad, the Indonesian government appointed Bio Farma for vaccine manufacturing. Until now, Indonesia has a provision of COVID-19 vaccines such as Sinovac, AstraZeneca, COVAX Facility and Sinopharm. Total vaccines that have come to Indonesia in the form of finished products and bulk are approximately 272 million doses. All vaccines used in Indonesia are approved by WHO, so that is an advantage for Indonesians to travel once travel restrictions are eased. The Indonesian government worked together with Bio Farma to secure the vaccine supply by doing the fill and finish process for the Covid-19 vaccine at Bio Farma's production facilities, with a total of 65.52 million doses of products that have been produced (Bio Farma, 2021). DCVMs are critical to developing or manufacturing low-cost, high-quality vaccines that can reach everyone.

6. Conclusion

Government support is the most important aspect that influences the smooth distribution of the COVID-19 vaccine, according to this supply chain information about the distribution of the COVID-19 vaccine to two separate countries with varied features and pandemic impacts. The reason for this is that the government can enact a variety of policies that must be followed by individuals and can have an impact on the performance of linked parties such as manufacturers, health care providers, and even local governments. The policies can vary, such as having a mutual relationship with the third party of the cold chain distributor, managing the logistic transportation queue in the border, and strict order to local governments to be fully aware of the distribution of vaccine into regions. The study provides a comprehensive set of success and barrier factors that underlie the COVID-19 vaccines distribution that can be used in a practical way for further improvement. The insight of this research provides an impact on practitioners. They can do the evaluation and manage which factor that they will work on first in the future. In addition, they can reimagine their value chains and gain a better understanding of how supply chains will evolve post- COVID-19.

This research is explanatory in nature, yet it does have certain limitations due to various shortcomings. There was not much previous academic literature concerning the supply chain of vaccines and most of the information presented here was taken from news or database sets readily available. These limitations open the door for more in-depth investigation. The outcome is limited by the fact that it is based on a snapshot for a specific period, in this example, from December 2019 to March 2022. In comparison to the existing condition, the future situation could be better or worse. The second limitation is that this study only focuses on two nations, Hungary, and Indonesia. More countries could be included in future studies to broaden the results and deepen the understanding. Furthermore, this research might be expanded into a comprehensive empirical study to aid in the formulation of better supply chain strategies and the evaluation of their effects on the issues associated with the distribution of COVID-19 vaccinations. This larger study could help in the application of the findings to future emerging crises. Another limitation of this study is that the sample only includes COVID-19 vaccinations. In the future, the same methodology can be used to identify and assess supply chain management difficulties for other sorts of products, such as food, healthcare instruments, and other items relevant to the pandemic situation, to broaden the scope of the investigation.

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