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Last mile logistics applied to the distribution of COVID-19 vaccines:

A prospection of good practices

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Abstract:

"Defining a public policy for vaccination against Covid-19 is one thing, ensuring its proper execution is another. Faced with the complexity of delivering millions of doses, only national and transversal coordination will ensure a smooth vaccination campaign. [The risk of queues, shortages of doses, unused stocks ordered, trafficking in vaccines by ill-intentioned individuals... Never has the proper execution of a public policy been so crucial" (GSS, 2020).

Hence the great attention given by practitioners and researchers to the question of the efficiency of logistics related to the distribution of Covid-19 vaccines and the logistics of the last mile.

What are the prospective applications of the delivery of anti-Covid-19 vaccines as a public health issue with strong constraints for logisticians and transporters? This is the issue to which this article attempts to provide an answer.

Based on a prospective approach to national and international best practices, the research highlights the unavoidable antecedents and irreducible best practices to be adopted by the players in the logistics of the last mile of vaccine distribution in Morocco. These include the development of micro-consolidation platforms, innovative vehicles, collaboration and cooperation in urban logistics, the adoption of innovative distribution modes (UAV, underground driving) and the application of digital technology.

Keywords: Logistics, Last mile logistics, Prospective approach, Distribution logistics, Vaccine distribution, Pandemic logistics, COVID-19.

La logistique du dernier Kilomètre appliquée à la distribution des vaccins COVID-19 : Une prospection des bonnes pratiques

Résumé :

« Définir une politique publique de vaccination contre la Covid-19 est une chose, s'assurer de sa bonne exécution en est une autre. Face à la complexité de la livraison de millions de doses, seule une coordination nationale et transversale, assurera une campagne de vaccination fluide. [...] « Risques de files d'attentes, ruptures de doses, stocks commandés non utilisés, trafic de vaccins par des personnes mal intentionnées... Jamais la bonne exécution d'une politique publique n'aura été aussi cruciale » (GSS, 2020).

D'où une grande attention par les praticiens et les chercheurs accordée à la question de l'efficacité de la logistique liée à la distribution des vaccins anti-Covid-19 et la logistique du dernier kilomètre.

Quelles sont les applications prospectives de la livraison des vaccins anti-Covid-19 comme enjeu de santé publique aux fortes contraintes pour les logisticiens et les transporteurs ? Telle est la problématique à laquelle l'article tente d'apporter des éléments de réponse.

Basés sur une approche prospective des bonnes pratiques nationales et internationales, la recherche met en évidence des antécédents incontournables et des bonnes pratiques irréductibles à adopter par les acteurs de la logistique du dernier kilomètre de distribution des vaccins au Maroc. Il s'agit notamment du développement des plateformes de micro-consolidation, de véhicules innovants, de la collaboration et la coopération en matière de logistique urbaine, de l'adoption des modes de distribution innovants (UAV, conduite souterraine) et de l'application de la technologie numérique et digitale.

Mots-clés : Logistique, logistique du dernier kilomètre, approche prospective, logistique de distribution, distribution des vaccins, logistique de pandémie, COVID-19.

Introduction

The new 2019 coronavirus (COVID-19) was first discovered in Wuhan in 2019 and has had varying degrees of impact on various industries in China and around the world. Vaccination is one of the ways to prevent and/or control the occurrence of infectious diseases. Many countries have already obtained millions of doses of one or more vaccines through bilateral agreements with manufacturers. This medical intervention also involves many logistical issues. In recent years, the research community has shown a growing and sustained interest in the logistical aspects of vaccination. When vaccine availability is limited or when efficacy is low, optimal vaccine allocation is imperative.

Based on the relationship of sharing of benefits between public entities and companies, an intercommunication of information, material and component flows is realized via information platforms. The objective is to ensure a real time sharing of logistic information to improve the time-cost ratio of the vaccination.

Use distribution information sharing to build a complete distribution chain relationship as the basis for unmanned distribution to complete the last mile. According to the distribution problems and distribution needs different distribution methods are provided to realize efficient and fast distribution. Thus, several supply chain challenges need to be considered when introducing new vaccines. Focusing on the entire supply chain should have more effect than optimizing individual components.

The last mile logistics distribution system is the last step in the supply chain from the company to the customer. It must be carefully considered to deliver goods to customers efficiently and economically. Thus, the last mile logistics has a great importance in the efficiency of the global immunization procedure.

This article traces the phenomenon of COVID-19 vaccine distribution and last mile logistics. It lists the prospective applications of vaccine delivery under the epidemic, analyzes the needs of the various logistics partners and puts forward, in a forward-looking vision of sharing thoughts, new possibilities of COVID-19 vaccine delivery integrated with last mile logistics issues.

What are the prospective applications of the delivery of Covid-19 vaccines as a public health issue with strong constraints for logisticians and transporters?

The article thus attempts to understand the possibilities offered to Covid-19 vaccine logistics in relation to last mile logistics issues. The aim is to examine the new possibilities offered by the Covid-19 vaccine supply chains in the SCM, especially in the field of services. Thus, after defining the concepts of vaccine distribution and last mile logistics, we will examine the current and future possibilities of Covid-19 vaccine distribution.

1. Coronavirus Vaccine Development and Distribution: Theoretical and Empirical Considerations

1.1. Empirical considerations on vaccination and vaccine delivery

Every year, millions of people are vaccinated as a preventive measure: they receive the annual flu shot. Preventive vaccination takes place before the onset of an illness and is intended to prevent the onset of the illness. In addition to preventive vaccination, reactive vaccination can take place when an illness occurs. Vaccination has the advantage of decreasing transmission, thus reducing the risk of infection (Medlock and Galvani, 2009).

The race is on to bring a coronavirus vaccine to market on a large scale. In the absence of a unanimous commitment to global distribution, countries may depend on bilateral agreements to procure vaccine. Countries may also set different priorities on who to vaccinate first. Protecting a portion of the population will not stop the pandemic but will reduce mortality from COVID-19.

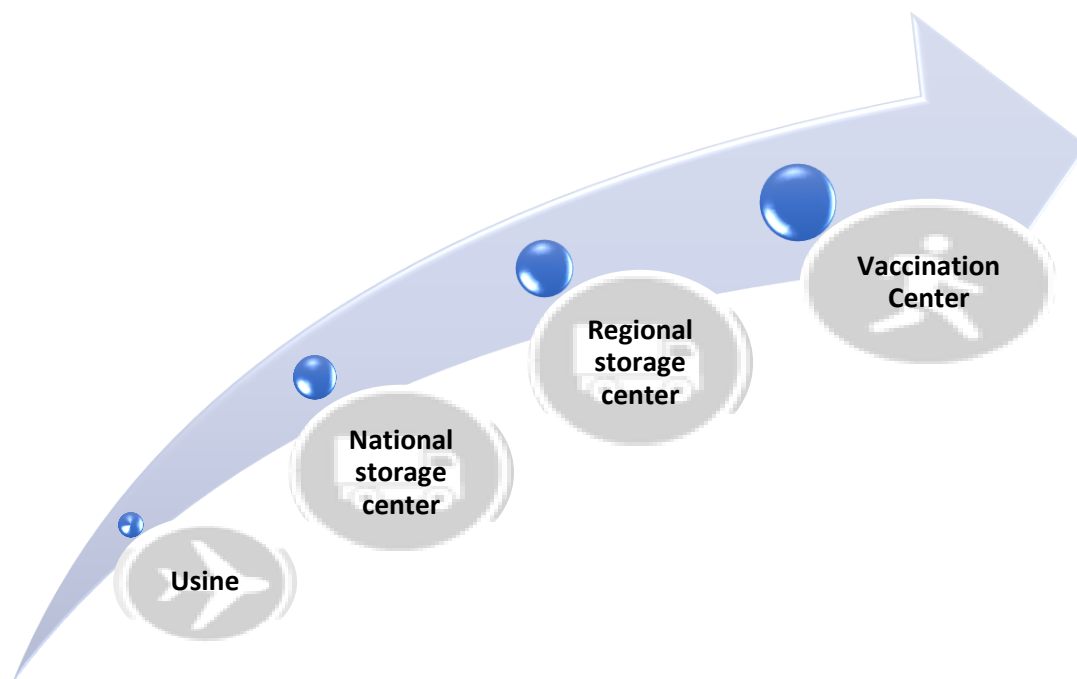
Thus, although vaccination is a medical intervention, it is impossible to conduct a successful vaccination campaign without good logistics. The importance of vaccine logistics is demonstrated by the growing number of studies on the topic (Montoya-Torres et al., 2021; Singh et al., 2021).

Once the decision to distribute the vaccines is made, several logistical hurdles can arise. The actual transportation and delivery of vaccines requires a cold room or freezer. Another problem that could slow down the development and distribution of a vaccine is the shortage of glass vials. Temperature control is also of utmost importance for some vaccines.

Several companies operating in the logistics sector have already prepared and begun to develop strategies for vaccine distribution. UPS has built two freezer farms near the company's air hubs. FedEx began building its freezer farm infrastructure nearly a decade ago in response to the H1N1 outbreak. It now has nearly 90 cold chain facilities around the world where vaccines can be safely stored. Pfizer has also built up a huge cold storage infrastructure. The containers are also equipped with GPS technology to enable real-time tracking.

Vaccine distribution requires efforts from every link in the supply chain (Figure 1). This could result in shipping delays as global and domestic transportation capacity is expected to be in short supply.

Fig. 1: Vaccine distribution supply chain



Source: Adapted from World Economic Forum, 2020

Ideally, the platforms developed will be flexible and responsive to changing needs. The demand for vaccines may also be negatively affected by better drugs that reduce mortality. To completely eradicate the virus, very high levels of induced population immunity are required, depending on the effectiveness of a vaccine and other interventions. Thus, pandemic logistics and especially vaccine distribution are of great importance.

1.2. Theoretical considerations of vaccine logistics

Vaccine distribution involves many logistical issues at the operational level (Duijzer et al., 2018). The question of how to organize the logistics chains involved must be answered. Thus, several researches address this issue in the literature (Hmioui and Bentalha, 2020). Managing a mass vaccination campaign is a huge logistical challenge, with decision problems related to issues such as vaccination locations, facility layout, the order in which the population is vaccinated, and staffing. The discussion of supply chain design plays a major role in developing countries, where supply chains are often insufficiently capable of integrating the introduction of new vaccines.

Aaby et al (2006) examine clinics and immunization centers. Decisions about clinic location, layout, and staffing directly affect vaccination effectiveness. Shrestha et al. (2010) develop a spreadsheet model for pediatric vaccine inventory control in the United States. Salmeron and Apte (2010) consider the method and approach to planning for disasters. They propose a two-stage stochastic programming formulation to minimize expected losses. The analysis reflects the importance of using stochastic models because of the uncertainty in the location of the disaster.

Arora et al (2010) consider the distribution of resources during a disaster. The authors assume that the available inventory is limited, but do not consider newly produced and supplied inventory. Rottkemper et al. (2011) consider a similar model but assume unlimited inventory at the central repository. The authors formulate a model of inventory relocation and solve for it using a rolling horizon to incorporate uncertainties.

Kaufmann et al. (2011) distinguish two segments in the vaccine supply chain in low- and middle-income countries. A first segment that circulates vaccines to the recipient country and a second segment that distributes vaccines in the recipient country. The authors recommend that coordination between the two segments of the vaccine supply chain be improved. In the epidemiological literature, numerous studies have examined this coordination and supply chain reconfiguration (Assi et al., 2013; Brown et al., 2014; Lee et al., 2015). Maruchek et al. (2011) focus on product safety and security. Samii et al. (2012) link influenza vaccine allocation systems to inventory control policies.

Zaffran et al. (2013) and Privett and Gonsalvez (2014) review the key challenges of the vaccine supply chain in developing countries. They discuss the importance of coordination, motivated staff, and information systems to improve decision making. Pishvaei et al. (2014) propose a method for designing a sustainable medical supply chain, considering the full life cycle of medical supplies and waste. Saif and Elhedhli (2016) also take into account environmental considerations when considering the design of a cold supply chain, i.e., a supply chain for goods, such as vaccines, that must be stored in a temperature-controlled environment. Yadav et al. (2014) investigate the possibilities of supply chain integration. Lydon et al. (2015) go even further and analyze the option of outsourcing some supply chain activities to the private sector.

Ramirez-Nafarrate et al. (2015) simultaneously study the location problem and point-of-care capacity planning. They formulate a mathematical program and propose a solution approach based on a genetic algorithm. Luangkesorn et al. (2012) study health care centers for prevention and screening in Abu Dhabi. They use simulation and queueing models and propose an adjusted design that reduces queue size. McCoy and Johnson (2014) consider the distance to the

vaccination center. The results show that integration and matching can significantly improve vaccinations.

Thäter et al. (2018) investigate how to develop optimal vaccination strategies against the spread of a generic disease. These vaccination strategies are derived from studying optimal control problems with different types of constraints. Adebimpe and Adeoye (2021) evaluated logistics management systems for vaccination in Nigeria. This was a descriptive cross-sectional study of 180 health workers. The practice of the immunization cold chain logistics system and the social aspect are discussed.

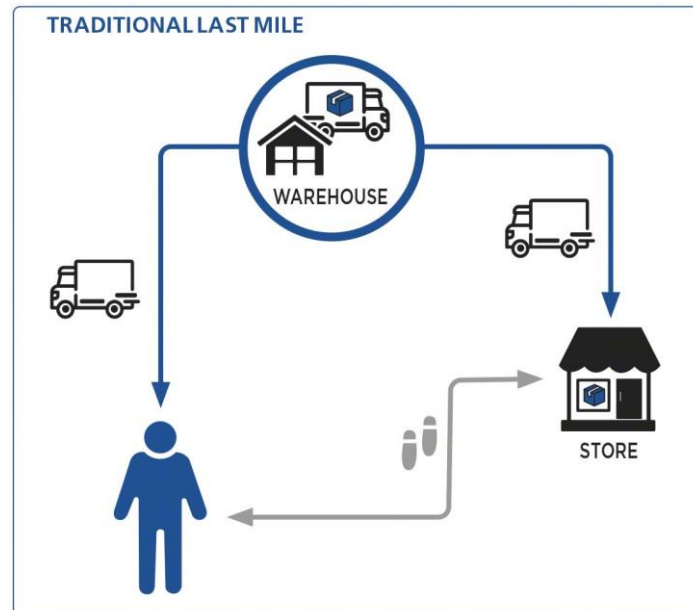
2. The last mile: A current logistical problem

The last mile is not a specific distance of quantification but an important link to complete the logistics distribution system. It is more an expression than an actual measure of distance and the final delivery stage can be several hundred kilometers long. It refers to the distance between the distribution center and the customer. It is the final stage of logistics distribution, which may involve door-to-door delivery.

Last-mile logistics is the final step in the delivery process (Figure 2). It begins at the distribution center and ends when the delivery is successfully completed. It refers to the final step in the delivery process from a distribution center or facility to the end user. Most often, last mile logistics involves the use of parcel or small package carriers to deliver products to consumers. Last-mile logistics allows shippers to get more products to consumers faster and at lower cost.

The last mile is considered the most expensive part of the supply chain. These high costs are related to the many inefficiencies of the last mile and poor environmental performance. The main last-mile problems are related to home deliveries. A second major problem, especially for home deliveries but also for clustered types of receiving, is that for the last mile, the level of consumer density is generally not high enough to operate at an acceptable cost level. It should be clear that once a courier must travel, say, 20 miles to deliver a package, this significantly increases the last-mile costs. Another problem with the last mile, from an economic point of view, is the high degree of critical mass or minimum size needed to set up a last mile network, especially for small retail chains.

Fig. 2: Last mile logistics in the warehouse



Source: Mecalux, 2020¹

In addition, over the past few decades, consumers have become increasingly aware of the environmental issues of logistics and transportation (Hmioui et al., 2020). As a result, they expect a steady decrease in carbon footprint.

But in most cases, they are not willing to make a trade-off between, for example, a longer delivery option and a more environmentally friendly delivery route.

The last mile is where the contact with companies and customers is the longest during all procedures. It directly affects overall customer evaluation and satisfaction as it is the most direct link for logistics companies to transfer business value and influence consumers. Therefore, improving the last mile distribution service level can effectively improve customer satisfaction and loyalty. Thus, several authors have already discussed this topic.

Gevaers et al. (2009) analyzed the significant characteristics that define mail order firms and that define efficiency and cost structures in the last mile. They analyze the characteristics that firms need to execute and the innovative concepts in the last mile to achieve optimization and cost reduction.

Based on the hierarchical analysis model, Aized and Srari (2014) constructed the last mile distribution system and used the Petri net to solve the congestion problem in distribution. The hierarchical modeling is implemented with a dynamic discrete event system. Yang et al. (2014) performed cluster extraction and analysis for electricity consumers. Ehmke and Campbell (2014)

¹¹ <https://www.interlakemecalux.com/blog/last-mile-delivery> (consulted on 12/06/2021).

noted that the delivery method of goods is a key factor in limiting the development of retail e-commerce. Through the development of home delivery mechanism, it can maximize the logistics service, improve customer satisfaction, attract more customers, and bring more profits.

Zhang and Chen (2015) believe that the last mile issue not only includes the distribution problem, but also the upstream and downstream interface, such as the route optimization problem, the choice of transportation modalities, and the customer service quality problems. Zhan et al. (2016) proposed some innovative ideas, such as visual distribution service, express business function evaluation, cabinet cooperation, Express drone, etc. Wang et al. (2016) proposed a large-scale mobile crowd assignment model in which a large number of workers are mobilized to perform last-mile delivery. Comprehensive experiments have been conducted in Singapore and Beijing.

Bányai (2018) discussed the issue of energy efficiency and environmental issues in logistics. In a traditional supply chain, the goal of improving energy efficiency is targeted at each part of the value creation chain. The author describes a real-time scheduling optimization model focused on energy efficiency. The scenario analysis evaluated its performance in increasing energy efficiency in last-mile logistics. Bates et al. (2018) sought to understand how last-mile deliveries in the parcel sector impact roads. They present an analysis of delivery performance and practices in last-mile logistics in central London, quantifying the impact of different levels of experience on overall route efficiency.

Deutsch and Golany (2018) considered the design of a parcel locker network as a solution to the last mile problem in logistics. This involves choosing the optimal number, locations, and sizes of parcel locker facilities.

3. Last mile logistics in Covid-19 vaccination: Prospective visions

3.1. Study methodology: A prospective analysis

The prospective is the process that aims, through a rational and holistic approach, to prepare the future. It does not consist in predicting the future, but in elaborating possible and impossible scenarios in their perceptions of the current moment based on the analysis of available data (Bentalha et al., 2019). Several prospective methods exist in management science: the Delphi method, the business prospective method, and the Prospective Dynamic Interrelational method (PRODIN).

The Delphi method was originally designed to collect data from a group of experts to assist in decision making. The Delphi method has been described as a qualitative, quantitative, and mixed-method approach. Delphi is based on the premise that the predictions of a structured group of individuals are more accurate than those of unstructured groups. Experts respond to questionnaires in two or more rounds. Thus, experts are encouraged to revise their previous responses considering the responses of other members of their panel. It is believed that in this process, the range of responses will narrow, and the group will converge on the correct response. The Delphi method relies on experts who are knowledgeable about a certain topic so that they can predict the outcome of future scenarios, predict the likelihood of an event, or reach a consensus on a particular topic.

The first applications of the Delphi method were in the field of science and technology forecasting. The objective of the method was to combine expert opinions on the probability and expected development time of a particular technology into a single indicator. Although, in its initial conception, the Delphi method was not designed as an open and inclusive participatory process, but rather as a methodology aimed at achieving consensus among stakeholders over time, new variants of the method have emerged and have allowed a wider range of stakeholders to contribute.

For the implementation of the Delphi approach, the researcher provides an iterative individual assessment of the problem with the option to revise this assessment at each iteration. The group assessment is provided each time, with respondents remaining confidential. Delphi panel size requirements are modest (10-18 experts) and follow-up interviews can be considered to enrich the study. The Delphi study does not depend on a representative sample of the population. The only major requirement for a Delphi approach is the selection of qualified experts.

In accordance with this methodology, our approach is based on a deductive reasoning that stems, first, from the theoretical definition of the theoretical frameworks developed. The first step is the formulation of the research outline and the theoretical and conceptual framework. Focusing on academic and professional journals, we collected nearly 32 articles dealing with the theme of last mile logistics and vaccine logistics.

After this first step, a committee was formed to select 12 experts in the field of logistics and supply chain potentially interested in the theme of pandemic logistics and in relation to logistics issues related to COVID-19.

3.2. Results and discussions

We analyzed vaccine logistics from a supply chain perspective. This allowed us to structure different theoretical currents that study the logistic decision problems related to vaccination. At the level of the last mile logistics of Covid-19 vaccines several current approaches and perspectives are questionable.

3.2.1. Micro-consolidation platforms

A frequent solution to improve last-mile delivery and collection would be micro-consolidation platforms, located close to the final destination. These are several actions aimed at bringing together shipments of goods from several shippers or at the address of several recipients, and organizing and executing the routing of the batch thus formed by a carrier.

Conway et al. (2011) identified efficiencies in Manhattan stakeholder behavior using consolidation platforms. Janjevic and Ndiaye (2014) showed that new policies and implementation strategies were essential for the adoption of a consolidation platform in Brussels, Belgium, and collaborative strategies to make it work in Singapore (Handoko and Lau, 2016). Similarly, Verlinde et al. (2012) analyzed consolidation programs in relation to behavior change.

The use of stations or proximity points is an innovative strategy to improve the efficiency of last-mile delivery, especially for the distribution of small and medium-sized goods. This approach is based on the use of a drop-off station where goods can be stored when customers are not at home until they can pick them up, thereby reducing costs and avoiding the risk of delivery failure (Edwards, 2009).

3.2.2. Innovative vehicles

Innovations introduced in the vehicle market have been disruptive: new engine technologies (e.g. autonomous vehicles and new means of delivery). Electric or hybrid vehicles are technological innovations capable of reducing environmental externalities. They have positive impacts on environmental and noise pollution and are mature for the market. The main constraint of electric vehicles is related to the autonomy of the batteries and the long charging time.

Researchers, such as Zunder et al. (2016), are focusing on improving battery performance and optimizing routing in last-mile delivery. Plus, they need refueling network infrastructure that is not yet developed.

In the category of bicycles and tricycles, cargo bikes have been developed in recent years. The electric traction has improved the capacity, becoming in the new generation of cycles almost equal to traditional vehicles. Fully electric vehicles are very important to reduce urban externalities produced by last mile delivery (Menga et al., 2013). Smart logistics with electric vehicles in urban areas seems to be an approach of the future for vaccine distribution (Schau et al., 2015; Ablola et al., 2014).

3.2.3. Collaborative and cooperative urban logistics

The concept of collaborative urban logistics is a new vision of last mile delivery where processes have a better consolidation and synchronization of existing resources. The concept of collaborative urban logistics is based on the sharing of resources and revenues in last mile delivery. Coordination is a key element in this process to ensure synergy between actors (Gunasekaran et al., 2015).

Fewer and smaller vehicles moving around the city also reduce congestion and wear and tear on the infrastructure. The main concept is to share resources, infrastructure, and transportation to perform last-mile delivery in urban areas. The idea is like the code-share agreement service between different airlines at airports (De Souza et al., 2014). The main benefits are reduced investment and management costs, better use of resources, and improved delivery performance in urban areas.

With a shortage of drivers and specialized personnel in all areas, there are currently no personnel available to make the last-mile delivery from the port to the destination of the vaccines. Once the vaccines arrive, distribution will depend heavily on local pharmacies. And as for remote and distant areas, the challenge of the last mile to rural health centers, given the requirements of the vaccine, is much greater. Hence the importance of effective cooperative logistics.

3.2.4. The UAV distribution modes (Drone or Unmanned Aerial Vehicle)

The drone express uses an autonomous program to control the device and uses radio remote control equipment to control a low altitude drone to deliver packages to their destination.

Several research studies have emphasized the current and future role of drones in distribution systems (Song et al., 2018; Grzybowski et al., 2020). Van Steenberghe and Mes (2020) explored how (UAVs) can contribute to humanitarian logistics. Huang et al. (2021) analyzed the role of

drones in transporting emergency supplies. The main finding is that these UAVs have the potential to significantly reduce the time and cost of post-disaster rescue missions. The prerequisite is effective planning of a drone delivery network. Rabta et al. (2018) recounted the applications of drones in last-mile distribution in humanitarian logistics with an optimization model for delivering multiple packages of lightweight relief items (e.g., vaccines, water purification tablets, etc.) by drones to several remote locations in a disaster-prone area.

The advantage of this mode is that it can effectively avoid traffic jams in cities and improve the efficiency of distribution. At the same time, it does not require human intervention, which can reduce costs. The main disadvantage is the inability of drones to deliver vaccines under temperature conditions and in bad weather. Typically, cold supply chain carriers used to transport medical supplies operate at roughly two to eight degrees Celsius. That's okay for most vaccines, which are stored at about four degrees Celsius, and not too far off from the requirements of Moderna's vaccine, which is stable for 30 days between two and eight degrees.

The cold supply chain problem is even more complicated when it comes to distribution, especially in parts of South America, Asia, and Africa. This is especially true about storage requirements. Not only is the climate warmer in these regions, but there may not be the infrastructure to support such storage. For example, if a power outage causes refrigeration to fail, vaccines would likely be rendered useless. Storage capacity will be further hampered by the volumes required, given that these areas are home to over six billion people combined.

Another problem with the use of drones is the ability of citizens to use vaccines without the help of a medical professional. Indeed, this point has an advantage related with the reduction of travel during major pandemics and a disadvantage related with the inability of some citizens to use the vaccines without professional help.

3.2.5. Underground pipeline networks

Underground urban logistics in developed countries has achieved some results. In 1996, the Dutch began studying the underground logistics system linking Hoofd-dorp, Schiphol Airport and the Aslwmeer Flower Market. In 1998, Germany began developing an underground logistics system of about 80 miles. Research on underground logistics in Germany, Japan and the United States shows that the underground logistics system can handle 30% of all express deliveries, and effectively mitigate the pressure of express delivery.

Dong et al. (2019) showed that underground urban logistics, as a complement to the integrated urban transportation system, can significantly improve urban traffic and logistics. Wei et al. (2020) conducted extensive research on the design and optimization of nodes and passages in the underground logistics network. This optimization is considered by the authors to be effective in reducing logistics time cost, exhaust emissions, and congestion costs.

3.2.6. Application of digital technology

Of course, shipment preparation is only one piece of the puzzle. Another important part is complete, real-time visibility into shipments from point of origin to final delivery. This can be achieved through the business intelligence functionality of a transportation management system designed for shipping packages around the world and, where appropriate, partnering with Internet of Things (IoT) providers that provide deep metadata for truck visibility.

Effective management of vaccine cold chain logistics will require precise coordination and cooperation among multiple parties to ensure the quality of the vaccines, which must be temperature-controlled, and the distribution of records for traceability. In addition, the continuity of the process becomes critical from the point of transfer at the manufacturer's receiving point to the subsequent distribution from central storage to the vaccination centers.

Abdul Halim et al. (2021) described the architecture required to integrate IoT and Blockchain into the vaccine supply chain management system to monitor the temperature of the insulated container or cold box. Izikki et al. (2021) analyzed cold chain logistics by exploring the state of the art on the use of IoT in cold chain logistics and particularly in healthcare and vaccine supply chains. The authors identified several challenges facing healthcare and vaccine cold chain logistics and highlighted several benefits of IoT technologies. Cui et al. (2021) discussed a blockchain-based solution to protect the entire vaccine circulation process with a tracking system. The proposed system uses blockchain as a global, unique, and verifiable database to store all circulation data. Through the insertion and querying of data in the global and unique database, the proposed system protects the circulation of vaccines.

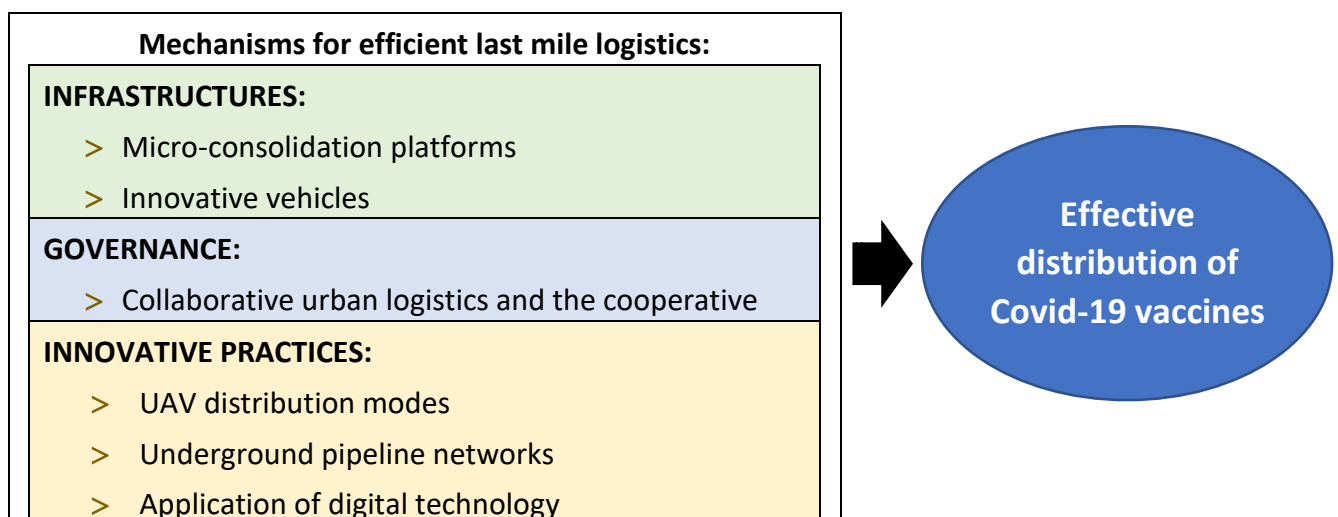
Having information about the exact location of any shipment and the possibility of any delays allows supply chain managers coordinating vaccine distribution to proactively manage shipments in transit, or even potentially divert them, to avoid vaccine degradation. Using a cloud-based, Big Data-enabled digital supply chain system that records every delivery event along a shipment's journey can also provide the data and analytics needed to detect sub-par logistics performance and uncover opportunities to optimize execution for even better results (Bentalha, 2020).

Transportation companies involved in vaccine distribution need to be especially vigilant about cybersecurity. Last December, IBM security experts uncovered large-scale cyberattacks against companies and organizations involved in the transportation and distribution of Covid-19 vaccines.

Highly coveted as a pillar of logistical efficiency, especially in services (He et al., 2019; Simoni et al., 2019; Weber et al., 2018; Liu et al., 2017; Ranieri et al., 2018) and sensitive products (Chevallier et al., 2021; Mangel et al., 2017; Weintraub et al., 2021), last-mile logistics is a key component of successful Covid-19 vaccine distribution (Sahito et al., 2020).

Ultimately, Figure 3 traces the key ingredients of efficient last-mile logistics in the distribution of Covid-19 vaccines.

Fig. 3: Last-mile logistics efficiencies for Covid-19 vaccine distribution



Another challenge of last mile delivery is to understand the interactions between the different actions to create the right balance that suits all public, private and customer actors. It is important to remember that improving last-mile logistics is not just about how deliveries work. The entire supply chain needs to be analyzed and the elements that need to be improved need to be streamlined. Regular use of modern systems that help manage last-mile logistics will also help. They increase efficiency and allow for quicker response to changes and customer demands. Such actions will avoid downtime, delayed deliveries and make more accurate route planning possible.

Conclusion :

Covid-19 is causing considerable human and economic damage. Vaccine manufacturers are racing against the clock to provide vaccines. Health authorities have also tried to anticipate the difficulties by setting priorities and building the most suitable logistics systems possible. But the gap between supply and demand necessarily means just-in-time production, which is more difficult to manage.

Shipping vaccines from one established, well-funded, and well-equipped distribution center to another, while still imposing the scale required to vaccinate 7.8 billion people, involves existing large-scale logistics networks and suppliers with decades of cold chain experience between them. However, localized last-mile vaccine logistics is - at the scale required to overcome Covid-19 - an entirely different prospect.

"Last-mile" logistics, generally defined as the ability to get products from regional hubs to individual customers with varying patterns and within a range of parameters, is critical to the success of businesses across all sectors. Given the imperative to deliver vaccines quickly to the entire population, addressing these logistical challenges is of utmost importance to healthcare organizations.

Everyone is hoping that a successful global rollout of vaccines in 2021 will bring a return to normalcy. By creating flexible and agile supply chains to meet the specific requirements of different vaccines, with real-time visibility of shipments, the logistics industry is helping to play its part in ensuring that every delivery is right the first time, on time, every time. Thus, we have outlined several future opportunities that may be available to supply chains during pandemics.

The paper aimed to explore the best possible practices of vaccine distribution with last mile logistics possibilities. Its main contribution is to provide a theoretical basis for exploring existing and future best practices in pandemic logistics or vaccine distribution. This work can be further developed through empirical studies to provide tests and generalizable results.

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