CONQUERING COVID-19

An Assault Plan for COVID-19 Vaccine Supply Chain Distribution

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The Logistics & Supply Chain Management Society
The Regional Professional Body for Logistics Practitioners

IDC ANALYZE THE FUTURE

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Foreword

As governments, communities, and people around the world grapple with the impacts of the COVID-19 pandemic, the need for collaboration on a local and global level becomes increasingly evident and important. Shared insights that can lead to cohesive, effective responses are imperatives for protection of lives and key to global economic recovery – the co-operation across the healthcare sector has resulted in a discovery pace where a viable vaccine may be available in the coming weeks. Our challenge now is accelerating the administration of a viable vaccine, ensuring that these vaccines can be compliantly transported, without breaking the cold chain from multiple production locations to urban and remote communities across the globe. Now more than ever the important role of transport, logistics and supply chain management is being recognized and will be tested. Professionals and providers across the logistics arena appreciate that the scale of this COVID-ask is unprecedented. Collaboration, co-opetition, leveraging collective experience will certainly put us in a better position than less cohesive approaches - This blueprint that has been consolidated by an experienced and diverse stakeholder community. It provides a foundation for a cohesive response, enabling maximum positive impact and minimal waste at a time where the health and socio-economic well-being of billions depend on timely, efficient handling and distribution.

Margi Van Gogh
Head of Supply Chain & Transport
The World Economic Forum

Executive Summary

The impact of the COVID-19 pandemic is of global significance, and 2020 is not a year that will soon be forgotten. The development of COVID-19 vaccines are imminent and seen as a solution that the world is looking for to see a return to some semblance of normal. When vaccines are available, getting the vaccine from production to the global population will be the next challenge.

Vaccine development is the first step in an extensive distribution process. Governments need to plan and build the strategies, infrastructure, and organization to manage the post-production supply chain for vaccine delivery. There will be significant differences between the global north and the global south in how governments can address these challenges.

A vaccine delivery ecosystem is required to coordinate this supply chain challenge. This VDE is a public-private partnership (PPP) that orchestrates the private and public networks to ensure that populations are effectively inoculated. This blueprint provides an overview that includes problem definition, direction, and opportunities for technology use cases in addressing:

- The global distribution process's scale and complexity, requiring processes, checks, and balances that provide supply chain control.
- The integrity and security of the vaccine, along with the protection of the information that goes with it. This protection level needs to occur through storage, delivery, and transport of the cargo as it travels within and between countries.
- Customs and international border crossing procedures, which need to be reviewed to prevent disruptions and delays, destroying the vaccine through poor temperature control, mishandling or incorrect documentation.
- End-to-end monitoring of temperature, ensuring the integrity of documents and data to meet compliance requirements, and last-mile distribution all need to be assured to reduce waste and slow the pace of the virus.
- The integration with healthcare systems to meet further compliance requirements and coordinate with any ad-hoc or interim facilities or procedures that may be required.
- The complexity of workforce, patient, PPE, and inventory scheduling.

This blueprint serves as an awareness tool to drive open engagement between stakeholders to discuss safe and effective options for ensuring vaccination distribution with minimal waste and maximum integrity to the world's population.

INTRODUCTION

RATIONALE

The challenge of combating COVID-19 is confronting governments across the globe. When a vaccine is available, getting the vaccine from the manufacturing sites to the global population will be the next challenge. While the current emphasis is vaccine development, governments need to plan ahead and build the ecosystem to manage processes, infrastructure, and organization to manage the post-production supply chain.

The scale of this exercise cannot be underestimated, with nothing of this size having been attempted before. Governments, logistics providers, shippers, warehouse providers, and technology vendors will all need to come together to integrate their particular skills and capabilities to ensure success in combating COVID-19.

The objective of this document, developed by the Logistics & Supply Chain Management Society (LSCMS) in collaboration with IDC, is to highlight and emphasize how government and industry can harness collective action for inclusive, safe, and sustainable distribution of coronavirus vaccines. When the vaccines become available, cold-chain compliant logistics solutions will be central to arresting this pandemic and aiding global socio-economic recovery. This playbook will discuss the challenges and opportunities for value chain and transport eco-system collaboration to facilitate safer, more sustainable, and globally inclusive distribution.

COORDINATING THE SUPPLY CHAIN CHALLENGE

The performance of logistics networks across the globe is relatively uneven, ranging from reliable infrastructure in the developed economies to less mature in the emerging ones. There has, however, been substantial effort put into building up infrastructure to support the improvement of distribution networks. The Logistics Performance Index (LPI) is considered a good gauge of the level of development of a country's logistics and transport infrastructure.

The World Bank LPI is a qualitative and quantitative index built through a survey of global supply chain and logistics operators giving feedback on countries where they operate, and data on key performance components that affect logistics effectiveness (e.g., infrastructure, road density, etc.) [1].

IATA identified that one of the crucial areas of focus is to prevent delay of vaccine shipments because of customs, border procedures, or the country's logistics infrastructure. The world bank LPI indicates countries where customs and border procedures are efficient, or not, as the case may be. Therefore, it is a good indicator for stakeholders to use to identify potential weaknesses and areas that require greater emphasis across the supply chain.

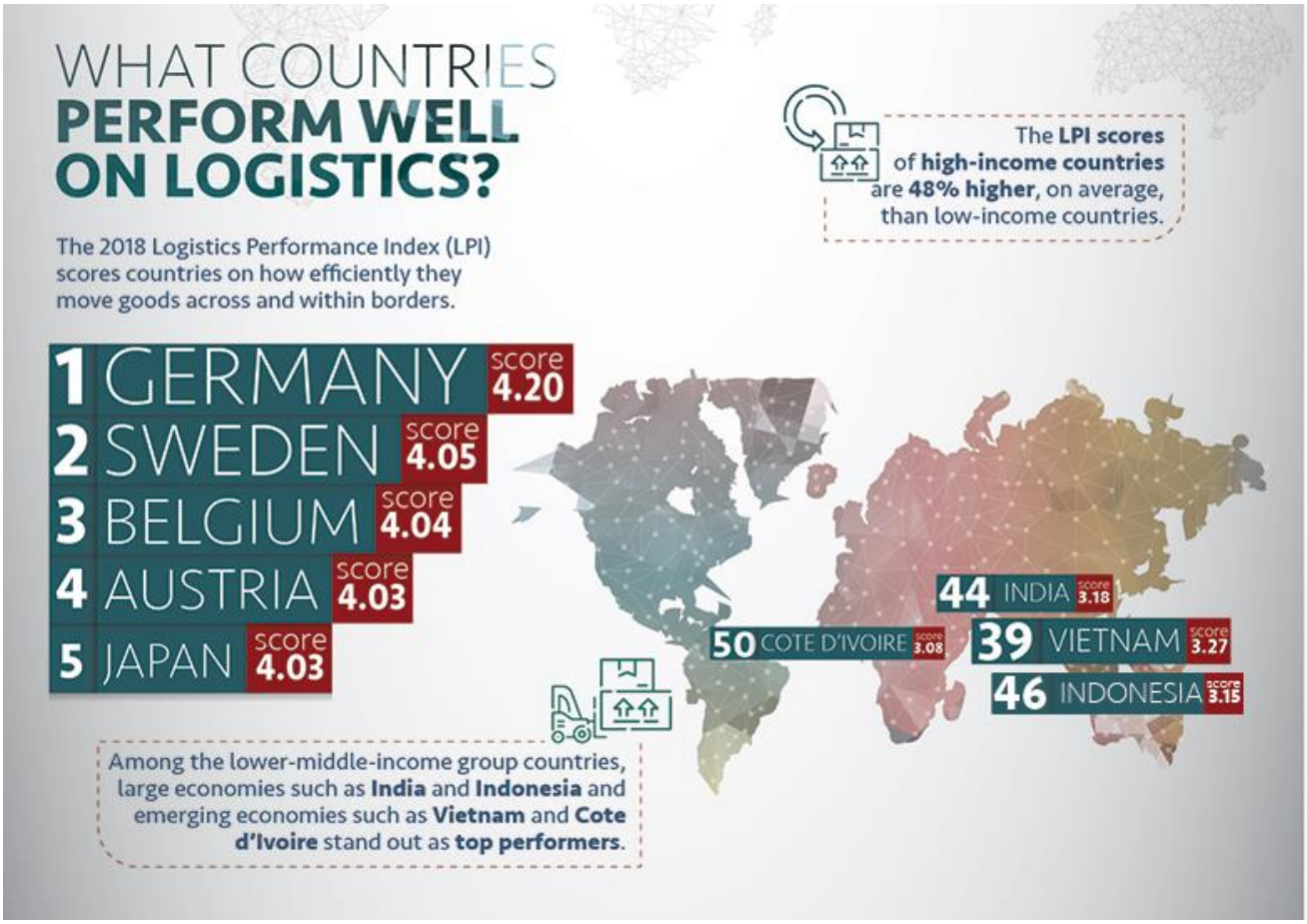

Figure 1. Which countries are known for logistics performance? Source: World Bank.

THE VACCINE PRODUCT FLOW

Pharmaceutical production typically occurs in capital cities with access to skilled labour, competent and stable infrastructure, and transport connectivity. The COVID-19 vaccine, when it is available, will require distribution to almost every part of the world, from high income countries to low income countries.

Distribution alone will be a mammoth task. It will be further complicated if there is a need to ship the vaccines at temperatures as low as -80 degrees Celsius. Many countries do not have the physical infrastructure to store vaccines in the quantities needed for a prolonged period at such extreme temperatures. The more remote the locations are, the more complicated this challenge becomes. The complexity increases exponentially as the vaccine travels further downstream in the distribution channel.

Suppose the more conventional temperature range of +2 to +8 degrees Celsius is suitable for vaccination storage. In that case, it allows for more efficient distribution to end users globally since transport can rely on available capabilities, capacities, and prior experience and knowledge. Even within this temperature range, there will still be challenges. Issues will likely arise, especially downstream, as a good proportion of countries have limited cold chain infrastructure – with many of these in high-temperature countries.

Lastly, no one service provider or entity has all the necessary infrastructure. Warehouses, storage containers, facilities, aircraft, vessels, trains, or vans are required to offer a complete, end-to-end solution for each country or region from the source of manufacture to where the vaccine is made available.

For a complete and robust system to be put in place and available in the short time required, the establishment of Public-Private Partnerships (PPP) with a range of government and non-government entities must occur in each country. Government and NGOs will need to implement extraordinary measures to ensure adapt standard procedures to facilitate the rapid flow of the vaccine to distribution points. Vaccine distribution, storage, and transport capacity will have to be increased and scaled for an as yet indeterminate period to reach the global population.

This blueprint does not address equity of distribution. The determination of priorities will occur at the country or regional level. Still, it is relevant to note that this will affect distribution requirements such as tracking, quantity and security.

GETTING IT THERE (TRANSPORTATION)

At the outset, it needs to be understood that not 100% of the vaccines, when they are available, will need to be shipped internationally or domestically by air. A combination of modes including air, ocean, and road freight will send the vaccines globally, with the possibility of multimodal options selected. Additionally, in-situ or in-country manufacturing will take place in countries like Australia and the United States.

Storage is necessary for various stages of the finished goods vaccine supply chain from the point of manufacturing, in-transit, and last mile.

Given the scope and size of the supply chain challenge to store and ship vaccines globally, no single second- or third-party logistics provider (2PL or 3PL) will be able to handle the entire end-to-end supply chain.

THE VACCINE DEPLOYMENT ECOSYSTEM (VDE)

THE COORDINATING ROLE

The requirements of coordinating multiple logistics providers, warehouse providers, last mile fulfillment, returns, information and financial flows, and government will require a coordinated ecosystem approach. This will require a lead or coordinating service provider. This provider will need to work in partnership with the lead public body in each given country to coordinate and manage the vaccine supply chain in that country or region. This service provider, fourth-party logistics provider (4PL), or lead logistics provider (LLP) will need to work to ensure supply chain visibility and planning is enabled through accurate and real-time data. Ideally, a partnership with a suitable technology provider or consortium will facilitate this capability and provide the rapid provision of a platform or tool. Stakeholders can monitor the vaccine supply chain's performance, and swift corrective action can then occur as the vaccine undertakes its journey from manufacturer to the patient's arm.

THE VACCINE DEPLOYMENT ECOSYSTEM

The importance of a close public-private partnership (PPP) that involves multiple stakeholders from private, non-governmental organizations (NGOs) and public institutions cannot be over-emphasized and is crucial to the success of any vaccine supply chain initiative. Traditional industry supply chains interacting with governments and institutions have limits to the scale at which they can efficiently operate, especially when working with scarce means. Given the scale of the challenge the need to develop an ecosystem across all the parties will be critical for success. This is an opportunity for a Vaccine Deployment Ecosystem (VDE), comprising the stakeholders as indicated in figure 2, to orchestrate the elements described in this document to enable regions and nations to scale up to the magnitude required and provide an effective distribution ecosystem for the vaccine from production to injection.

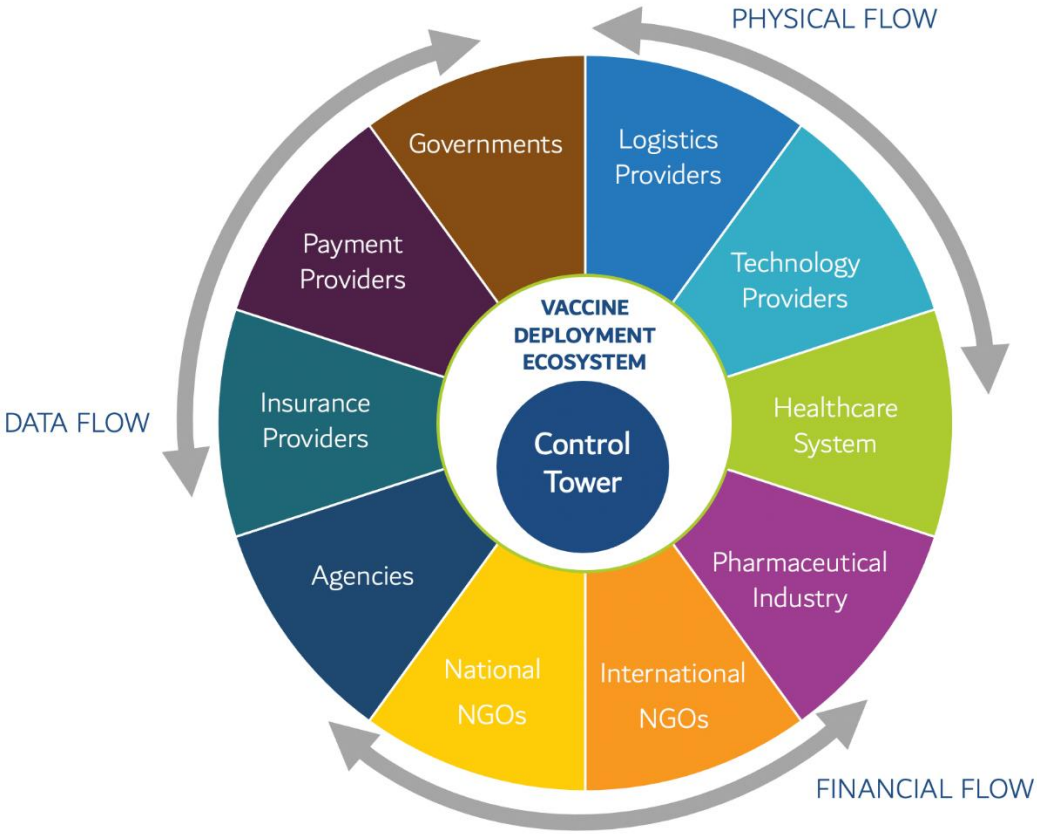

Figure 2: The Vaccine Deployment Ecosystem

ADDRESSING THE SCALE AND COMPLEXITY OF THE SUPPLY CHAIN CHALLENGE

The scale and complexity of the COVID-19 vaccine supply chain is only just starting to be understood. Unlike MERS, SARS, and Ebola, this pandemic has affected every person and the demand for the vaccine will be unlike anything the pharmaceutical supply chain has had to fulfil before.

As figure 3 highlights, supply chain and logistics activities to support cargo volume in terms of shipment volume and storage space will be a consideration. Considerations for adequate shelf space, inventory allocation to ensure adequate shelf life, labeling requirements for individual countries are needed. Coupled with this is the need for the additional vaccination equipment – syringes, swabs, plasters, etc, the need to ensure the vaccine's integrity (especially temperature monitoring), and then the challenge in managing mass vaccination.

> *We see one of the greatest challenges to be solved is the ability to optimize the allocation of supply and distribution to demand in support of mission priorities in case of hot spot and changing prioritization across countries with varied regulations. This will be compounded by the supply and transportation constraints (cold storage and life) and availabilities. Manufacturers will require multi-enterprises working together to stack projected inventories for all critical materials and production capacity utilization, visualize the allocation of supply to demand across the entire supply chain from end to end and identify bottlenecks to fulfilmentnd distribution priorities and dynamically repositioning vaccine inventories. Organizations should be aware of the pressure from prioritization of vaccine distribution and be prepared for disruptions with alternative supply chains.*
>
> -- Thomas Muth
> DELMIA Strategic Business Development & Offer Marketing Director
> Dassault Systèmes B.V.

Additionally, coordination is required to manage the supply chain, coordinating the transportation systems, coordinating the storage and last-mile distribution, and providing the overall visibility across the entire system. Finally, companies must address the availability and management of personnel to assist in the distribution process and final administration. Greater collaboration is a solution to this; however, companies will need to address cross-organization communication and resource management.

Multiple track and trace systems, allowing traceability from the manufacturing site, through distribution centres, between and across countries to the final vaccination centre will generate enormous amounts of data. This data will need to be integrated with vaccination management to notifications to ensure people attend the vaccination centres at a timely rate to avoid overcrowding. Data verifying the vaccines' traceability, shipping process integrity, temperature control - all this data will need to be stored, verified, and secured.

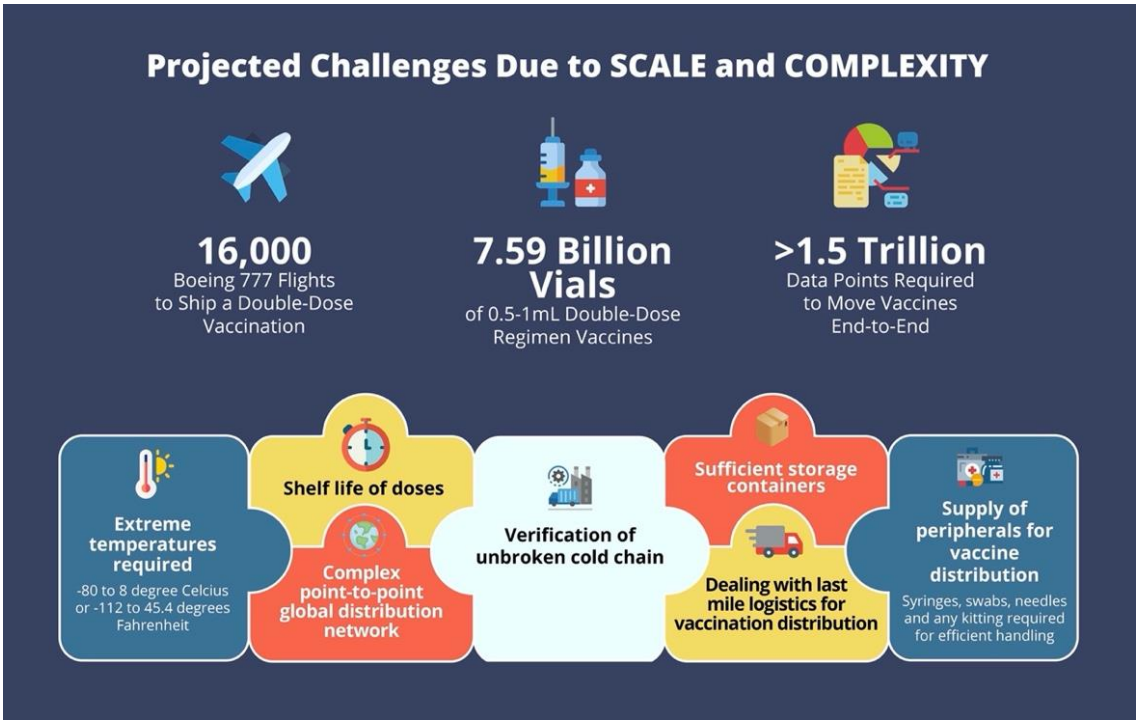

Figure 3. Projected challenges due to scale and complexity of the COVID-19 vaccine supply chain

This section will address the complexity of the different aspects of the supply chain journey. For each element, use cases that provide opportunities for technology to support solutions are outlined. These use cases will briefly describe the key goal or desired outcome and the potential technologies supporting that outcome.

A. SUPPLY CHAIN CONTROL

> *Pharmaceutical companies and 3PLs face unprecedented challenges in distributing COVID-19 vaccines, including scaling massively and instantaneously, navigating different regulatory timelines and distribution priorities and dynamically repositioning vaccine inventories. Organizations should be aware of the pressure from prioritization of vaccine distribution and be prepared for disruptions with alternative supply chains.*
>
> -- Antonio Boccalandro, President, Blue Yonder APAC

The critical element of managing the complete vaccination supply chain is to provide end-to-end visibility that allows for full orchestration and remote management. The lack of visibility hinders the ability to respond to changes and disruptions with an agility that will ensure delivery and optimize costs. The shift to an ecosystem response approach requires that the supply chain control tower be upgraded to have an "ecosystem control tower." This control will also relate to setting standards and ensuring integration across the supply chain. A modern control tower capability permits operators to see what is happening in the supply chain and the broader business. It allows partners to be able to analyze data in real- or near-real-time and then take action. Supply chains can then act as a cohesive whole, providing a resilient path for the vaccine from producer to the patient's arm.

While the use of the term "supply chain control tower" implies a single entity, system or platform, the reality is that it is an aggregation of many different digital systems. Each part of the control tower coordinates a specific part of the supply chain. This does not mean in order to coordinate the vaccination of large portions of the population that companies or governments must invest in a whole series of control towers. Instead, partnerships will require that integration occurs between systems to ensure the modern control tower will have a flow of information back and forth, allowing for the required visibility. Companies are already beginning to utilize some aspects of cloud as a delivery mechanism for transaction data and analytics. In IDC's 2020 Supply Chain Survey, 90% of companies are participating in at least one cloud-based supply chain network, with two-thirds of those participating in more than one. The interconnected platforms are allowing for the scale to support the data necessary to enable a true VDE. For example, a logistics control tower will ingest the

appropriate data to facilitate the next actions related to fulfillment tasks. The control tower's inventory management portion will help companies and institutions understand what inventory they have, where it is, and how deployment can occur. The information flows through manufacturers, transportation providers, distributors, governments, and hospitals. The main requirement here is that integration permits data to flow between the different supply chain parties. This data allows them to have visibility, support decisions with data, and quickly act on that data, providing the necessary agility.

TECHNOLOGY USE CASES

Dynamic Supply Network Management	Distributed Supply Chain Management	Supply Chain Automation
KEY: Through intelligent communication and scheduling, bottlenecks in distribution and supply would be alleviated before they happened through predictive analytics.	**KEY:** Drive greater operational efficiencies through improved interoperability with external trading partners to provide increased visibility of movement of medical supplies and other goods throughout the supply chain. Improve the ability to track and trace shipments from manufacturer to distributors to delivery.	**KEY:** Automation of the components of the supply chain – trucks, trains and ports/shipping – driving predictability, variability; thereby reducing costs, inclusion of external data sets e.g weather information.
Technology deployed: Cognitive, Analytics, B2B Networks, Cloud	Technology deployed: Distributed ledger technology; Smart contracts; Identity management	Technology deployed: Cloud, IoT, mobility, cognitive/AI

Source: IDC 2020

B. LOT LINEAGE AND INTEGRITY

Serialization standards have been improving globally, and with this, pharmaceutical companies are adopting batch-level traceability to guarantee drug and vaccine provenance. However, when something goes wrong, determining the source and location of batches can take days or weeks due to a lack of integration and disparate processes, especially in emerging markets. In that amount of time, the rest of the contaminated batch can travel further and be used on hundreds of patients before identifying and removing contaminated doses from the supply chain. This problem is exacerbated if doses are falsified or are counterfeit. Track and trace is mostly a reactive function, requiring tracing of a material's origin back through the supply chain. With high-volume distribution comes the need to ensure rapid authentication and verification of doses.

Additionally, it is not only the authenticity that needs to be verified. The handling of the dose, including ensuring an unbroken cold chain that meets the required temperature conditions, or managing the shelf life of vaccines while balancing supply and demand.

Centralized platforms exist where third-party participants in pharmaceutical supply chains can share relevant information such as shipping documentation and product master data with each other. Alternative options such as creating one-to-one connections between company systems exist, but are costly and require tracking of relationships down the supply chain. Using platforms that allow for multiple party integration to follow shipments as they are dispersed throughout the supply chain, and integrate sensor data to monitor temperature requirements (see the section under 'Temperature'), combined with mobile authentication systems provide an efficient way of tracking vaccinations and ensuring the integrity of the dose.

TECHNOLOGY USE CASES

Lot Lineage	Next generation digital security	Global Unified Track & Trace
KEY: Enable real-time access to a product's history throughout the supply chain to reduce the time spent tracking and tracing	**KEY:** A cybersecurity strategy supported with current technologies. giving patients confidence that their personal information is secure.	**KEY:** Detect counterfeit and diversions, patient safety, global recalls, optimize drug supply chain
Technology deployed: Blockchain, cloud, and IoT	**Technology deployed:** Blockchain, end-to-end encryption, advanced security analytics	**Technology deployed:** Cloud, IoT, blockchain, supply chain analytics

Source: IDC 2020

C. PHYSICAL SECURITY AND INTEGRITY

High-value vaccine transportation will require security measures over the entire transportation process. The cargo needs to be secured and monitored with preventive measures against fraud, hijacking, and theft at each distribution stage. Supply chain participants will need to maintain physical security while also preserving the integrity of the vaccine. Additionally, external variables such as light and temperature are a significant factor in ensuring vaccine shelf life and quality and must be recorded throughout the vaccine's journey.

The IoT sensors used, including geospatial, temporal and temperature probes used to generate and record accurately timestamped temperature and movements of cargo must be reliable with secure data storage systems. Logging and encryption must be in place to ensure data integrity and prevent any alterations. All transporters must then take responsibility for recording and sharing data relevant to the point-to-point stock movement. Sensors need to move with the cargo and transport vehicles, especially land transport vehicles, where external risk factors are highest, and the cargo is most vulnerable. These sensors will need to connect real-time to communications networks to record data and alert personnel based on critical milestones[2]. Events covered should include logistics timing and efficiency, fraud prevention, critical-failure warnings, and prevention and distribution efficiency analysis. The parameters for alerts and recording should consist of all measurement values, timestamp, intervals, limits, status, and location. [4]

To add to the complexity, each country may be receiving and distributing different vaccine lots from different sources (i.e., Manufacturers and countries) over different batches and in stages. Different vaccines may have diverse storage temperatures and humidity constraints, and differing tolerances for temperature excursion. While not desirable, temperature variations (or excursions) are bound to occur at some point during the supply chain journey. However, not all excursions (minor) may render the vaccines invalid or unfit for use. The temperature variation tolerances must be defined and qualified from an authoritative source to avoid wastage and avoid the ineffective administration of vaccines to a particular populace.

The different vaccines will come equipped with different temperature measuring and tracking devices with proprietary, closed-loop integrity monitoring by some manufacturers. These devices add to the complexity of data integration. Ultimately, the variety of parameters monitored, devices used, locations visited, and environmental conditions to which the vaccine is exposed requires data to be collected and administered by each company in the supply chain. The safety, security, and integrity of the vaccine inventory are better managed from a national or global perspective if this data integrates with an overarching control tower platform[5]. If planned appropriately, this is certainly an achievable outcome as vaccines procurement will be centrally managed and distributed by government or semi-government agencies. In-country distribution from the point of importation to the vaccination point will be centrally administered and operated and not commercially driven on a decentralized basis.

TECHNOLOGY USE CASES

Physical Safety & Risk Management	Geo Spatial Safety	Individualized Facility Access
KEY: Reduce safety violations, accidents and risk by training, enabling visibility and enforcing policies, SOP's and training compliance requirements.	**KEY:** Continuous automated monitoring of processes across all physical locations to support improved safety, curb potential physical risks, and provide access control.	**KEY:** Control access to buildings, facilities, and other institutional spaces, restricting entry by unauthorized individuals.
Technology deployed: IoT, Computer Vision, AI/ML, Risk & Safety Mgt Software, Learning/Content System	**Technology deployed:** Sensors, cameras, AI/ML, wearables	**Technology Deployed:** IoT, AI, GIS, and smart networks

Source: IDC 2020

D. CYBERSECURITY

The WHO has reported a 500% increase in cyberattacks. These attacks most commonly involve spam emails using fake URLs, malware, or social engineering to access usernames and passwords. In the context of this blueprint, at risk is corporate intellectual property (IP) and patient data. The potential for exploitation increases as employees from companies in the supply chain must work from home. Employees moving away from centralized corporate networks to distributed home-based connections increase risk unless companies take measures to ensure they are hardening security.

The objective of data security is to apply the appropriate controls that ensure the desired level of protection for:

- **Confidentiality:** To protect the content from being disclosed to unauthorized entities or individuals
- **Integrity:** To validate the content and protect it from changing or identifying changes as it is accessed and/or transmitted over time
- **Availability:** To allow the intended use of data for productivity and other purposes

Actions that companies can take include:

- **Use cloud services.** Services include labels such as Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS). The details of the individual services provided under these labels are beyond the scope of this document, but they have the benefit of increasing the effectiveness of operations. While increasing connectivity may seem counterintuitive when discussing security, cloud services often have more security protocols than most companies. Companies will need to train employees to be vigilant against emails that invite them to enter username and password information or configure two-factor authentication (2FA) to increase login security.
- **Monitor data movements.** Data is constantly flowing into, out of, and throughout the organization's network and systems. Use sensors to identify when and where sensitive data is transmitted to provide critical insights into whether the information is being used legitimately or leaked, either purposefully or mistakenly. Place these sensors at crucial access positions such as email gateways and internet access points.
- **Tighten access control.** Allow access to the data for the minimum necessary number of individuals. Introduce capabilities that prevent the sending of sensitive data via email or other

unauthorized file transfer solutions. Consider access control in conjunction with encryption to provide policy-based access at the individual file level.

- **Implement secure off-site networks.** Consider using a virtual private network (VPN) to secure remote access to company data. VPNs use techniques such as the encryption of data while moving between servers and remote locations to safeguard information security.
- **Manage 3rd party supply chain risk.** As the number of partners and connectivity to those partners increases, the opportunities for cyberattacks increases. The publicity associate with the COVID-19 vaccine may also excite unwanted attention to gain access to systems, proprietary, or personal data. It is necessary for companies involved in this distribution to evaluate the cybersecurity health of the third-party ecosystem and determine the risk levels of partners.

TECHNOLOGY USE CASES

Regulatory Cybersecurity Compliance	Cyber-Risk Management
KEY: Organizations plan for a continuation of increasingly prescriptive cyber regulations around data privacy and protection. Firms must adapt to meet evolving multi-jurisdictional requirements.	**KEY:** With extremely sensitive customer data in hand, insurance organizations must have strong ongoing commitment to manage cyber risks smartly and effectively, not just to adhere to regulatory requirements, but to also manage customer trust and brand reputation.
Technology deployed: AI, RPA, dynamic security assessments, third-party risk scoring, advanced application security testing	**Technology deployed:** Advanced analytics, next-gen security

Source: IDC 2020

E. DRUG DELIVERY

IN-COUNTRY VACCINE TRANSPORTATION

There are three main stages of domestic transportation that will need to take place once a vaccine arrives in a given country.

1. Port / Airport / Border to Distribution Centre
2. Distribution Centre to Hospital, Clinic or Vaccination Centre
3. Secondary warehouse / Holding facilities to Hospital, Clinic or Vaccination Centre

Suppose the use of a uniform tracking and tracing technology is not possible from the manufacturer to the final destination of the vaccine. In that case, tracking the vaccine must occur from when it crosses the border in a country to the final administration of the vaccine. At the point of entry into the country, supplier verification and cold-chain integrity must occur to prove product authenticity. Processes will need to address:

- Integrity. Refer to the earlier section on lot lineage regarding the traceability requirements. Also, temperature integrity will need to be assured.
- Inventory position. The reverse logistics section will talk to repositioning requirements should vaccine inventory need to be moved to a location where it can be utilized better.

- Security. While this may not necessarily be a concern in the global north, there may be fear, mistrust, and concerns about affordability in some locations that will result in pilferage, theft, and counterfeiting.

Data Management & Security	***Route & Location Information***	***Order Management & Status***	***Physical Security***
Encryption of data at rest and in transit	*Route monitoring and geofencing*	*Digital job order management*	*On-demand video and surveillance*
Data loss prevention in place	*Real time alerts on change in sensor status*	*Proof of delivery and traceability*	*Remote locking and unlocking*
Big data handling capabilities with analytical technology	*Threshold monitoring on temperature measurements*	*Sensor logging (eg. Temperature, tilt, asset performance, etc)*	*Vehicle tracking and immobilization*

Figure 4: TMS support requirements to support COVID-19 vaccine distribution3

A plethora of transport management system (TMS) providers exist to manage the transportation of the vaccine, including addressing requirements for data management and security, route and location information, order management, and physical security (refer figure 4).[7] As discussed in the section on supply chain control, integration should be an important consideration as supply chain visibility should be heightened to increase agility in responding to changing requirements during the vaccination distribution process.

TECHNOLOGY USE CASES

Managed Transportation (4PL)	**Traceability**	**Dynamic Capacity Balancing**
KEY: This 4PL model assigns one entity to manage many separate parties through systems integration, best practice implementation, and data aggregation. Having fewer or even a single provider in a "managed transportation" model allows for greater control tower visibility, improved logistics expertise, best practice implementation, and continuous improvements.	**KEY:** Ensure a safe and secure supply chain that can track items, lots and shipments from production through to the patient through connected intelligent systems that store and collaboratively share chain of custody information.	**KEY:** Develop mode and route modelling capabilities that maximize available capacity based on short-term demand forecasts. Adjust capacity requirements, thereby reducing empty miles.
Technology deployed: Enterprise hardware, personal devices, cloud, big data/analytics, blockchain, mobile, connectivity services, and transportation management systems (TMS)	**Technology deployed:** Cloud, Networks, RFID, IoT, WMS, TMS, GTM, asset management	**Technology deployed:** Cloud applications, network and routing optimization software, procurement, and transportation management systems

Source: IDC 2020

IN COUNTRY WAREHOUSING / CENTRAL DISTRIBUTION CENTRE

It will be necessary to makes use of local storage and fulfillment capacities to receive entire pallets and then break them down into parcel-sized units for warehousing and subsequent last-mile delivery. This would have to be the modus operandi for large destination countries or regions and a long-term solution for vaccine types that can be transported under less stringent temperature requirements. For strict temperature handling, more detailed information can be found under the section on the availability and quality of cold storage.

Implications of cost-cutting or lean management programs are a consideration in that they intend to increase efficiency. However, they could potentially impact the quality of handling during the distribution of vaccines. Time pressure could cause issues with quality checks, skipping of steps resulting in reduced shipment quality, insufficient checking of supplier certification, or documentation problems.

TECHNOLOGY USE CASES

Smart Warehousing	Real-time Inventory Management	Individualized Facility Access
KEY: Tightly integrated process workflow and physical automation provide augmented and autonomous execution in the warehouse.	**KEY:** Real time visibility to inventory in storage / facilities enabled by IoT and collaborative supplier relationships. This improves order orchestration and fulfillment service levels.	**KEY:** Control access to buildings, facilities, and other institutional spaces, restricting entry by unauthorized individuals.
Technology deployed: Robotics, AR/VR, cloud, cognitive, and mobile, ruggedized devices	**Technology deployed:** Cloud, industry cloud, IoT, analytics, AI/ML, blockchain, inventory management, mobile	**Technology Deployed:** IoT, AI, GIS, and smart networks

Source: IDC 2020

F. COVID CUSTOMS & INTERNATIONAL BORDER CROSSING

> *Importers and exporters will likely need to plan for both regulatory and political constraints designed to regulate vaccine trade across borders. Import admissibility restrictions will ensure vaccines comply with national health and safety standards of importing countries. Likewise, protectionist policies will likely drive export controls to ensure vaccine availability at home.*
>
> -- E2Open

A critical area where the COVID-19 vaccine distribution supply chain could fail would be at the point it crosses an international border. Many countries have complicated and specific border control procedures. In developing countries, primarily in the global south, this is an even more cumbersome and lengthy process often influenced by corruption and illegal practices.

A country's ranking on the LPI mentioned above is often a reflection of how good or otherwise a country's customs and border control processes are. Regardless of whether the vaccines will be shipped in active or passive temperature-controlled packaging (TCP), shipments stuck at the port or point of entry can quickly degrade and be deemed unusable.

As part of the plan put in place at the country level, engagement with customs and border control authorities is paramount to ensuring the smooth flow of vaccines when they are shipped. To facilitate the flow, countries can consider the implementation of green lanes to expedite processing at the border and look at trade automation processes that integrate the flow of vaccines through the border, facilitated by cloud-based processing of documentation and the use of sensors to verify authenticity.

TECHNOLOGY USE CASES

Connected Ports & Marine Transport	Global Trade Automation
KEY: Secure and efficient cargo movements through ports and ferry terminals for more efficient and more secure operations at ports	**KEY:** Instrumentation of physical containers is integrated with trade systems/distributed ledger-based settlement for both import and export of goods, allowing for streamlined "green lane" processing and improving time through customs.
Technology deployed: GPS, sensors, wireless communications, WIFI, IoT, cloud-enabled analytics, mobile	**Technology deployed:** Blockchain/trade systems, BDA, industry cloud, mobile, and IoT

Source: IDC 2020

G. AVAILABILITY AND QUALITY OF COLD STORAGE

TEMPERATURE CONTROL

Ensuring correct temperature control throughout the supply chain is critical to the storage and transportation of vaccines and any pharmaceutical products. There is a need to maintain specific temperature bands under which vaccines are stored and transported.[8]

PRODUCT STORAGE

The storage facility site will need to have the necessary licenses and permits from the relevant regulator within the given country or region to store and handle medicinal products for human consumption.

Unless a waiver (whether temporary or permanent) is given in consideration of the critical nature of ensuring necessary levels of a population are vaccinated, the site will need to have certification by International Certification Body of facilities, storage, and operations in compliance with international good practice (GxP) guidelines and be equipped with critical components such as temperature monitoring devices, alarms and back-up generators.

The vaccines currently being developed will require varying degrees of temperature-controlled storage. In conforming to GxP guidelines, this would essentially mean that temperature-controlled storage facilities (e.g. cold rooms, Walk-in or standalone freezer units), needs to be subject to:

- Qualification Unless a waiver (whether temporary or permanent) is given in consideration of the critical nature of ensuring necessary levels of a population are vaccinated, this involves documented testing to ensure that pre-defined acceptance criteria are met with a high degree of confidence.
- Checking. Ensure the equipment is functioning well.
- Verification. The application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine compliance with the GxP principles.
- Inspection. Design Qualification (DQ), Installation Qualification (IQ), Operational Qualification (OQ), Performance Qualification (PQ)
- Validation. Documented testing demonstrates that a process consistently produces results meeting pre-defined acceptance criteria. Series of qualifications should be included in the Validation Master Plan (VMP) [9]

Detailed Standard Operating Procedures (SOPs) that are aligned and in compliance with the overall supply chain plan to ensure vaccine quality and integrity are maintained will need to be developed and will encompass elements such as:

- Documentation and Handling of Inbound Product
- Storage Handling, Pick, Pack Operations
- Packing Requirements for Outbound Product – Both secondary and primary
- Documentation and Handling of Outbound Product [9]

MASTER VALIDATION PLAN

The Master Validation Plan is a planned summary of qualification activities of facilities that is an overview of the validation program and includes components such as the organizational structure of the site, regulatory requirements, approach and schedule of validation.[9]

STORAGE OF SUPPORTING PERIPHERALS

Along with the vaccine, there will also be a need to store the supporting medical peripherals such as personal protection equipment (PPE) used by front line workers, medical syringes, storage of used equipment for subsequent disposal and the necessary coolants that fuel the vaccine chillers for transport and deployment; this will be especially crucial for regions such as the Global South which have tropical climates or more extreme high temperatures. [1]

FUTURE DEVELOPMENT

Some suggestions could include intensifying existing facilities via the allowances for more Gross Floor Area (GFA) to be built (e.g. increasing plot ratio, releasing more land near existing facilities for development) or giving incentives such as tax breaks to allow investors and developers to do speculative development in certain areas that were previously not economically viable; allowing speculative developments in new areas would extend and expand the existing cold chain networks which could benefit the economy in the long term post-COVID-19.[1]

TECHNOLOGY USE CASES

Smart Warehousing	Configured Workflows	Cold Chain/IoT Data Records
KEY: Tightly integrated process workflow and physical automation provide augmented and autonomous execution in the warehouse.	**KEY:** Configured workflows of best practice processes ensure product quality and service-levels, allowing scalability of distribution	**KEY:** Help life science companies and supply chain participants to transmit and store time, temperature, and location of cold chain shipments to maintain safety and effectiveness while intelligently deploying inventory.
Technology deployed: Robotics, AR/VR, cloud, cognitive, and mobile, ruggedized devices	**Technology deployed:** Personal devices, cloud, big data and analytics, mobile, connectivity services, and transportation management systems	**Technology Deployed:** IoT, networks and connectivity, supply chain analytics

Source: IDC 2020

H. TRANSPORTATION AND MOVEMENT

Supply chains pre-COVID-19 were already very siloed and fragmented. Developments in the last months have exacerbated the situation significantly. Labour shortages, grounded commercial fleets, and closed borders are new challenges that have gripped supply chains globally.

The logistics industry has been significantly disrupted due to COVID-19. In particular, the air freight industry has already been in turmoil as a result of the pandemic, with pharmaceutical companies already absorbing higher air freight costs. COVID-19 vaccine distribution will radically increase demand and will have impact on the pricing for cold chain transportation – both land and air. Prioritization decisions will need to be made as increased e-commerce transactions have added to demand for last mile logistics.

> *Vaccine distribution and transportation will require special considerations related to delivery urgency, temperature control sensitivities and end-to-end traceability. Initial manufacturing will likely be centralized in a few countries, with complex multi-modal global distribution by air and road arrangements. As intellectual property is shared, manufacturing will localize, shifting the focus to more national and regional distribution.*
>
> -- E2Open

When a vaccine is available, it will not necessarily be transported by air across the globe simultaneously. Within Europe, for example, much of the vaccine can be distributed by road. Some countries, like Australia, have already indicated an intention to manufacture the vaccine in-country. Additionally, a complete regimen, be it a single or double dose, will not be available immediately for everyone within a population. Also, not every single person may want to or need to be vaccinated.

When it comes to execution, many design choices must be made for the vaccine distribution supply chain. These decisions will be made within the context of traditional business drivers such as cost, lead-time and balancing supply and demand. Additional influencers also come into play including maintaining quality and product integrity, the location of storage nodes within the supply network, delivery performance, differentiation of product storage requirements, inventory optimization, and risk management.

Aside from the physical flow of product in a supply chain, information needs to flow upstream and downstream. This information flow seldom happens in the best of circumstances.

Given the vast number of participants in a supply chain ecosystem —exporters, forwarders, importers, truckers, factories, customs, distribution centres, customs brokers, health authorities and carriers — ensuring cohesive collaboration is a delicate ongoing task. Factoring in different channels of communication, for example WhatsApp, emails, physical couriers, timelines become a huge variable and this removes the much-needed predictability in vaccine supply that countries greatly affected by the pandemic desperately require.

PHYSICAL SHIPPING DOCUMENTS POSE AN ADDITIONAL RISK

In cross border supply chains, the various means of transmitting shipping documentation also pose substantial risks and challenges in the shipment of vaccines.[4]

VACCINE INTEGRITY DURING SHIPMENT

The efficacy of vaccines are in part due to effective storage and handling, and this applies in-transit throughout the entire supply chain journey – from the time they are produced, until they are administered. In order to effectively maintain integrity of cold chain handling, temperature control and monitoring must occur.

Temperature control and monitoring require either active or passive solutions, and usually fall under the category of temperature-controlled packaging (TCP). TCP solutions are usually described as either "Active" or "Passive" solutions.

Refrigerated or reefer containers provide temperature controlled environments during transportation

Active solutions such as refrigerated (or reefer) trucks or containers rely on an external source of power, such as battery, electricity, or dry ice. They are reliable and offer big payload spaces, however, there is limited supply of active solutions and costs are high if there is no full load.

Passive solutions come complete with their own insulation and use water/gel or phased changed materials (PCM) as cooling elements. The size of these solutions vary from parcel to pallet size. They are lower in cost and users have the flexibility to increase the volume whenever required. [2]

The correct and appropriate TCP selection is perhaps one of the most critical components of a safe and secure vaccine transport. The following are some of the factors that should be considered.

- **Tested and Certified TCP products.** All pharmaceutical and medical products have a temperature tolerance. When a product is moved or stored outside of this range, its efficacy or shelf life is affected. Ensuring the TCP, whether active or passive, is tested or certified to meet the tolerances required is essential to maintaining integrity during transit.
- **Scalability and Flexibility.** The number of vaccines to ship within a specific country's or manufacturer's supply chain will vary greatly. The TCP solution selected will need to be able to scale accordingly.
- **Domestic Rules and Regulations.** Local rules can complicate vaccination handling and add extra considerations when managing cold shipments. An example of this might be if a country or mode of transport may restrict the importation of dry ice. An alternative solution will be to use frozen PCMs in place of dry ice. That shipment may then become stuck at customs and there may be inadequate facilities such as power supply for active solutions or dry ice top-up services or cold rooms. How long will the TCP solutions last before it is out of the temperature compliance? These are considerations that a user must plan before embarking on a solution.

Finally, any TCP will need to be able to maintain vaccines at the required temperature, which at this stage is speculated could be as low as -80 degrees Celsius. [2]

END-TO-END CONNECTIVITY

Aside from product flow, a critical enabler of an effective and efficient supply chain is information flow. The flow of information is crucial in any supply chain, However, with the transport of vaccines, minimising the risks of exposing the vaccine to external factors such as environmental risks, security risks, and mishandling is crucial and requires a well-coordinated process for appropriate monitoring throughout the transportation and storage journey.

To overcome the disparate and disjointed communication process, as intimated earlier in this blueprint, a digital platform that connects all these different stakeholders, like a control tower, can make a huge difference. Underpinning and streamlining the way all parties in the supply chain communicate, all authorised parties to the shipment will be able to see the location of the vaccine at any point in time and in real time. The intent is for vaccines to travel quickly, with minimal delay?.[3] As a result, this could help to anticipate any delays and ensure all parties up and downstream can be prepared for contingency plans to ensure that the supply chain does not break and the goods move as per intended timelines.

Digitalisation of the documentation required for fast customs processing can be implemented with either high or lower technology capabilities. Authentication of the information source can occur with digital signatures and certification. Identification of the cargo can be validated with relevant data polled from an integrated monitoring system, such as a fleet management system that collects the data with the IDs and timestamping with location data.[3]

Ultimately, the compliance requirements for vaccine transportation will need to be assured, along with the integrity of the cold chain. Having the end-to-end connectivity of parties in the supply chain will require extensive coordination and partnerships, however ensuring public safety and reducing the loss of life makes this a worthwhile pursuit, and one that will result in real business and national benefits after the need for COVID-19 vaccinations has abated.

TECHNOLOGY USE CASES

Predictive Vehicle Tracking	Dynamic Real-time Carrier Performance	Cold Chain/IoT Data Records
KEY: Live vehicle tracking through onboard devices gives location of asset in real time and estimates the probability that pickup/delivery commitments will be met.	**KEY:** Provides visibility in real-time carrier movements, indicating whether specified pickup and delivery times will be met.	**KEY:** Help life science companies and supply chain participants to transmit and store time, temperature, and location of cold chain shipments to maintain safety and effectiveness while intelligently deploying inventory.
Technology deployed: IoT, personal devices, cloud, big data/analytics, mobile, APIs, telematics, connectivity services, and live vehicle tracking	**Technology deployed:** Distributed ledger technology/blockchain, Smart contracts, Identity management	**Technology Deployed:** IoT, networks and connectivity, supply chain analytics

Source: IDC 2020

I. TEMPERATURE

An essential requirement of vaccine storage is an environment of between -80 to 8 degrees Celsius, depending on vaccine being shipped. The global footprint of cold chain networks has been rising due to a growing middle class and increasing demand for fresh produce. However, there is a significant shortage of cold chain facilities to handle a mass vaccination effort, especially in the Global South (refer Figure 5).

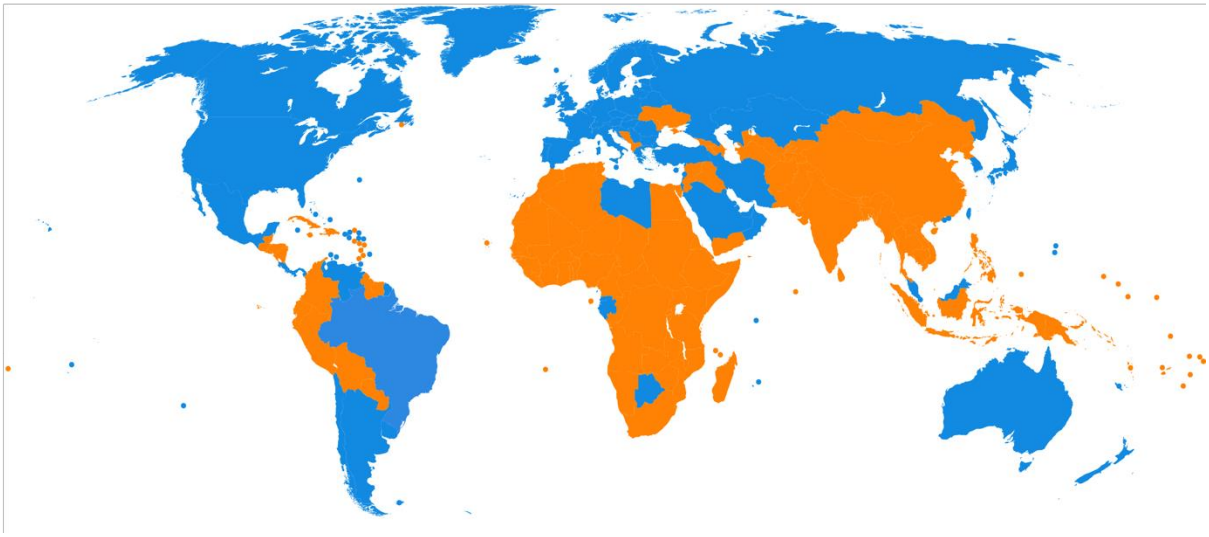

Figure 5: Global North (blue) vs Global South (orange), showing countries above and below the world GDP (Purchasing Power Parity) per capita in 2010, which was US$10,700. Source: IMF.

While many logistics players have been investing in extending and expanding their cold chain capabilities to meet this growing demand, most are developed on a built-to-suit basis when needed. As a result, the available supply of cold storage facilities within the market is likely to remain scarce when the vaccine eventually arrives.

Additionally, most cold chain networks link urban centres to major hubs, including airport logistics centres and food processing zones. These networks will not reach the 40% of the population which are located in rural areas. Another challenge for rural areas includes the need for access to a constant electric supply, as an interruption in power can render vaccines useless.[1]

The availability of thermal packaging solutions to maintain the temperature integrity of the COVID-19 vaccines will be a challenge, whether it is for +2°C to +8°C or -80°C. As discussed in the previous section, both active and passive TCPs are required, and manufacturers face the challenge of producing enough containers to prepare for the vaccine's availability. Hence it is necessary to plan for the eventual need for sufficient containers in advance.

Another consideration is that active TCPs can only handle +2 to +8 or up to -25°C and cannot manage -80°C. Passive containers that are available today do not have the capabilities to maintain -80°C for an extended duration. That leaves a single-use temperature-controlled pallet shipper to do the work for -80°C shipment profile. With single-use pallets, the packaging is thrown away after just one use, and this creates waste.

Dry ice is another alternative; however, large quantities are necessary for this option. For +2 to +8 °C shipments, the passive containers need large pre-conditioning facilities to prepare the phase-change materials.

> *COVID-19 vaccine candidates range in stability profiles from ultra-frozen to refrigerated. Managing these profiles is critical to maintaining approved vaccines' efficacy from manufacture to administration in this unprecedented distribution effort. Deploying appropriate vial-level temperature traceability across the immunization supply chain is necessary to ensure effective handling and delivery of vaccines to those who elect vaccination.*
>
> -- Tony Cecchin, VP & GM Global Supplies
> Zebra Technologies.
> President of Temptime

MONITORING TEMPERATURE CONDITIONS

Data loggers can track the temperature of a shipment accurately. They can assist with enabling remote monitoring and alerts and meeting regulatory guidelines concerning temperature during vaccines' storage and movement. Like TCPs, data loggers are also broadly categorised into "Active" or "Passive" tags or loggers, and key characteristics as outlined in figure 6.

	Active Data Loggers	Passive Data Loggers
Collection of data	Real-time data collection with live shipment data	Upon arrival at destination, often manually scanned or uploaded
Data available in flight	Varying capabilities for in-flight monitoring	No
Time and location data linked to incidents	Possible	Limited indication of where incidents occur.
In-transit integration	Can be linked with other devices to increase detail of logged data	No
Cost	More expensive	Low-cost and disposable

Figure 6: Active and passive data logging capabilities[6]

THE ROLE OF DATA

For shipments that travel point-to-point domestically or have limited routes, the passive temperature monitoring solution may be sufficient. Data is captured at critical points or is manually uploaded. This frequency of data collection may be adequate for determining the likelihood of vaccine effectiveness. However, if supply routes are complicated, then truly live and verifiable data provides increased supply chain visibility. Real-time data capabilities allow coordinating parties to be alerted if temperature excursions occur outside of acceptable parameters. Organizations then can immediately coordinate replacements or other remedies rather than waiting until after the shipment arrives at the destination.[6]

> *The success of a COVID-19 vaccine hinges on collaboration, trust, availability and turning vast amounts of data into actionable insights. While the creation of a vaccine will be monumental, we then need to find a way to manufacture and distribute billions of doses. AI and Analytics will help tackle this challenge we face ubiquitously.*
>
> -- Andy Zook, Senior VP, Asia Pacific SAS Institute

For added security, depending on the geography and local conditions, road transporters could be required to reinforce other security initiatives with cargo doors sensor, cameras and secure lock seals. All these functions and sensors should interface with a reliable fleet management system which should in turn be part of the overall vaccine supply chain control tower.

A recent report from the International Air Transport Association's Centre of Excellence for Independent Validators in Pharmaceutical Logistics found that incorrect shipping procedures cause degradation of a quarter of vaccines by the time they've arrived at their destinations.

Selecting the correct packaging, route optimization software, and real-time temperature loggers will provide transparency and full chain of custody from production to destination at the correct temperature to ensure the vaccines' efficacy. Logistics companies at all stages of the supply chain need to be trained to manage vaccines distribution and handling the thermal packaging solution.[10]

TECHNOLOGY USE CASES

Cold Chain/IoT Data Records	Vehicle Monitoring
KEY: Help life science companies and supply chain participants to transmit and store time, temperature, and location of cold chain shipments to maintain safety and effectiveness while intelligently deploying inventory.	**KEY:** Use sensor-based technologies to increase safety and security of shipments and drivers through real-time monitoring and tracking. Available sensor data is to identify disruptions and safety incidents and provide timely alerts.
Technology Deployed: IoT, networks and connectivity, supply chain analytics	**Technology deployed:** IoT (standalone or embedded sensors), communications networks, cloud, analytics, next-generation security

Source: IDC 2020

J. FAIRNESS & PRIORITY OF DISTRIBUTION

> *Reimagined healthcare for COVID-19 needs to ensure availability and affordability of vaccines. This calls for a connected, visible, agile and responsible supply chain in an ecosystem enabled by technology and superior risk management. Effective use of IOT couple with other technologies can ensure the vaccine reaches every person on earth in the shortest possible time, which is critical.*
>
> -- Girish Ramachandran, President, Tata Consultancy Services Asia Pacific

In the global north, policies that ensure equitable distribution will likely fall into a similar model as per the National Academy of Medicine model in figure 7. However temperature-controlled distribution is expensive, and not all economies have equal access to funds and infrastructure to ensure fair distribution to their populations. Additionally, vaccine nationalism affects the willingness for countries to remove restrictions on global supply. These policies will influence the forecasting and optimization of distribution.

The World Health Organization (WHO) is spearheading an alliance of nations, providing access to tools to fight COVID-19. This access includes the COVAX initiative which aims to accelerate COVID-19 vaccine development and manufacturing. The intention of this initiative is to ensure fair and equitable access to vaccines for every country in the world. However, in doing so and given vaccination production constraints, this only provides doses for a minimum of 20% of member country populations. The question of equitable allocation will still remain for every nation.

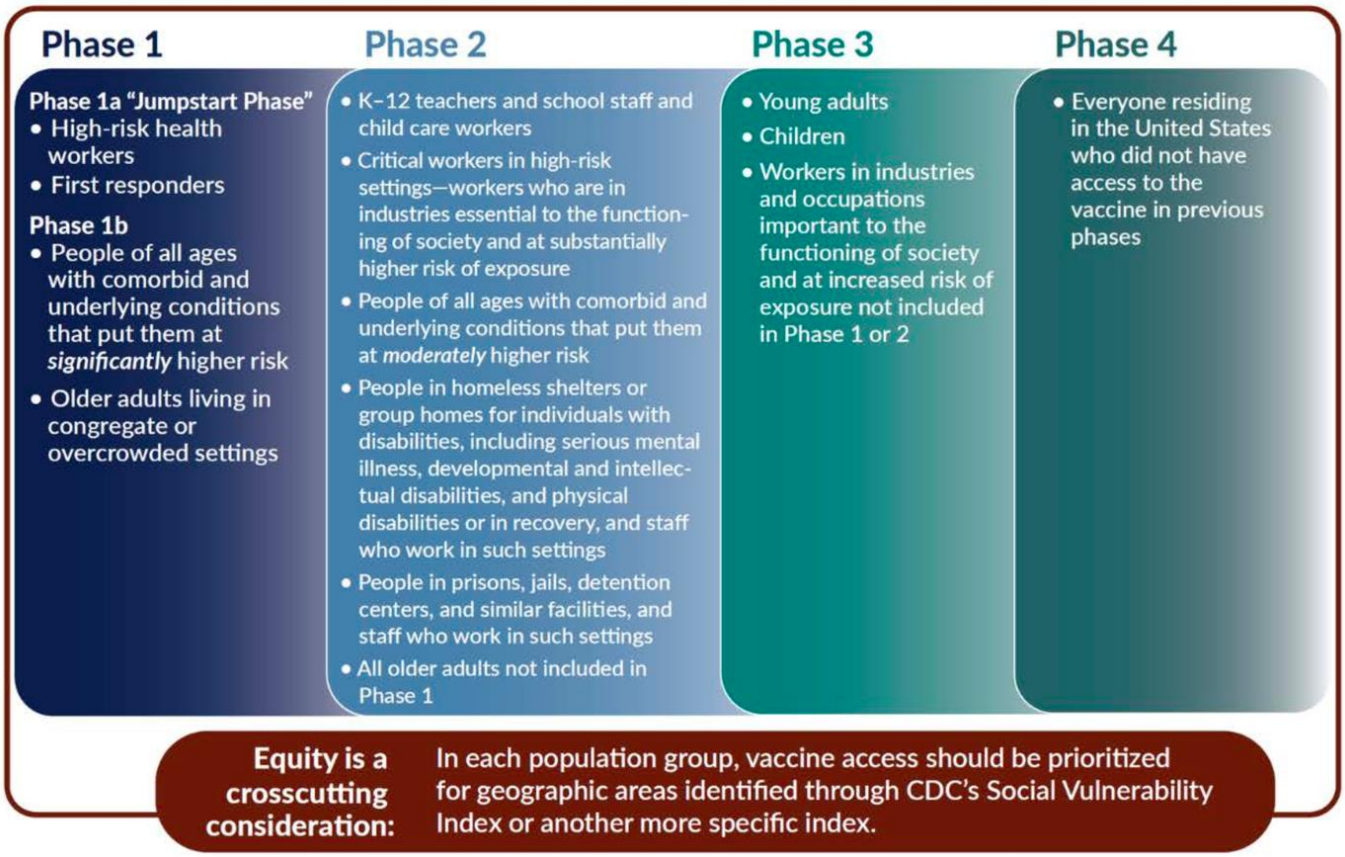

Figure 7: A phased approach to vaccine allocation for COVID-19. Source: National Academy of Medicine

While it is not within the scope of this document to determine how vaccinations should be allocated, there are technology advancements in cloud-based platforms that allow health agencies to affordably leverage technology for insights and predictive analytics to determine better distribution solutions. These will provide the opportunity to address greater portions of the population with the available resources. Health agencies need to work with vendors that provide platform-based data analytics, electronic data warehouse technologies, and cloud tools that optimize reporting and advanced analytics.

TECHNOLOGY USE CASES

Health Information Exchange (HIE)/Interoperability	**Inventory Intelligence**
KEY: HIEs and interoperability ensure that the value of heath information is fully realized not only through its storage and record keeping but also through effectively sharing it across disconnected systems, networks, and facilities to where it is needed and can make an impact on patients and the delivery of care.	KEY: A continuous assessment of vaccine inventory position relative to demand, production capacities, and supply position will reduce inventory levels and lower management costs.
Technology Deployed: Cloud, databases, health IT standards, and protocols, electronic health records (EHR), interoperability frameworks	**Technology deployed:** Cloud, IoT, BDA, and cognitive

Source: IDC 2020

K. DISTRIBUTION PROCESS

After finding the solutions to solve the storage and transport equation, the final logistics step would be to deploy the vaccine to inoculate the general population. Clinics, medical centres, and hospitals are likely places to conduct vaccinations. However, this will divert critical medical resources from other, potentially more urgent medical needs. Furthermore, many emerging economies will struggle to accommodate the numbers required, given their general lack of sufficient medical infrastructure. A large urban area of millions may have only several large medical facilities, leading to long wait times. For those living in rural communities, long commutes may be required, or they may experience delays in vaccine distribution to those communities.

While some economies have well-established distribution networks and capabilities, the vaccines' eventual deployment to the general population will be fraught with hurdles given the unprecedented task, even for the most mature of networks. As such, authorities need to start planning to ensure their systems are in place when the vaccine arrives. Establishing public-private partnerships with cold-store or warehouse developers now will assist with capacity due to limited supply.

Some countries already have the capability for temporary medical facilities for testing. Expansion of this may be one option if temperature control requirements can be met as described in previous sections. For some countries, the setting up of temporary medical facilities will require time and resources that many local governments might not have. A potential solution for this would be to convert existing real estate within the hospitality sector (e.g. hotels, motels, resorts) currently under-utilized and generally more spread out than medical facilities. The segregated rooms within the hospitality asset can act as a natural barrier to prevent the virus's spread, given the large populations expected at the location to receive the vaccination. Additionally, access to electricity will assist in maintaining the cold chain required.

Other considerations will also need to be addressed:

- Temperature control, security and the setting up of multiple deployment points creates the potential for lapses at each step that could result in loss of doses. Vaccination points like the testing stations will need to have SOPs that address the traceability, temperature and security.

- The coordination of workforce and patients will require scheduling and timing to prevent overcrowding, and patient records will need to be updated to record the vaccinations themselves.

- Identity and access management will be required to verify patient access. While hospitals have protocols for double-checking identity with patients, the volume and stress on the system will need to ensure that these checks are meticulously carried out, and ensure that access is limited to those that are scheduled.

TECHNOLOGY USE CASES

Digital Workforce Management	Cold Chain/IoT Data Records
KEY: Equip with intelligent collaborative, social, and self-service applications for improving skills, communicating, scheduling work, tracking, improving, and rewarding performance.	**KEY:** Help life science companies and supply chain participants to transmit and store time, temperature, and location of cold chain shipments to maintain safety and effectiveness while intelligently deploying inventory.
Technology Deployed: Cloud Cloud, AI/ML, collaboration and social applications, schedule management tools, HCM software	**Technology Deployed:** IoT, networks and connectivity, supply chain analytics

Source: IDC 2020

L. TIMING AND ALERTS

Regardless of the facilities that are used for immunisation, workforce and patient management will need to occur to minimise the risk of further COVID-19 virus transmission, and to ensure general safety. The WHO recommends limiting the number of individuals present at an immunisation visit and holding more frequent, smaller vaccination sessions.

WORKFORCE SCHEDULING

For vaccination facility employees, scheduling and access systems provide automation that can assist in managing shifts and disruptions to attendance – like if a frontline worker were to get COVID-19. Automation capabilities in the scheduling of employees help in deploying frontline workers in a very fluid environment. Assuring workers that they have a well-managed, safe schedule and providing early notice of changes and disruptions can increase morale during this very stressful period. Notifications through messaging or dedicated employee apps can streamline communications and provide assurance for employer and employee alike.

PATIENT SCHEDULING

Similarly, the management of appointments and timing at vaccination points will require additional coordination. This management will need to address:

- Prioritisation requirements determined at the country level
- Scheduling on a large scale to avoid crowding and ensure a safe environment
- Notifications and alerts through convenient methods to increase attendance reliability and compliance
- Integration with patient management and record-keeping in the local country to meet regulatory requirements
- Ensure personal and hospital data is secure
- Address payment requirements through industry-approved payment mechanisms

Traditional scheduling methods for staff and patients may be suitable prior to COVID-19 or is coping with current levels, however there will be an increased load due to testing and vaccination. The addition of vaccination locations, staff rotations, disruptions due to illness, patient prioritisation and accounting for safe distancing will increase the stress on traditional systems.

TECHNOLOGY USE CASES

Digital Workforce Management	Embedded Communications Apps	Open Access Scheduling and Payment
KEY: Equip with intelligent collaborative, social, and self-service applications for improving skills, communicating, scheduling work, tracking, improving, and rewarding performance.	**KEY:** A simpler, low-cost approach allows software developers to create niche applications more rapidly, particularly in vertical markets where a more customized approach may be needed or preferred versus the horizontal appeal of many core UC&C solutions today.	**KEY:** Open access scheduling enables consumers to directly schedule an appointment using online tools that address the increasing demand for convenient booking options. This value of open access scheduling and payment is mostly realized through its impact on timely access to care, revenue optimization, quality of care, and patient experience.
Technology Deployed: Cloud Cloud, AI/ML, collaboration and social applications, schedule management tools, HCM software	**Technology Deployed:** APIs, SDKs, communications platform-as-a-service, voice/telephony, messaging apps (instant messaging, SMS, chat, email)	**Technology Deployed:** EHR and integrations between EHRs and scheduling tools, if nontethered; Patient-facing portals, websites, and mobile apps; Cloud; Industry-approved payment mechanisms

Source: IDC 2020

M. REVERSE LOGISTICS

Due to supply constraints, there may be a need to reposition vaccines to locations where they will be more effective. Also, if the cold chain is broken, arrangements will be necessary to discard vaccines that may have been damaged, expired or contaminated. The scale again will be an issue here. It will be essential to safeguard the personnel involved in handling and disposal.

SUSTAINABILITY IN DELIVERY AND DISTRIBUTION

If one goal in vaccine distribution is to reach as much of the population as possible, another important objective is sustainability along the supply chain. It is critical to consider which types of packaging and modes of transport are reusable, and how to organize reverse logistics sustainably. Based on experience in standard reusable parcels, return logistics can be difficult to execute (and ultimately unsuccessful) in certain less developed economies of the world. Nonetheless, one of the largest, focused distribution efforts in history, namely, supplying a COVID-19 vaccine to the global population, should not be carried out using unsustainable means of transport. Therefore, it is critical to consider innovative packaging solutions and recycling opportunities and optimal waste management in the use of one-way packaging.

If the TCP, is reusable, repositioning the containers after each delivery will add a level of complexity in the supply chain that will need to be coordinated, with scheduling of resources and factoring in the costs of the return journey.

TECHNOLOGY USE CASES

Advanced Enterprise Reverse Logistics Execution	Container Or Packaging Optimization
KEY: Enable end to end capture, tracking, disposition and reconciliation of returns data, to optimize reconciliation, return and minimise costs.	**KEY:** There is improved visibility between suppliers and customers on items such as reusable totes, pallets, and containers. Suppliers and customers collaborate through a system to manage incoming shipments and the proper return of these items for continued reuse.
Technology Deployed: Returns systems, IoT, traceability, mobile devices, AI, analytics / reporting, integration to core ERP and WMS systems.	Technology Deployed: Enterprise hardware, personal devices, cloud, big data and analytics, mobile, connectivity services, and container/packaging management systems

Source: IDC 2020

N. PAYMENTS & FUNDING

Countries like Singapore and Japan are considering providing vaccinations free to all citizens who want or require inoculation. Other nations will implement co-payment or full payment options. Suppose vaccination points are increased to deal with the volume required. In that case, payment collection will need to be added to the administrative requirements in a streamlined fashion to avoid bottlenecks. Consumer centricity has gained attention from payers, providers, and healthcare in general in recent years. Concepts that have been foundational in retail and finance, such as customer relationship management (CRM) and segmentation, previously ignored in healthcare, are now rising in importance.

When insurance is used as the payment method, there are opportunities to streamline the process to ensure that the vaccination process is not delayed, or bottlenecks do not occur as a result. These include the use of:

- Mobile devices to facilitate a contactless environment at the point of vaccination
- Artificial intelligence (AI)/cognitive systems and Robotic Process Automation (RPA) across insurance business functions such as claims processing and the servicing of policy owners
- Digital IDs to ensure funding disbursements for co-payments/full-payments are accurate and seamless, with the added benefit of accurately matching of patients to their data during the vaccination process

There are already established processes for health providers and insurance companies that facilitate the payment process. The potential issue again is with the scale of the processing required, and the options that are available at the point of vaccination. Age demographics of the expected first rounds of vaccinations at state-wide level also present digital challenges. It is here in which schemes such as Singapore's national facial verification system aim to at least partially address the issue of digital competency by allowing facial maps to act as authentication for transactions. Health providers and insurance companies would do well to consider additional digital capabilities to assist with this scale, as well explore wider ecosystem plays such as those from the public sector or collaborative private sector efforts, which will also be valuable for future capabilities in the market post-COVID-19.

TECHNOLOGY USE CASES

Coordinated consumer transactions	Contextual and Value-Centric Insurance	Robotic Process Automation-Based Claims Processing
KEY: Integrate data and common consumer experience in sales channels, enrolment portals, service desks, marketing campaigns, claims adjudication and appeal, and all health management cases.	**KEY:** Implement a hassle-free service at the "moment of truth" (during the claims process) which will improve transparency enhance the overall customer experience, forge trust, and increase brand loyalty by using technologies which allow the customer to see precisely what stage they are at in the process and how both the insurer and third parties are handling claim requests	**KEY:** Reduce the administrative load caused by the submission of paper and electronic forms by hundreds of thousands of provider organizations to hundreds of commercial and government payers for payment using arcane rules, aging software, and often manual processes. Human touches can be reduced, and processes can be improved to speed error-free payment.
Technology Deployed: CRM (sales, service, marketing, and health), member/patient identity management, enterprise master person index, master data management, interactive voice response	**Technology Deployed:** Blockchain/ distributed ledger technologies. Smart contracts, cloud-enabled infrastructure, Open architecture/ standards. Modern APIs and app development frameworks. Sensor-based technologies. Cognitive technologies.	**Technology Deployed:** Software rules engines, macros, scripts, and analytics that can be overlaid on manual processes or on inefficient software workflow applications

Source: IDC 2020

O. SAFETY & PPE

During the entire vaccine distribution process, worker health and safety needs to be maintained. Shortages of PPE has the potential to cause constraints in the operating environment of organizations involved in the distribution of the vaccine. This increases the requirements for social distancing, shift splitting and other processes to avoid contact, thereby further decreasing productivity and throughput at each stage of distribution.

PERSONAL PROTECTIVE EQUIPMENT (PPE) SUPPLY

During the early period of the COVID-19 pandemic, PPE was in high demand, and production levels took several months to meet required inventory levels. These items include gloves, aprons or coveralls, eye or face protection, surgical masks, head and foot ware. Moving forward, the management of PPE supply will need to occur in order to reduce the impact on the effective administration of vaccines at scale.

In IDC's 2020 Supply Chain Survey, 83.3% of companies responded that COVID-19 was already having or expected to have a major impact to their supply chains this year. As the demand from the vaccination efforts hit the supply chain, it can be expected that this disruption will continue. Supplier management capabilities will need to extend beyond ERP systems to integration with suppliers. The use of AI or cognitive systems to monitor PPE inventory availability and position will assist with the assurance of supply and allocation of resources accordingly.

WORKER SAFETY

Existing medical industry protocols for protecting workers will be, of course, extended to vaccination points, ensuring sanitisation and correct use of PPE. Additional measures may include the use of technology for contact tracing, and physical management of procedural workflows to ensure that minimal contact occurs.

Proximity sensing through badge, wearables (eg. watches) or mobile devices (phones or tablets) can be used to continuously track and record workforce movement in some cases, or proximity in others with the goal of:

- Avoiding proximity risk scenarios (eg. Less than 1-2m apart)
- Collecting data to identify hotspots
- Provide historical contact tracing

Ultimately the goal is worker safety, and ensuring that adequate inventory of PPE, and utilising available technology for that protection only serves to ensure that the necessary volume of vaccinations can occur, reducing the risk to our front-line workers.

TECHNOLOGY USE CASES

Social Distancing & Contact Tracing	Physical Safety & Risk Management	Inventory Intelligence
KEY: Continuous monitoring of social distancing across the workplace, rapid contact tracing, access control and proximity alerts.	**KEY:** Reduce safety violations, accidents and risk by enabling visibility and enforcing policies, SOP's and training compliance requirements.	**KEY:** A continuous assessment of PPE inventory position relative to demand, production capacities, and supply position will reduce inventory levels and lower management costs.
Technology Deployed: Wearables, connectivity, geofencing, HCM software, cloud, IoT, CCTV or computer vision	**Technology Deployed:** Risk management and safety tracking software, IoT, Computer Vision, AI, Video / Content distribution Systems	**Technology Deployed:** Cloud, IoT, BDA, and cognitive

Source: IDC 2020

CONCLUSION

It is evident to all stakeholders that the long-term goal of achieving widespread access to COVID-19 vaccines faces several obstacles. Freight capacity, however, will not be the primary challenge for the distribution of vaccines, as some originally envisaged. There is adequate capacity to ship vaccines, especially if individual governments dictate that their respective national carriers or military allocate needed capacity. A phased approach to production and allocation will be over an extended period. Not all vaccines will need to be shipped by airfreight. Additionally, some countries like Australia, for example, have elected to produce the vaccines in the country.

The challenge exists because the distribution of vaccines will need to happen in the most remote locations globally or in areas where resources are insufficient to meet distribution needs. These vaccines will potentially require storage and transportation while maintaining strict temperature requirements. These requirements make it an even more difficult proposition primarily in the global south, where there is often a warmer climate and limited cold-chain logistics infrastructure.

It will not be enough to simply ship and make vaccines available in capital cities. Vaccines will need to be shipped under stringent logistics conditions to remote locations. Suppose adequate TCP is not readily available, or available in sufficient quantities. In that case, dry ice could be used for cooling. Supply chain issues such as bottlenecks at the destination city could result from centralized dry ice production, especially if refilling is required every 3-5 days.

SUPPLY CHAIN VISIBILITY IS KEY TO THE VDE

Even before the pandemic, real-time visibility along the supply chain was a challenge for most companies due to the limited willingness of stakeholders to share data, the complexity of supply chains, and the lack of data standardization and interoperability of disparate systems used by stakeholders. For the safe and efficient movement of vaccines to a given populace, visibility of the end-to-end VDE is the cornerstone for reliable tracking of vaccines and early detection of potential transportation bottlenecks. The establishment of a strong technology backbone and data-sharing mechanisms is required before vaccine production. The VDE, led by governments, should specify clear data-capability requirements when selecting suppliers and logistics providers. When selected, stakeholders should provide timely and accurate data in standardized formats – from sourcing to end-use points, such as vaccination centers and hospitals. Adapting existing solutions to the VDE would allow for extensive shipment visibility, inventory and security management, demand forecast, and disruption monitoring.

A VDE can significantly relieve pain points by successfully preventing disruptions along the supply chain and meeting unprecedented challenges. The VDE should be three-way agreements between vaccine manufacturers, logistics service providers, relevant technology providers, and health authorities and governments.

Ultimately, the supply chain for full, safe, and secure distribution of vaccines globally is a tremendously complex challenge. To overcome this challenge, a VDE must be set-up and tested before vaccines are even available. Working in concert with global resources, countries can and will be ready to implement safe and efficacious distribution.

VDE IMPLEMENTATION

LSCMS strongly advocates for Vaccine Deployment Ecosystems (VDEs) to be implemented as soon as possible. To this end, with our network of partners and experts regionally and globally, LSCMS is able to engage with governments, government agencies, pharmaceutical companies and service providers to design, test and implement a country or regional VDE.

The coordinating, consulting, and implementation efforts by LSCMS, will be spearheaded by our Board and Executive Members led, by Joe Lombardo esq. and Micahel Culme-Seymour.

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ACKNOWLEDGEMENTS & CONTRIBUTIONS

With thanks to:

- Blue Yonder APAC
- Dassault Systèmes B.V.
- E2Open
- Enterprise Singapore
- SAS Institute
- Tata Consultancy Services Asia Pacific
- Websym Solutions Private Ltd.
- World Economic Forum
- Zebra Technologies

ACRONYMS & ABBREVIATIONS

2FA	Two-Factor Authentication
2PL	Second-Party Logistics
3PL	Third-Party Logistics
4PL	Fourth-Party Logistics
AI	Artificial Intelligence
AI/ML	Artificial Intelligence/Machine Learning
API	Application Programming Interface
AR/VR	Augmented Reality/Virtual Reality
B2B	Business-to-Business
B2C	Business-to-Consumer
BDA	Big Data & Analytics
CCTV	Closed-Circuit Television
COVAX	The vaccines pillar of the Access to COVID-19 Tools (ACT) Accelerator
COVID-19	Coronavirus Disease 2019
CRM	Customer Relationship Management
DQ	Design Qualification
EHR	Electronic Health Record
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
GFA	Gross Floor Area
GIS	Geographic Information System
GxP	International Good Practice Guidelines
HCM	Human Capital Management
IaaS	Infrastructure-as-a-Service
IATA	International Air Transport Association
IIoT	Industrial Internet of Things
IMF	International Monetary Fund
IoT	Internet of Things
IQ	Installation Qualification
LLP	Lead Logistics Provider
LPI	Logistics Performance Index
MERS	Middle East Respiratory Syndrome
NGO	Non-Governmental Organisation
OQ	Operational Qualification
PaaS	Platform-as-a-Service
PCM	Phased Changed Materials
PPE	Personal Protection Equipment
PPP	Public-Private Partnerships
PQ	Performance Qualification
RPA	Robotic Process Automation
SaaS	Software-as-a-Service
SARS	Severe Acute Respiratory Syndrome
SDK	Software Development Kit
SMS	Short Message Service
SOP	Standard Operating Procedure
TCP	Temperature-Controlled Packaging
TMS	Transport Management System
VDE	Vaccine Distribution Ecosystem
VMP	Validation Master Plan
VPN	Virtual Private Network
WHO	World Health Organisation
WMS	Warehouse Management System