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IMPROVING PHARMACEUTICAL SUPPLY CHAINS IN HUMANITARIAN SETTINGS

LEARNINGS FROM THE BUILDING CAPACITY TO IMPROVE HEALTH COMMODITY MANAGEMENT IN HUMANITARIAN AND DISASTER SETTINGS PROGRAM

Cover photo: JSI

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The Building Capacity to Improve Pharmaceutical and Medical Commodity Management in Humanitarian and Disaster Settings Program helps staff from international organizations and local NGOs by equipping them with training, guidance, resources, and follow-up support. JSI manages this program, funded by USAID's Bureau for Humanitarian Assistance (BHA).

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PREFACE

Since 2018, the Building Capacity to Improve Pharmaceutical and Medical Commodity Management in Humanitarian and Disaster Settings Program (the program) has strengthened the capacity of people managing health supply chains in humanitarian settings. This compilation of learnings provides insights from the program's work with local and international humanitarian response organizations. It focuses on supply chain management (SCM) practices for pharmaceutical and medical commodities (PMCs) in humanitarian settings, specifically for organizations that provide services in the initial response, during protracted emergencies, and in the nexus between humanitarian and development work.

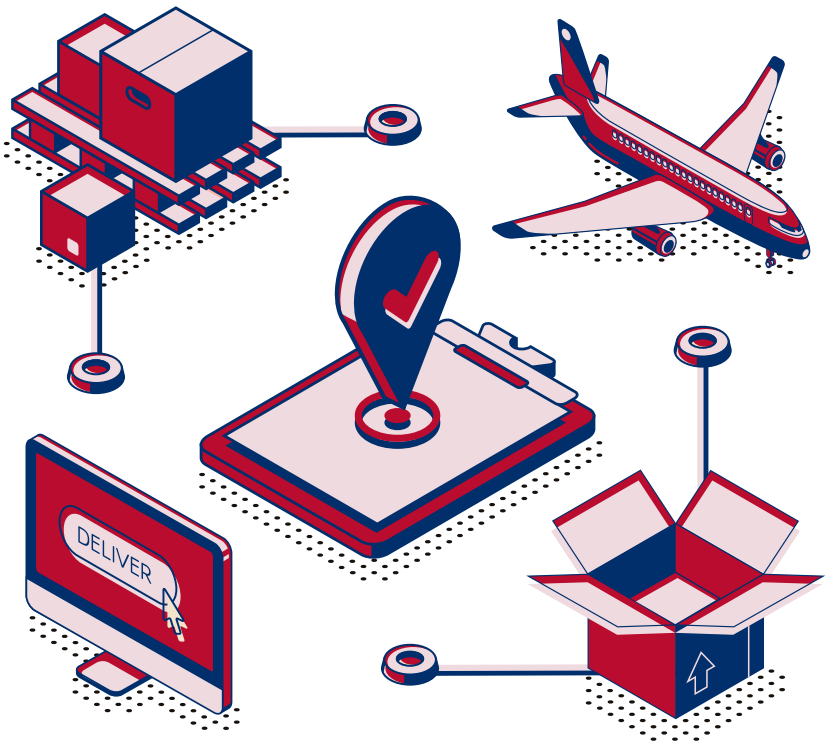
This document covers the importance of data for decision-making, with an emphasis on data preparedness for quantifying health commodities in order to respond to emergencies. Also, as responders transition from the use of emergency health kits during first response to procurement of individual commodities in more stable situations, the supply chain becomes more complex and access to logistics and population data is critical for averting stockouts of essential medicines in the health facilities upon which affected populations rely. These learnings are based on insights from more than 28 interviews with humanitarian partners.

The annexes also summarize health supply chain practices, challenges, solutions, and considerations gathered as part of the program's work to strengthen the SCM capacity for PMCs in humanitarian organizations. They include 10 learning briefs based on case studies from a variety of humanitarian organizations (Annex A), and links to 12 online technical discussions that took place over two years with more than 2,388 live attendees, featuring guest speakers who work on the ground in 13 humanitarian organizations (Annex B). A compilation of challenges and solutions derived from learnings across all program activities, categorized by SCM function, is included in Annex C. Annex D lists tools and manuals for quantification and electronic logistics management information system (eLMIS) selection, and Annex E contains information about the International Association of Public Health Logisticians (IAPHL)'s Humanitarian Commodities Logistics (HCL) Community of Practice, which has become a resource for many humanitarian health supply chain managers and is a repository for SCM information relating to PMCs. Annex F is a literature search that contributed to learning for this program.

INTRODUCTION

Natural and man-made disasters are becoming more frequent, more complex, and longer lasting, with greater impact on affected populations. Governments, communities, and implementing partners (IPs) are increasingly under pressure to respond effectively with insufficient resources. When a crisis hits, humanitarian organizations must deploy medicines, health supplies, and personnel to affected areas quickly; secure adequate storage; mobilize transportation to reach the population in need of services; and ensure that the right medicines and health supplies are available to save lives. This requires careful planning and preparation.

For every link in the supply chain, managers, logisticians, and health workers make critical decisions that depend on data availability and information visibility up and down the supply chain. Logistics data are needed to quantify health supplies and procure the right quantity of the right high-quality products at the right time and at the right cost.



PREPARING FOR DATA-DRIVEN DECISION-MAKING

In the context of health supply chains, data-driven decision-making refers to the use of information, metrics, and data to guide strategic decisions that align with funder and organizational goals, objectives, and initiatives. When organizations fully recognize the value of their data and invest in the infrastructure and capacities that enable their use, staff and stakeholders at all levels can make informed, timely decisions, regardless of their roles.

Achieving data visibility and using it for decision-making is an iterative process that goes beyond simply selecting the right analytics technology to identify the next strategic opportunity. It is a core component of building resilient pharmaceutical supply chains and advancing the maturity trajectory of an integrated supply chain. See JSI's Supply Chain Integration Framework for more details on the stages of supply chain maturity.

Data-driven decisions are the result of data preparedness, which is defined as "the ability of organizations to be ready to responsibly and effectively deploy and manage data collection and analysis tools, techniques, and strategies in a specific operational context before a disaster strikes." [1] By investing in systems, processes, and human resources, organizations can maximize the value of their data, promote data-driven decision-making, and foster a culture that embraces data preparedness and use for better outcomes. Organizations that initiate a data collection and use process must consider these factors:

1. **Align with organizational goals:** Understanding the specific information needed to support strategic and operational decision-making helps prioritize data collection efforts.

2. **Data relevance and quality:** Gathering high-quality data that directly relates to the problem or decision in question is critical, as inaccurate or incomplete data can lead to flawed decisions.

3. **Timeliness:** Understanding the time-sensitivity of decision-making processes helps determine data collection frequency and timeliness.

4. **Data sources and integration:** Identifying a variety of data sources facilitates a comprehensive perspective and more holistic decision-making. It may involve integrating data from internal systems, accessing external databases, and leveraging data partnerships.

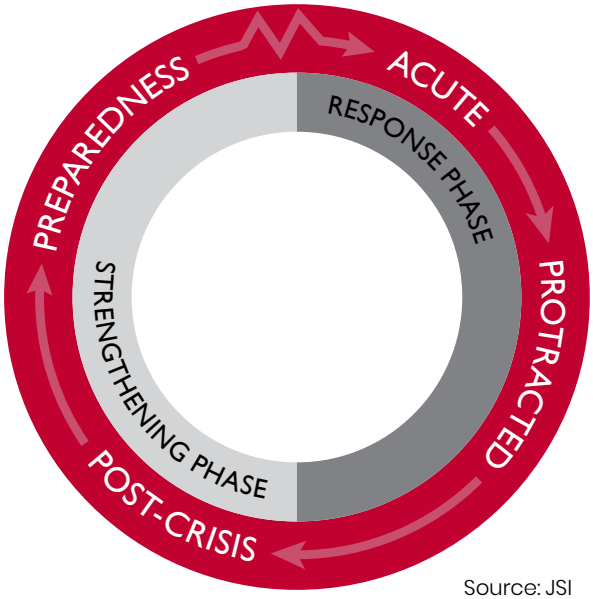
5. **Data privacy and security:** Ensuring that data collection and use comply with privacy regulations and protects sensitive information is essential, especially as it relates to building trust with stakeholders and communities, particularly in fragile and humanitarian settings, in which data can become politicized.

6. **Analytical tools and expertise:** Having access to analytical tools and skilled data analysts is crucial for extracting insights, identifying patterns, and generating visualizations that support decision-making quickly during disasters.

7. **Continuous improvement:** Evaluating the effect of data-driven decisions, measuring outcomes, and seeking opportunities for optimization are important for continuous improvement.

1 https://hhi.harvard.edu/

FIGURE 1. PHASES OF THE HUMANITARIAN RESPONSE

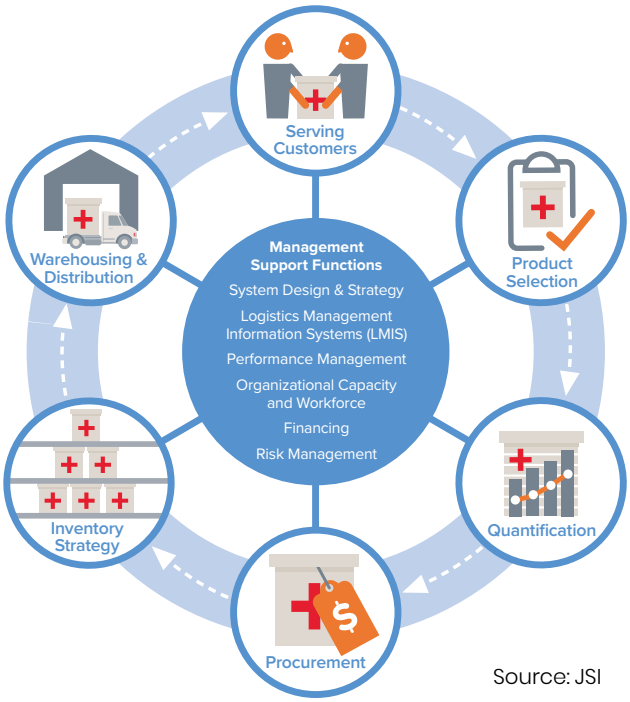


Source: JSI

Even though the cycle of humanitarian response (Figure 1) is well understood by most humanitarian organizations, few consider data preparedness and how critical it is to include data as an overarching component of the response.

During the preparedness phase, organizations need to identify the types of humanitarian events they may face; determine which data are feasible and useful to gather; and identify reliable sources and resources and classify them based on past emergencies. Data from events that happened far back may be obsolete, but the challenges and lessons may still be valid.

FIGURE 2. THE LOGISTICS CYCLE



Source: JSI

Data preparedness requires staff who can analyze and use data to resolve supply chain bottlenecks and provide leaders with information to make decisions for every supply chain function in the logistics cycle (Figure 2).

Data preparedness is part of the supply chain risk management strategy that humanitarian organizations should develop and implement at all stages of crisis response.

Photo: JSI

COORDINATION AND DATA SHARING

Coordination and data sharing are critical components of a humanitarian response. In this context, data preparedness can serve as a foundation for humanitarian partners to collaborate around. At every level of the supply chain and within local communities, stakeholders can benefit from coordination to find practical ways of gathering and sharing data. A lack of readiness, skills, or resources for using and sharing data among humanitarian responders can result in wasted resources, missed opportunities, and, most importantly, poor health outcomes and lost lives.

Community leaders can help gather information on the number of children, pregnant women, adolescents, and adults who require special treatment; where these people are located and what their needs are; and information about incoming and outgoing displaced populations. When approaching a population with services, organizations should rely on community leaders, as they are trusted and reliable. Community leaders can also help organizations educate people on the importance of following treatments, such as taking the full course of antibiotics to reduce antimicrobial resistance. This information is invaluable at the onset of a humanitarian assistance intervention and during protracted emergencies. It will save IPs time and contribute key inputs to the quantification (forecasting and supply planning) process. In fragile and humanitarian settings, though, it is always important to survey a range of people who are affected to get a variety of perspectives, with proper ethical board approvals, awareness of the local reality, and in adherence to humanitarian principles.[2] There may be varying

2 UNOCHA Humanitarian Principles

information, opinions, tensions, and ethical considerations due to political and other complexities that are exacerbated during crises, particularly about data related to population movements.

During interviews with humanitarian organizations, respondents mentioned the importance of sharing information about pre-qualified suppliers at the local and country levels, although it is essential to ensure that these suppliers provide high-quality commodities and are approved by funders. Often, international funders may not approve local suppliers, so generally they are only advisable for non-pharmaceutical supplies. Many organizations may struggle with the long lead times of international procurements, which may eventually be mitigated by the development of local markets.

Some humanitarian organizations have coordinated to conduct joint assessments, using QUAMED[3] to audit local suppliers based on the World Health Organization's Good Distribution Practices and Good Storage Practices for pharmaceuticals. While this can be a first step in identifying suppliers, additional information is required to meet BHA or other funder requirements. Nonetheless, these organizations have shared information on suppliers, demonstrating a willingness to collaborate that may eventually lead to options that meet funder requirements as markets develop and grow and standards are harmonized.

Other organizations have pooled their transportation to deliver health supplies to places blocked by conflicts. In northern Nigeria, where the International Rescue Committee strengthened decision-making for health commodity management by implementing data review teams, coordination of supply chain data improved availability of health commodities and coordination of transportation options.

Even though coordination and data sharing can save time and resources for most organizations, internal factors, including data privacy and identity protection of the people served, hinder their ability to share information. Organizations are rightfully protective of patient privacy, especially when people have been displaced and are under threat. Other barriers include project implementation timelines that do not match contract timelines managed within the same and other organizations. However, coordination and data sharing are opportunities for organizations to maximize resources, close service delivery gaps, and learn from each other.

During the COVID-19 pandemic, governments, nongovernmental organizations (NGOs), manufacturers, suppliers, academia, scientific institutions, and pharmaceutical companies collaborated extensively to develop vaccines and rapid test kits, as well as new systems to detect the virus, provide accurate information, and administer vaccines. A significant outcome of this collaboration was the development and implementation of digital technologies for efficient information sharing and real-time data analysis. These technologies had a crucial role in monitoring virus spread, tracking cases, providing timely updates to the population, and enabling effective response strategies. Humanitarian organizations could adapt and use several of the digital technologies used during the COVID-19 pandemic for other commodities and health concerns.[4]

DIGITAL TECHNOLOGIES USED DURING THE COVID-19 PANDEMIC

- **Contact-tracing apps:** Governments and health authorities developed mobile applications to assist in contact tracing. With Bluetooth or GPS technology, these apps tracked individuals' interactions and notified them if they came into contact with someone who tested positive for COVID-19. Apps such as these can be used to trace similar types of data points that relate to

3 https://quamed.org/about-us/

4 Table 1 Digital technologies used in the COVID-19 pandemic (nature.com)

LEARNING BRIEF HIGHLIGHT

Forging Local Networks to Distribute Life-saving Health Supplies in Ukraine

Amid Russia's ongoing war against Ukraine, local organization 100% LIFE identified alternate distribution networks to deliver life-saving HIV treatments to all areas, including war zones. 100% LIFE coordinated with government and private networks to distribute medicines and collected information from partners to find alternate transportation options. Preparedness played an important role in this local organization's readiness to respond. It mapped scenarios, located alternate warehouses, and helped staff to relocate immediately.

Forging Local Networks to Distribute Life-saving Health Supplies in Ukraine

During Russia's war against Ukraine, local organization 100% LIFE identified alternate distribution networks to deliver life-saving HIV treatments to all areas, including war zones.

BACKGROUND

100% LIFE is the largest patient-led nongovernmental organization (NGO) in Ukraine. Its mission is to provide access to antiretroviral therapy for all people living with HIV, and to advocate for increased access to HIV, tuberculosis (TB), and hepatitis treatments. Since 2001, 100% LIFE has implemented programs funded by the Global Fund to Fight Aids, Tuberculosis and Malaria; USAID; the United Nations World Food Programme; and others. After the Russian invasion in 2022, 100% LIFE began also supporting emergency programs for reproductive health care and other health services.

PRACTICE

Prior to the war, 100% LIFE had put preparedness plans in place, mapping out scenarios that included searching for alternative warehouses in western Ukraine to move products away from Kyiv. If war broke out, 100% LIFE planned to find companies to provide alternate logistics services and contact government authorities to understand their emergency procedures.

As the risk of war increased, 100% LIFE's staff and their families moved to western Ukraine on the recommendation of 100% LIFE's board of directors. The early relocation of staff meant that they were able to keep working during the 2–3 weeks just after the war started, which was critical. Even before the COVID-19 pandemic, the organization had digitized its work flow, which eliminated any need to move physical documents. Even with preparedness plans in place, most emergency actions were adapted during the first month of the war, as it became clear that none of the regular logistics companies were able to operate.

Transportation complexities during the beginning of the war presented many supply chain uncertainties. All airports were immediately closed and flights were cancelled. Logistics companies stopped making deliveries, and warehouses that 100% LIFE used were closed and could not receive health products.

Photo: 100% LIFE

Distributing health supplies in March 2022.

Photo: 100% LIFE

Evgeniya Rudenka leads 100% LIFE's PSM team. She has been instrumental in identifying new distribution options for delivering life-saving health supplies.

Location: Ukraine
Organization: 100% LIFE
Setting: Complex war zones
Supply chain management practice area: Warehousing and distribution
HR cadres involved: Supply chain, pharmacy, and warehouse managers

This series of learning briefs focuses on health supply chain practices that can be implemented by humanitarian partners to resolve common challenges and improve the delivery of pharmaceutical and medical commodities.

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tracking interactions between people, vehicles, warehouses, etc.

- **Data analytics and modeling:** Data analytics and modeling tools were used to analyze large datasets and generate insights into the virus's behavior and spread. These tools allowed researchers and policymakers to understand patterns, forecast the effect of interventions, and make informed decisions. Modeling can be applied to any system, not only in the context of outbreaks. For example, one could model a population on the move and how it will affect a local host community, including the health system and supply chain, when the population arrives.

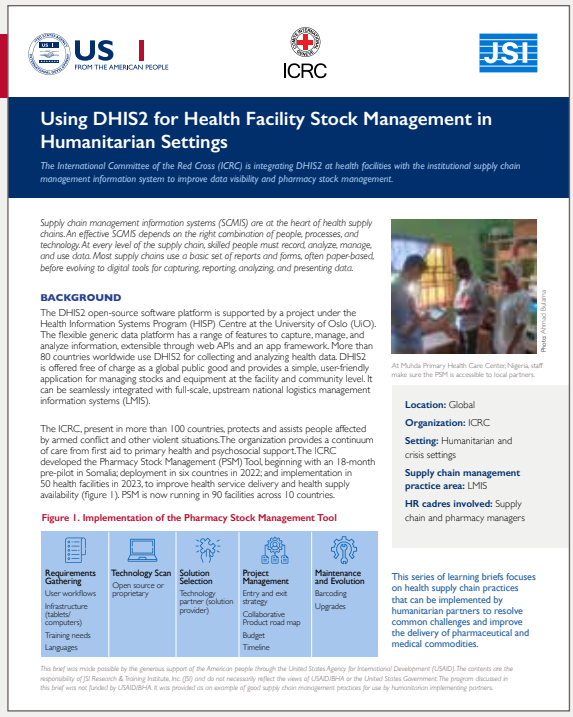
- **Vaccine distribution and monitoring systems:** Digital platforms were developed to manage vaccine distribution, track inventories, and monitor immunization progress. These systems streamlined the vaccination process, ensured equitable access, and facilitated efficient reporting and data management. The Vaccine Collaborative Supply Planning Initiative aimed to shift decision-making power to country leaders using their data and evidence to forecast and plan vaccine needs based on actual demand, experience with mass campaigns, and a clear understanding of the stock status in their countries. Similar distribution and monitoring systems could be used for other commodities.

Data dashboards were used extensively during the COVID-19 pandemic, collating real-time public and private sector health data, including confirmed cases, deaths, testing, and vaccination figures, to keep the public informed and support policymakers in refining interventions. Despite the effort, challenges with data collection quality and consistency remained a concern. Inconsistencies and the lack of official standards in government reporting of statistics across countries made global compari-

LEARNING BRIEF HIGHLIGHT

USING DHIS2 LMIS FOR PHARMACY STOCK MANAGEMENT IN HUMANITARIAN SETTINGS

To resolve a range of information challenges, the International Committee of the Red Cross (ICRC) integrated the DHIS2 LMIS with the institutional SCM information system at health facilities. ICRC partnered with the University of Oslo to develop the open-source PSM Tool, an integrated and standardized system that has moved processes from paper to digital management, with improved stock visibility, planning, and optimization.



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Using DHIS2 for Health Facility Stock Management in Humanitarian Settings

The International Committee of the Red Cross (ICRC) is integrating DHIS2 at health facilities with the institutional supply chain management information system to improve data visibility and pharmacy stock management.

Supply chain management information systems (SCMIS) are at the heart of health supply chains. An effective SCMIS depends on the right combination of people, processes, and technology. At every level of the supply chain, skilled people must record, analyze, manage, and use data. Most supply chains use a basic set of reports and forms, often paper-based, before evolving to digital tools for capturing, reporting, analyzing, and presenting data.

BACKGROUND

The DHIS2 open-source software platform is supported by a project under the Health Information Systems Program (HISP) Centre at the University of Oslo (UiO). The flexible generic data platform has a range of features to capture, manage, and analyze information, extensible through web APIs and an app framework. More than 80 countries worldwide use DHIS2 for collecting and analyzing health data. DHIS2 is offered free of charge as a global public good and provides a simple, user-friendly application for managing stocks and equipment at the facility and community level. It can be seamlessly integrated with full-scale, upstream national logistics management information systems (LMIS).

The ICRC, present in more than 100 countries, protects and assists people affected by armed conflict and other violent situations. The organization provides a continuum of care from first aid to primary health and psychosocial support. The ICRC developed the Pharmacy Stock Management (PSM) Tool, beginning with an 18-month pre-pilot in Somalia; deployment in six countries in 2022; and implementation in 50 health facilities in 2023, to improve health service delivery and health supply availability (figure 1). PSM is now running in 90 facilities across 10 countries.

Figure 1. Implementation of the Pharmacy Stock Management Tool

Requirements Gathering	Technology Scan	Solution Selection	Project Management	Maintenance and Evolution
User workflows	Open source or proprietary	Technology partner (solution provider)	Entry and exit strategy	Barcoding
Infrastructure (tablets/ computers)			Collaborative Product road map	Upgrades
Training needs			Budget	
Languages			Timeline	

Photo: Ahmad Rukaina

At Muhda Primary Health Care Center, Nigeria, staff make sure the PSM is accessible to local partners.

Location: Global
Organization: ICRC
Setting: Humanitarian and crisis settings
Supply chain management practice area: LMIS
HR cadres involved: Supply chain and pharmacy managers

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sons difficult, and up-to-date and accurate offline government statistics were not always accessible. However, innovative visualization approaches emerged, such as open-source repositories, which present viral sequence data to create a global map of the spread of infection. This was enabled by data sharing based on open-source code. Such speed of data sharing had not been seen in previous outbreaks and could be applied in other national, regional, and global disasters.

The pandemic renewed focus on the importance of preparedness, including of data for health supply chains, reflected by countries' interest in the Emergency Supply Chain Playbook developed by USAID's Global Health Supply Chain Program and in developing continuity of operations plans, such as described in the Ready to Save Lives: A Preparedness Toolkit for Sexual and Reproductive Health Care in Emergencies. However, many humanitarian health supply chains remain fragmented or operate as parallel systems long after the onset of a disaster or conflict, which may result in supply gaps and inefficiencies. This is an opportunity for NGOs to invest in systems, processes, and human resources that support information sharing and coordination among humanitarian and development organizations on the ground, as well as with national health systems and other partners.

ENTRY POINTS FOR COLLABORATION

Collaboration and data sharing among organizations can have numerous benefits, including increased efficiency and improved decision-making, leading to better outcomes for the communities they serve. Dialogue and information sharing with key coordinating bodies, including relevant global and country-level clusters and sectoral working groups, can facilitate connections across organizations and prevent duplication of effort. Humanitarian organizations can move toward increased data sharing by considering the following entry points for developing common tools for data collection and information sharing:

Standardizing data collection: Developing common tools can facilitate standardized data collection methodologies across multiple organizations. This ensures data consistency and comparability,

enabling better analysis and insights. Standardization also simplifies data aggregation and integration, making it easier to identify trends and patterns.

Data sharing and collaborating: By adopting common tools, organizations can establish a shared platform for data storage and exchange. This promotes collaboration and allows organizations to share relevant data, preventing duplication of effort and enabling a more comprehensive understanding of a situation, especially in similar geographies and communities. Data sharing can lead to more effective and timely responses.

Interoperability and integration: Common tools should prioritize interoperability so that different systems and databases can communicate and share data seamlessly. This allows organizations to integrate data from various sources and leverage collective information to make better decisions. Interoperable tools also make it easier to transition between organizations or hand over projects without data loss or disruption.

Collaborating on tool development: Humanitarian organizations can collaborate in the development and improvement of common data collection tools. This can involve sharing expertise, best practices, and lessons. Collaboration also fosters a sense of community and shared responsibility, enhancing overall data quality and usefulness. In addition, governments benefit from the standardization of tools and data collection processes, as it can strengthen interoperability and provide consolidated information at the national and sub-national levels.

Engaging local communities: It is vital to involve local communities in the design and implementation of data collection tools. By seeking their input and feedback, organizations can ensure that the tools are culturally sensitive, contextually appropriate, and meet the specific needs of the communities they serve. Engaging communities also promotes transparency, accountability, and trust. This is particularly important when planning to provide sexual and reproductive health supplies or primary health services to crisis-affected populations.

A collaborative approach also helps protect vulnerable populations and overcome critical challenges, such as antimicrobial resistance. For example, one of the organizations interviewed performs heart surgery on children who have suffered rheumatic heart disease and need valve repair. When children are diagnosed with streptococcal infection and prescribed antibiotics, the organization's staff said that in some communities, people are reluctant to take antibiotics. If organizations designed a shared track-and-trace tool to monitor treatment completion, they could avoid severe health complications, save significant resources, and more importantly, save lives.

In the humanitarian sector, many practices and standardization efforts are still in initial stages, but as learned during the COVID-19 pandemic, if the broader community standardized data collected to plan quantification, procurement, and distribution, it would be easier in early stages of an emergency to take action on the bases of standard data and dashboards. For example, during the current emergency in the Occupied Palestinian Territory, health supply data are being collected from partners responding to the war and shared with the broader Health Cluster community to help prevent over- and understock of key life-saving supplies. While the dashboards are still limited by the data the cluster can collect—accuracy depends on the data partners provide and data are incomplete because not all partners provide data—it is a good first step in standardization, harmonization, and visualization to coordinate data sharing across humanitarian organizations responding to the crisis.

PRACTICES IN HEALTH SUPPLY CHAIN SYSTEMS AND TOOLS

In development settings, SCM systems are increas-

LEARNING BRIEF HIGHLIGHT

DATA VISIBILITY: MONITORING PHARMACEUTICAL AND MEDICAL COMMODITIES IN HUMANITARIAN AND CRISIS SETTINGS

Health supply chain managers are responsible for analyzing and monitoring every aspect of their supply chains to ensure timely delivery of medicines to people in need. An important tool for doing this is a logistics management information system, which provides visibility to inform decisions and performance management in the supply chain cycle. Data visibility allows supply chain managers to track key indicators through every function of the pharmaceutical and medical commodities supply chain. Use of data dashboards is helping to foster a culture of data-driven decision-making and corrective actions in many organizations.

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Data Visibility: Monitoring Pharmaceutical and Medical Commodities in Humanitarian and Crisis Settings

Using data visibility tools to improve supply chain performance and increase the availability of life-saving health supplies.

BACKGROUND

Health supply chain managers are responsible for analyzing and monitoring every aspect of their supply chains to ensure timely delivery of medicines to people in need. An important tool for doing this is a logistics management information system, which provides visibility to inform decisions and performance management in the supply chain cycle. Data visibility allows supply chain managers to track key indicators through every function of the pharmaceutical and medical commodities supply chain.

DATA VISIBILITY

Supply chain data visibility refers to accessibility and clarity of information that makes it easy to retrieve, analyze, and understand the flow of commodities. Data that are presented in a way that is comprehensible and actionable transforms into information, which facilitates performance monitoring and corrective actions, as described in Figure 1.

Figure 1. Benefits of Using Supply Chain Data Visibility Tools

ACCURACY	With clear data, SC managers make decisions based on facts and trends rather than assumptions, leading to more accurate and effective outcomes
TIMELINESS	Data visibility enables quicker access to relevant information, allowing for timely decisions in response to rapidly changing situations
PREDICTIVE ANALYSIS	Visible data allows organizations to forecast future trends, enabling proactive rather than reactive decision-making
STRATEGIC PLANNING	Data visibility helps in identifying patterns and opportunities, aiding in strategic planning and long-term performance improvement

Location: Global

Setting: Humanitarian crisis settings

Supply chain management practice area: Performance monitoring

HR cadres involved: Supply chain, pharmacy, warehouse, and program managers

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ingly centralized, digitized, and interconnected with upstream suppliers and manufacturers, as well as downstream distribution to the last mile. These systems have been built over decades with the help of large investments by international funders and country governments, but many of them still lag in preparedness. Some large humanitarian organizations have invested heavily to build robust, digitized supply chains with end-to-end visibility, but most—especially small organizations—use simple tools and standalone systems that do not provide the data or analytics that enable effective use of data for decision-making.

Many different tools, technologies, and methods can help humanitarian organizations build a more connected supply chain with improved data for decision-making and better data preparedness. They include systems such as digitized LMIS, mobile technologies for data collection, and dashboards to visualize supply chain data. Based on interviews with several humanitarian organizations, the more resource-intensive and investment-heavy systems are rarely used.

Humanitarian organizations could benefit from implementing one or more of the many tools and systems that facilitate data collection and logistics information management, such as the DHIS2-LMIS, the Purchasing and Inventory Management System (PIMS) developed by the International Medical Corps, and Commcare. The widely used open-source DHIS2 LMIS works in offline mode for essential logistics data collection at the last mile and was implemented for the PSM Tool that ICRC developed in partnership with the University of Oslo (see learning brief highlight on page 12). PIMS provides a comprehensive system for managing procurement and inventory operations with real-time data. Commcare enables frontline health workers to track

LEARNING BRIEF HIGHLIGHT

SUPPLY CHAIN VISIBILITY FOR INFORMED RESUPPLY DECISIONS: USING CSTOCK TO COLLECT LOGISTICS DATA IN CRISIS SETTINGS

inSupply has implemented cStock across four of Kenya's arid and semi-arid lands, where the environment is challenging and populations are hard to reach and sometimes migratory. In these resource-constrained settings, the area's nomadic community health volunteers, who have no supply chain management training and sometimes low literacy levels, use cStock through their phones to report stock data to supervisors, triggering resupply. cStock makes the system accessible with familiar visuals and voice features and can capture logistics data offline and submit it when internet access is available.


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Supply Chain Visibility for Informed Resupply Decisions

Using cStock to Collect Logistics Data in Crisis Settings

INTRODUCTION

In situations of humanitarian crisis, access to supplies, especially for health services, is a primary concern that can save countless lives. To manage a supply chain, humanitarian responders and program managers must have visibility into the supply situation on the ground, and in the case of health supplies, into the lowest levels of health service delivery.

BACKGROUND

cStock is a mobile solution for reporting and resupply of health commodities at the community level. With user-friendly dashboards, and combined with an IMPACT[1] Team approach, cStock can strengthen health supply chains in low resource settings. From 2017 to 2018, Kenya-based JSI affiliate inSupply Health piloted cStock in Siaya, a mostly urban county in Kenya. The pilot offered a digital approach to strengthening the community supply chain, resulting in reduced stockouts of critical commodities.

For the past three years, under the Supply Chain Alternatives for Last Mile Equity (SCALE) project, inSupply has supported Kenya's Ministry of Health (MOH) in implementing cStock across four of Kenya's arid and semi-arid lands (ASAL), which pose challenging environments. The ASAL counties face geographical, infrastructure, political, resource, and capacity difficulties, leading to fragmented and disrupted health supply chains. The SCALE project worked with marginalized populations that are remote, hard to reach, and sometimes migratory. inSupply used human centered design processes to adapt cStock to these resource constrained settings, as well as to the area's nomadic community health volunteers (CHVs), who often have less access to training than their urban peers.

1 Information Mobilized for Performance Analysis and Continuous Transformation

inSupply Health

JSI

inventory, consumption, and procurement decisions through customizable forms and workflows with few technical requirements. See Annex D for a list of the most commonly used systems and their pros and cons.

For data visualization, the more commonly used tools are PowerBI, Tableau, and similar tools, depending on budgets and skill sets. These tend to be used at the central level and rarely facilitate data analyses at the facility level, where Excel sheets are most commonly used. Spreadsheets, which are easy to use and require little training, are a temporary solution for data management, especially given potentially high onsite staff turnover. Supply chain data generated by organizations at the local level are typically analyzed and visualized at central offices using programs like Python, or migrated from Excel sheets to Access databases. Some organizations are developing more robust tools such as MS Dynamics 365 to integrate data from the field and allow full visibility, although not in real time.

Several organizations use enterprise resource planning systems to automate routine tasks, but these systems typically connect only central-level warehouses, suppliers, and procurement teams, providing visibility of the supply chain externally without collecting supply chain data specifically. Platforms such as iMMAP and the Data Entry and Exploration Platform provide qualitative data, statistics, and analytics related to NGO operations, geographical presence, and other information that helps organizations understand the humanitarian assistance ecosystem, but they do not collect supply chain data.

DATA PREPAREDNESS FOR QUANTIFICATION

A central activity in any humanitarian response is to determine the quantities of health supplies needed, also known as quantification. The importance of these processes cannot be overstated, and their effectiveness is indispensable to providing timely assistance to affected populations. The accuracy of the quantification results and their subsequent effect on supply chains highlight the importance of data-driven decision-making for an effective humanitarian response.

To prepare for quantification ahead of a crisis, humanitarian organizations must know which data will help them, and where, how, and to what extent they can gather them. Such data preparedness enables organizations to be ready for quantification in a variety of scenarios.

Humanitarian settings are characterized by supply and demand uncertainty that complicates medical commodity quantification. In natural and sudden-onset disasters, people's needs can rise significantly, and in new areas and populations in the cases of internally displaced persons or an influx of refugees from neighboring countries. At the same time, the capacity of national systems to meet the needs of populations can decrease, sometimes dramatically, as disasters or conflicts overwhelm or limit access to normal services. Similarly, the market for PMCs can be affected and the logistics infrastructure damaged, inaccessible due to conflict, or overwhelmed due to an influx of humanitarian aid and a lack of storage space and transport capacity.

QUANTIFICATION DEFINED

Quantification is the process of estimating the quantities and costs of products required for a specific health program, and determining when the products should be delivered to ensure an uninterrupted supply. Quantification includes forecasting and supply planning.

Forecasting is the process of estimating the quantities of products that will be dispensed or used to meet the health needs of the particular population at a specific future time. Forecasting can be based on historical consumption (quantities dispensed or used), services, morbidity and/or demographic data, and assumptions about future demand, program plans, and performance. When historical data are unavailable or unreliable, assumptions will also be needed to estimate program performance and product consumption.

Supply planning involves determining the total product quantities and costs required to fill the supply pipeline to ensure optimal procurement and delivery schedules, taking into account forecasted consumption, minimum and maximum stock levels, order and shipping lead times, and desired shipment arrival dates.

Humanitarian organizations typically start by collecting demographic data: the number of children, adolescents, and adult men and women living in a community or a refugee camp; the burden of disease; the number of organizations working in the same geographical area; and the number and status of any health facilities. This helps organizations estimate the number of vaccines, family planning methods, antibiotics, and other essential medicines and supplies needed to serve and treat the population. Some organizations we interviewed mentioned that during the preparedness phase and in the initial response, rough quantification estimates are made based on local population or census data. These estimates help them decide how much of each medicine and supply to procure if more accurate quantification or forecasting is not possible. Once service provision has been established, organizations begin to collect service statistics and/or consumption data to refine their forecasts and supply planning projections.

Increasingly, humanitarian partners are exploring the nascent proliferation of technologies that enable use of big data for analysis and modeling. Data from satellite mapping, health and population surveys, and other traditional sources can be combined for situational analyses to improve data preparedness and contingency planning. This includes "nowcast" data that capture changes in real or near-real time. With access to varied sources from many angles and the use of artificial intelligence and machine learning, predictive data modeling and simulation exercises will be increasingly helpful as humanitarian organizations try to predict and prioritize PMC needs. The literature search in Annex F includes articles on a variety of ways that data and technology can be used for analysis.

Given the urgency to determine which data to use for quantification during a crisis, there is often a disconnect between data, decision-making, and response. Health supply chain staff are often pharmacists with experience in pharmaceutical management. During our interviews, they mentioned a disconnect between program and administrative/financial staff, as the data used for forecasting and procurement differ from the data generated onsite (i.e., consumption, inventory). They also mentioned the need to involve staff from different departments in SCM training to improve data use and management in key decisions.

To prepare for procurement, organizations need a list of local and international pre-qualified suppliers. Data preparedness involves selecting necessary medicines and supplies and identifying reliable suppliers. Technical tools like Quantimed, QAT, Pipeline, and Forelab aid in anticipating needs but may lack adaptability and require training, and must be combined with interpersonal strategies and interagency communication.

Interpersonal approaches involve methodologies for data collection through conversations to foster in-depth understanding. Trained interviewers, using tools and empathetic mindsets, ensure accurate data collection. Involving local leaders enhances community representation and buy-in by applying informal approaches for effective communication.

Beyond technical and interpersonal tools, interagency frameworks focus on collaboration among agencies, responders, funders, and governments. An example is the Ethiopian Interagency Government-NGO Forum, which fosters transparency and preparedness by facilitating collaboration between NGOs and government institutions. While offering benefits like enhanced collaboration and knowledge sharing, challenges include collaboration difficulties and sluggish response. Success depends on diverse organizational participation for accurate data and improved forecasts.

Some organizations have used more advanced situational analysis tools such as a nowcast component that uses open-source data like events, the economy, and infection rates to supplement operational feeds to gain live or near-live understandings of what is happening in a humanitarian environ-

ment. Predictive analytics provide possible future scenarios and enhance awareness of all the variables within a humanitarian emergency. Moreover, it helps plan for things like shelters by simulating different scenarios, thinking about how many people might arrive, how quickly, and how well the operation can handle it all. Decision-makers can tweak factors like arrival rates to see how it changes shelter needs over time. This way, it's not just predicting; it's getting ready with the right resources when needed, making the whole process more efficient during crises.

A response with health goals dictated by the national health organization requires a focus on an interagency framework for quantification as multiple organizations attempt to work together. An individual organization responding to a more localized crisis may rely more on interpersonal approaches and technical tools.

The landscape of PMC supply chain data and quantification is complex and requires careful selection of tools and frameworks tailored to specific contexts. The convergence of technical tools with interpersonal frameworks like interview training and local engagement yields a comprehensive approach. The Ethiopian Interagency Government-NGO Forum exemplifies the potential of interagency collaboration. Whether an organization is focusing on technical quantification, working interpersonally with affected populations, or coordinating at a national or global level, the data required for a quantification process can vary greatly. Therefore, the accuracy of these processes will rely on the proper selection of the above tools and the extent to which organizations practice data preparedness.

THE KIT-BASED QUANTIFICATION PROCESS

Quantification in humanitarian situations, specifically in the context of quantification for various emergency health kits, is a dynamic and strategic process that relies on data preparedness. It involves careful consideration of the purpose, scope, medical needs, and budget to ensure that the right kits or products are procured and resources are allocated efficiently. Organizations should consider the cyclical nature of disasters and how to change approaches to avoid reliance on a kit response when unnecessary. This might mean shifting as quickly as possible to the procurement of individ-

Photo: International Medical Corps

ual products, while understanding that kits may be required again if another disaster strikes. In some cases, going back to using kits in certain situations may be necessary for short periods. With enough preparedness and redundancy, organizations could rely on kits for only few and specific scenarios. The kit-based quantification process involves the following steps.

1. **Defining objectives and scope:** The quantification process begins with a clear understanding of the objectives and scope. Humanitarian organizations identify the purpose of the items or kits they intend to procure, such as responding to a specific health crisis, natural disaster, or refugee influx. Each crisis may require different types of kits tailored to the needs of the affected population. Once the purpose is established, humanitarian organizations determine the scope of the quantification process. They consider the scale of the response, ranging from the needs of a single health facility to those of an entire region. The scope also influences the types and quantities of kits required.

2. **Identifying health service needs:** In accordance with the identified purpose, humanitarian organizations assess the specific health service needs of the affected population. This includes determining the types of PMCs and supplies required for effective health care delivery and selecting the appropriate health kit. For instance, in a disease outbreak, kits may include personal protective equipment, diagnostic tests, and treatment medications. In the first phase of a response, as needs assessment data are still being compiled, standard emergency response health kits are an off-the-shelf way to ensure that commodities can be mobilized quickly. Identifying health service needs in a crisis involves a comprehensive analysis that includes reviewing historical data, conducting field assessments, and consulting with health professionals and experts. Historical data may not always reflect the rapidly changing dynamics of a crisis, and data on health service needs, consumption patterns, and other essential variables may not be readily available, making it challenging to formulate precise needs on an item-by-item basis. While population-level data provide a broad understanding of health care needs, they may not capture the nuanced requirements of specific regions within a crisis-affected area. A one-size-fits-all approach to kit procurement may overlook critical variations in health care needs. Coordinating bodies, such as the Health Cluster, if activated, may provide needs assessment and prioritize information to facilitate emergency supply procurement and delivery.

3. **Kit procurement:** Once the health service needs are determined, humanitarian organizations order the necessary kits, which are pre-packaged with sets of PMCs tailored to specific purposes. The objective is to order the number of kits that meet the estimated needs, considering the scope of the response, transport and storage availability, and budget. A few kit quantification tools are publicly available, including those for cholera and reproductive health (see Annex D).

4. **Using budget to prescribe kit purchases:** Budget considerations are central to the quantification process. Humanitarian organizations must make informed decisions about how to optimize the allocation of their resources when purchasing kits. In cases where the budget is limited, prioritization is essential. Organizations may need to allocate resources to the most critical and high-impact kits, and maximize the efficiency of their budget by ensuring that the kits they purchase align with the identified health service needs. This helps prevent resource wastage and ensures that the right supplies are available to mitigate the crisis. Although the process varies from organization to organization, potential budgetary restrictions have an overshadowing effect on many of the examples of forecasting and kit-based quantification that humanitarian responders do.

THE CHALLENGES OF SHIFTING FROM KITS TO INDIVIDUAL PROCUREMENT

It is important to shift from kit use in humanitarian contexts for several reasons. Pre-packaged kits are designed for use in the acute phase of a crisis but are not optimal in protracted situations. While kits provide fast access to health supplies in a crisis, they often fall short of meeting the specific health service needs of affected populations and are more likely to waste resources in terms of excess supplies. Humanitarian organizations should consider transitioning from a kit-based approach to procurement of individual items, first by breaking down kits and then ordering the items themselves, as soon as feasible, typically within 3–6 months of the onset of a crisis. While such a transition can be a complex, it offers the potential for more targeted and efficient delivery of health supplies.

Humanitarian organizations face multiple challenges when attempting to shift from kits to procuring individual items. Depending on the existing infrastructure, including storage space and digital supply chain tools, it can be a lengthy and resource-intensive endeavor. In some cases, it may be necessary to return to kits temporarily, and there is little guidance on parameters for determining the need to start a transition. Transitioning from kits to individual items requires careful planning, time, resources, and collaboration and can take several years to ensure alignment with the context, requirements, and objectives of a specific humanitarian response. It involves more sophisticated quantification, procurement, LMIS, distribution, and coordination of stakeholders.

Breaking down kits

Transitioning to individual procurement requires the meticulous breakdown of kits into their constituent components to identify which items are relevant to the affected population's health care needs. This requires a deep understanding of health service requirements, pharmaceutical registration laws, and local and cultural aspects that influence demand for the items, and careful inventory management.

Stages of readiness for transitioning from kits

Organizations must assess readiness to transition from kits. This involves stages that may include determining if kits are given to patients, individual practitioners, or organizations. It also encompasses monitoring and evaluating the use of these kits at each level. Achieving a seamless transition at each stage is a complex and resource-intensive endeavor.

Resources and skills needed for transition

Moving from kits to individual procurement requires adequate resources and skilled procurement professionals, data analysts, and logisticians who can design and implement a tailored strategy. This shift is resource-intensive, and organizations may need to invest in personnel and infrastructure. For example, for international procurement, kits may clear customs more easily, while procurement of individual items requires careful planning to comply with importation requirements.

Interagency collaboration and communication

Transitioning from kits individual item procurement often necessitates improved communication and collaboration among different humanitarian organizations, funders, and governments. Coordination is crucial to align efforts and resources efficiently.

Basic tools vs. advanced systems

While there are sophisticated software tools for procurement and quantification, many organizations rely on basic tools such as spreadsheets and notes. Shifting to individual procurement may require more advanced digital tools, which means that organizations may need to invest in technology and training.

Why shift from kits?

- **Precision in medical response:** Kits are pre-assembled and may contain unnecessary items or limited quantities of items that are needed for a particular situation. Individual item procurement allows tailored responses, ensuring that supplies are matched to the needs of each situation.
- **Efficiency and cost-effectiveness:** Procuring individual items reduces waste and unnecessary expenses associated with kits. When resources are more efficiently allocated, humanitarian organizations' financial burdens are reduced.
- **Flexibility and adaptability:** Individual item procurement provides flexibility to respond to changing needs, ensuring that PMCs are readily available.
- **Community acceptance:** Not all local organizations and communities want kits over longer periods. Individual procurement is easier to customize for communities.
- **Improved forecasting:** Transitioning to individual items requires a more robust forecasting system, which in turn enhances humanitarian crises preparedness. Accurate forecasting allows organizations to better understand and meet the health service needs of affected populations.

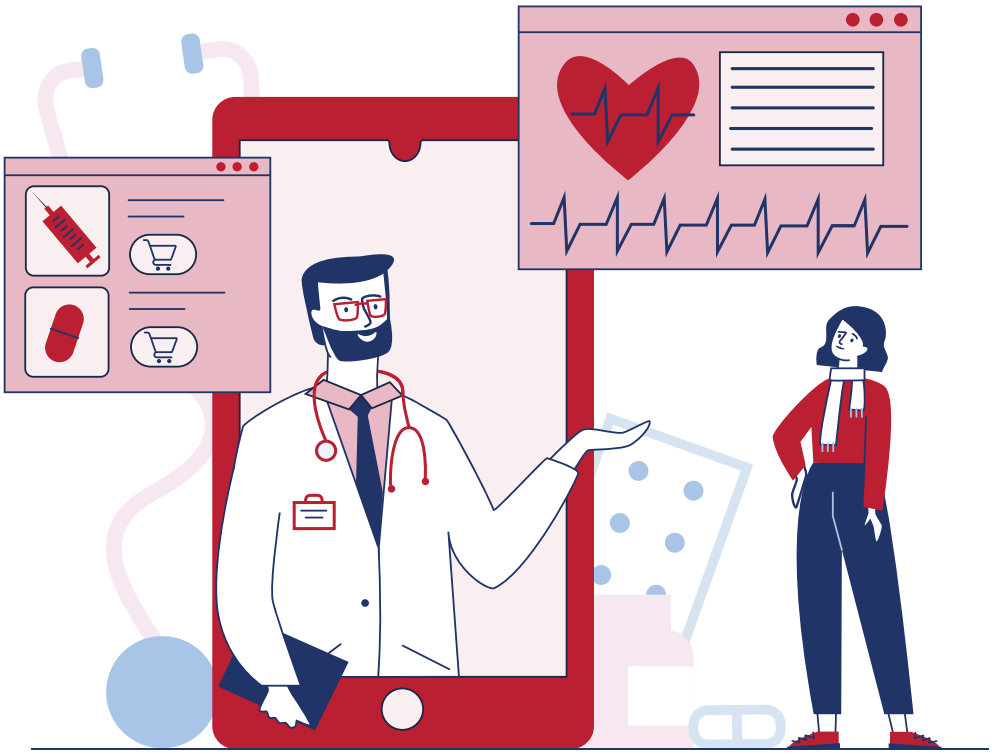
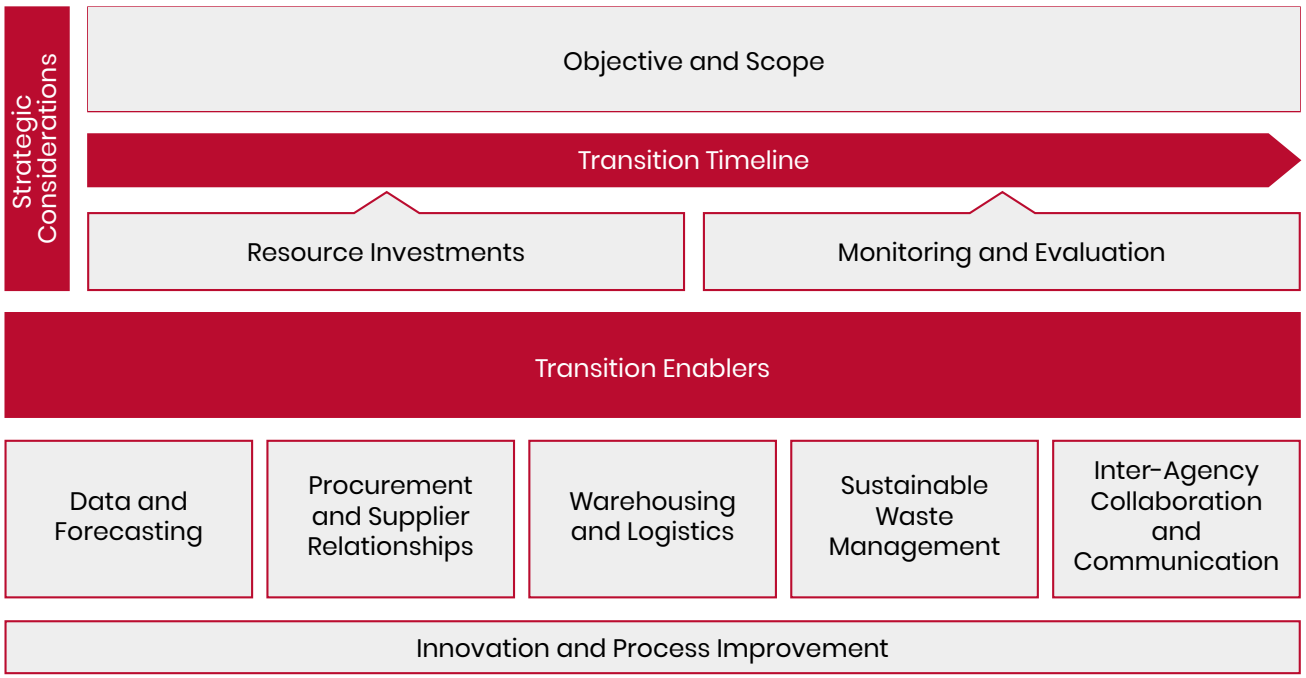


FIGURE 3. TRANSITION FRAMEWORK



A FRAMEWORK FOR TRANSITIONING FROM KITS TO INDIVIDUAL ITEMS

Transitioning from kits to individual item procurement in humanitarian contexts requires careful planning, investment in resources and skills, collaboration, and innovation. It entails establishing an SCM system that can respond to changes in demand, which requires data visibility up and down the supply chain. The framework below can guide humanitarian organizations in this effort.

1. **Objective and Scope:**
   - Clearly define the objectives of the transition.
   - Scope the transition in terms of the range of medical items to be procured individually.

2. **Transition Timeline:**
   - Determine and communicate to all stakeholders the length of time required for transition.
   - Anticipate and plan for a phased transition with incremental progress; communicate progress including any delays to all stakeholders.
   - Set milestones to track progress and adjust strategies as needed.

3. **Resource Investments:**
   - Allocate resources for all required steps.
   - Invest in staff training and capacity building for required steps.
   - Budget for any required infrastructure changes or capital investments (such as those in warehousing and logistics).

4. **Monitoring and Evaluation:**
   - Establish a monitoring and evaluation framework to assess the progress of the transition.
   - Collect data on the impact of the shift, including cost savings, access, and medical outcomes, on humanitarian responses.
5. **Data and Forecasting:**
   - Strengthen data collection and management tools to improve the quality of essential logistics data—consumption, stock-on-hand, and losses/adjustments.
   - Select and implement a forecasting system that takes into account individual items rather than pre-packaged kits.
   - Set up a team of experts to manage forecasting and data analysis, with a focus on using data to make decisions.
6. **Procurement and Supplier Relationships:**
   - Identify and establish relationships with multiple suppliers to source individual items.
   - Develop procedures and strengthen procurement capacity to diversify the pool of suppliers.
   - Implement systems to ensure the quality of individual items.
7. **Warehousing and Logistics:**
   - Adapt warehousing infrastructure to accommodate individual items.
   - Develop or modify logistics and inventory management systems to handle diverse individual medical items.
8. **Sustainability and Waste Management:**
   - Evaluate procedures for reverse logistics and medical waste disposal.
   - Adapt sustainable practices for managing and disposing medical supplies to minimize waste and environmental harm.
   - Ensure that the transition process does not lead to unnecessary waste or inefficiencies.
9. **Inter-Agency Collaboration and Communication:**
   - Coordinate with other humanitarian organizations to share insights, best practices, challenges, and resources.
   - Promote communication among organizations to create a collaborative approach.
   - Join a community of practice (such as IAPHL) to learn from experts and organizations implementing itemized procurement.
10. **Innovation and Process Improvement:**
    - Encourage innovations for better forecasting, inventory management, and use of technologies to optimize SCM and regulatory processes.
    - Continuously evaluate, optimize, and adapt the transition process and the maturity of internal SCM systems to improve effectiveness and efficiency.

CONCLUSIONS AND CONSIDERATIONS

In humanitarian disasters and settings, having the PMCs and supplies needed to respond requires planning and preparing supply chain data to quantify and procure them. Humanitarian organizations seeking to improve their health supply chains can select from the variety of tools and methods outlined in this document to advance data preparedness. While each initiative to improve a supply chain is valuable, IPs must develop their supply chain strategically, ideally managing all projects through an integrated supply chain for resilience and sustainability.

Many humanitarian organizations are limited in how they can improve their pharmaceutical supply chains and transition from kits to individual items because of short funding cycles and pressure to deliver health supplies quickly. Few funders provide humanitarian organizations with budgets to develop information systems that can support data preparedness, quantification, and overall use of data for decision making. However, there are opportunities to find funding for an information system, and USAID BHA supports proposals that include investments in supply chain integration and development of information systems that will improve humanitarian responses.

While funding is challenging, a lack of organizational commitment to or prioritization of the supply chain often impedes NGOs' ability to cultivate a proficient information technology workforce and transition from Excel sheets to more sophisticated data management tools. Being able to transition is crucial for streamlining data collection, analysis, and the timely generation of reports to support informed decisions.

Organizations often operate in isolation, adhering to funders' stipulations and failing to exchange information and best practices. This can result in failure to share insights about data collection, analysis, and evaluation challenges and solutions. This means missed opportunities to enhance availability of timely data for quantification and procurement of medicines and supplies within specified timeframes.

Organizations should consider building an integrated supply chain over time, with key indicators to monitor performance, rather than managing supplies contract-by-contract or over-relying on emergency kits. A more integrated supply chain will require upfront investment but ultimately save money through cost efficiency and by lowering opportunity costs across the organization. In humanitarian settings, an integrated supply chain can provide a level of redundancy to preposition supplies and ensure improved continuity of operations across all projects, rather than managing supplies by individual funder or contractual mechanism.

To ensure sufficient commodities to meet needs, all humanitarian partners must coordinate within their organizations and with other IPs. In many humanitarian disasters, coordination is ad hoc, although in recent emergencies there have been some improvements including the formation sub-working groups that help collect essential information about commodities, warehouses, transportation fleets, etc. These collaborative efforts need to be systematized, standardized, and institutionalized.

Community involvement can help base solutions in reality and create accountability to affected populations. Community members, if surveyed across a range of individuals including affected populations, can help validate demographic information and

provide information about upcoming changes and preferences. When transitioning from health kits to individual items, organizations can also consider analyzing the disease burden as well as cultural and local contexts to decide which pharmaceuticals will be used, in part by requesting feedback from the community and local leaders, community health workers, and midwives. Community members and affected populations can also serve as watchdogs by reporting on stockouts, adverse reactions to medicines, and other supply chain challenges. They can also help garner local support for sharing information, improve facilities and storage space by contributing to renovations, and extend transportation and storage options by leveraging the non-public or private sectors.

Humanitarian organizations should consider the benefits, costs, and implications of transitioning from kits to individual items in terms of infrastructure and potential for improving data preparedness and coordination. For many organizations, the rationale for transitioning is not always connected to usage or wastage, but rather directed by financial resources. An effort to systematize data and decisions related to transitioning, ideally in a collaborative context, could benefit the humanitarian community.

Through informed choices, adaptability, and astute data management, humanitarian organizations can enhance PMC quantification, ultimately contributing to better health care responses for the people who are affected.

ANNEXES

ANNEX A. LEARNING BRIEFS

Based on case studies and interviews with humanitarian organization staff, the program produced the following learning briefs to serve as resources for humanitarian organizations and their partners. Some of them were translated into Arabic, French, and Spanish.

Data Visibility: Monitoring Pharmaceutical and Medical Commodities in Humanitarian and Crisis Settings

Ensuring Good Storage and Distribution Practices to Protect the Quality of Health Supplies

Forging Local Networks to Distribute Life-saving Health Supplies in Ukraine

Inventory Management for Health Supplies in Humanitarian Settings

Minimizing the Environmental Consequences of Humanitarian Supply Chains

Strategies for Navigating Health Commodity Procurement in Humanitarian Settings

Human Resources and Capacity Building in Humanitarian Organizations

Getting Medicines to Palestinian Refugees: A Simple Tool Links Data to Monitor Stock Levels for Pharmaceuticals

Protecting the Quality of Pharmaceuticals in Bangladesh

Improving Supply Chain Performance through Data Review Teams

Supply Chain Visibility for Informed Resupply Decisions: Using cStock to Collect Logistics Data in Crisis Settings

Standardizing Paper-based LMIS Tools to Optimize Inventory Strategy

Reducing Procurement Lead Times with Streamlined Importation Processes

Using DHIS2 for Health Facility Stock Management in Humanitarian Settings

ANNEX B. ONLINE TECHNICAL DISCUSSIONS

Over a two-year period, the program hosted online technical discussions on a variety of SCM topics that humanitarian partners identified as barriers to PMC delivery. The discussions, as well as previous webinars hosted by the program, are available on-demand through JSI's YouTube channel.

2022

When to feel confident when procuring pharmaceuticals from suppliers in the local market

Achieving shorter lead times during emergencies

Protecting the quality of pharmaceutical products in every phase of the humanitarian response

Learning from effective inventory management practices to improve the availability of pharmaceutical products

Risk management plans are crucial to minimizing disruptions in the availability of pharmaceuticals in the last mile

Examples of how coordination helps improve the delivery of pharmaceuticals and medical supplies for an effective humanitarian response

2023

Minimizing the Environmental Impact of Humanitarian Health Supply Chains

Protecting the Quality of Health Products in Every Phase of a Humanitarian Response, Part 2

A Review of Good Warehousing and Handling Practices in Emergency Settings

Using DHIS2 for Health Supply Chain Management in Humanitarian Settings

Improving Quantification Processes in Humanitarian and Disaster Settings

Tools and Practices for Improving Workforce Performance to Manage Humanitarian Health Supply Chains

ANNEX C. CHALLENGES AND SOLUTIONS FOR DELIVERING HEALTH SUPPLIES IN HUMANITARIAN AND EMERGENCY SETTINGS

Introduction

Humanitarian supply chain management (SCM) involves buying and delivering health supplies and services to the place where they are needed in the immediate aftermath of an emergency and during recovery. Strong health supply chains save lives and are a critical component of humanitarian crises. With funding from USAID's Bureau for Humanitarian Assistance (BHA), JSI implements the Building Capacity to Improve Pharmaceutical and Medical Commodity (PMC) Management in Humanitarian and Disaster Settings Program, which improves the capacity of international and local nongovernmental organizations (NGOs) to manage PMCs.

The program equips SCM staff with training, guidance, resources, and follow-up support. This includes blended learning and in-person training; development of learning briefs that showcase proven practices for managing PMCs; technical discussions where practitioners share learnings; and engagement in the Humanitarian Commodities Logistics (HCL) Community of Practice, a subgroup of the International Association of Public Health Logisticians. The program also supports BHA implementing partners with mentoring and technical assistance to institutionalize good PMC policies and practices.

Through the program's HCL Community Education Series, humanitarian health logisticians and SCM experts participated in online technical discussions on a variety of supply chain topics. Through 12 webinars over two years, the program gathered a wealth of information about the challenges that humanitarian organizations face. This document is a collection of challenges and proposed solutions based on the technical discussions and learning from program activities and their numerous participants. It is organized by SCM function. All technical discussions are available on-demand through JSI's YouTube channel.

QUANTIFICATION

Quantification is the process of estimating the quantities and costs of the products required for a specific health program (or service), and determining when they should be delivered to ensure an uninterrupted supply for a health program. Quantification is a critical SCM activity that links information on services and commodities from the facility level with program policies and plans at the national level.

1. **Challenge: Difficulties obtaining good-quality consumption data for forecasting commodity requirements.**

Solutions:

a) Use consumption data collected from clinics during the forecasting step of quantification. Continuously review and improve data collection mechanisms to ensure data accuracy and reliability to determine the required quantities of supplies.

b) When possible, visit a sample of service delivery points to validate data reported against data collected. Provide on-the-job training to improve data collection and reporting.

c) Establish data review teams that routinely use data to identify supply chain problems and take action to improve the supply chain. Structured use of supply chain data improves data collection and reporting.

d) Conduct periodic audits and assessments of supply chain data collection and management processes to identify areas for improvement and implement corrective measures.

e) Triangulate consumption data with alternate sources such as supervision and health facility survey data to validate and cross-check the consumption data collected from clinics and other service delivery points. Incorporate supportive supervision to provide continuous feedback on data quality and recording and reporting processes.

f) Create systems that recognize and reward accurate and diligent data reporting at all levels. This could involve recognizing individual or team efforts to maintain high data quality standards.

2. Challenge: Fragmented forecasting and quantification processes.

SOLUTIONS:

a) Find collaboration and coordination opportunities to achieve a more diverse quantification team and to synchronize processes among stakeholders both internally and externally.

b) Establish a quantification team that includes members from relevant departments and agencies to conduct quantification activities together, and review and update forecasts and supply plans.

c) Create shared data repositories or folders accessible to all stakeholders. This can be a single source of data related to forecasting and quantification, reducing fragmentation, and improving transparency.

3. Challenge: Difficulties obtaining accurate, comprehensive, and up-to-date information on population size, epidemiological information, treatment protocols, and consumption patterns, especially in resource-constrained settings.

Solutions:

a) Improve data collection and management systems. This can involve implementing electronic health record systems to capture and analyze patient data; strengthening surveillance systems for better disease monitoring; and conducting regular surveys or assessments to gather population and consumption data. Collaborate with local health authorities and organizations to share data.

b) Establish a commodity coordination committee that includes relevant partners who meet routinely to monitor stock status, share information, and act to ensure continuous supply.

c) Invest in capacity-building initiatives for health care workers involved in quantification. Provide training on data collection methods, analysis techniques, and interpretation of guidelines so health care professionals can improve their skills for accurately estimating the required quantities of health commodities.

d) Integrate technology-driven solutions to streamline data collection and analysis. For example, use mobile applications for data collection and implement forecasting models supported by artificial intelligence to automate and standardize quantification, reducing human error and enhancing accuracy.

e) Address challenges related to data availability and accuracy with a multi-faceted approach involving improved data systems, capacity building, and the integration of technology-driven solutions.

PROCUREMENT IN LOCAL MARKETS

Only effective and rigorous procurement policies, processes, and procedures can ensure a reliable flow of commodities into the supply chain and respond effectively to any contextual or operational changes. To design the procurement strategy, the procurement unit must develop an understanding of the market by studying market structure, competition, supply chain, products and product quality, value as a customer, and prices.

1. **Challenge: Lack of organizations with resources and expertise to inspect suppliers manufacturing sites.**

Solution:

a) When planning local market surveys, explore options for sharing information among humanitarian organizations to minimize the need for multiple suppliers site visits in a year, ensuring efficient use of time and resources.

2. **Challenge: Lack of trained/professional staff to execute market survey management tasks.**

Solutions:

a) Improve the capacity of your organization by investing in the training and development of human resources to conduct market surveys effectively. If funds are available, consider contracting QUAMED or other vendors to conduct professional analysis and market surveys, depending on organizational and funder requirements.

b) Form a multidisciplinary team comprising logistics, procurement, medical, and sometimes funding staff to conduct market surveys. This ensures a comprehensive evaluation using different perspectives.

3. **Challenge: Insufficient knowledge and capacity to assess local PMC supplier information management systems (IMS) and quality management systems (QMS).**

Solution:

a) Obtain the IMS and QMS information from the shared report for QUAMED's most recent assessment of potential suppliers to evaluate their IMS and QMS capabilities and suitability.

4. **Challenge: Insufficient price discovery during market surveys.**

Solution:

a) When conducting market surveys, make price discovery an objective of the survey to gather important price data for decision-making. Conduct market surveys regularly and include as many suppliers as possible, including local ones and those in nearby countries. Include all costs (product price, delivery costs, and at what level) to conduct comparable analysis of prices and related costs.

5. **Challenge: Monitoring local supplier quality control practices is time-consuming.**

Solution:

a) As part of planning a market survey, summarize the evaluation criteria related to the supplier's quality control practices, including testing protocols, documentation, and monitoring of product quality.

PROCUREMENT LEAD TIMES

A major consideration when opting for international procurement is lead time. Procurement can be delayed for many reasons, including legal and policy restrictions, not only in the origin and final destination countries but also in other countries involved in the global supply chain. Procurement eventually determines how fast and effectively you can deliver health products to the last mile, especially during a humanitarian response.

1. **Challenge: Meeting defined timelines and lead times (e.g., price quoting, purchase order processing, freight) is difficult.**

Solutions:

a) Establish clear key performance indicators (KPIs) to measure performance and monitor timelines for different process steps.

b) Include KPIs in supplier contracts with incentives to meet the targets including lead times and timeline KPIs. Work with suppliers during negotiations to establish realistic performance metrics.

2. **Challenge: Delays and bottlenecks can occur at different stages of the supply chain, resulting from documentation inaccuracy, limited container availability and vessel space, delays in receiving import waivers, and limited truck availability.**

Solutions:

a) Conduct process mapping and process optimization to identify bottlenecks and take corrective action. Improve planning and processes to ensure the availability of necessary equipment; reserve space on vessels; and improve forecasting exercises to reduce lead times.

b) Develop and use electronic checklists for increased visibility and monitoring, and process mapping and timelines to better plan and prepare for supply chain inputs and resources.

3. **Challenge: Difficult supplier relationships and negotiations.**

Solutions:

a) Leverage negotiating power while respecting supplier partners.

b) Facilitate collaboration by engaging suppliers, offering services to local authorities, and sharing best practices and experiences to improve the flow of goods and reduce lead times.

c) In cases when multiple partners are providing health products, establish mechanisms for coordinated supply planning to avoid duplication; share supplier information; and leverage each partner's relative procurement advantage.

4. **Challenge: Broken local market and long lead times for international procurement can cause shortages.**

Solution:

a) Increase projected quantities to provide buffer stock to protect against stockouts while closely monitoring stock levels to avoid excess stock and expiries. Regularly review and adjust the projected quantities based on updated information and market conditions. Explore options for diversifying suppliers and consider building strategic partnerships with reliable local suppliers to reduce dependence on a single source.

QUALITY ASSURANCE

Counterfeit and substandard products in the marketplace cause significant quality risks for the supply system and harm the environment. Public sector procurement processes and national regulatory agencies must implement appropriate quality assurance (QA) measures to ensure that only good-quality products enter the supply system. Procurement addresses this responsibility through the technical specifications issued in the tender document, which identifies key product quality requirements such as product certification, labeling and packaging, and shelf-life, and pharmacopeia standards (when applicable).

1. **Challenge: Inappropriate temperature and humidity conditions for pharmaceutical storage and distribution caused by inadequate power supply, unsuitable warehouse infrastructure, difficult topography, and limited availability of suitable transport compromise overall product integrity.**

Solutions:

a) Manage risk by developing contingency plans, diverse and comprehensive alternative transportation methods in challenging environments, and information-sharing mechanisms.

b) Optimize distribution intervals by accounting for storage conditions at warehouses and storage nodes in your system and implementing short distribution intervals for sites where temperature control is a problem. This lessens the duration of exposure to unfavorable storage conditions and reduces the risk of compromised product quality and waste.

c) Maintain an optimum level of safety stock at facilities based on consumption and storage capacity to mitigate the consequences of power supply and infrastructure limitations.

d) Ensure a monitoring mechanism for temperature and humidity conditions during transportation and handling.

e) Implement and monitor temperature control measures, such as using air conditioners, dehumidifiers, and solar-powered fans to control temperatures and humidity in warehouses and facilities.

f) Explore alternative energy sources such as solar to protect the quality of vaccines and other cold-chain products in warehouses.

g) Arrange stacks for better air circulation, promote passive ventilation with screened windows, and install heat ventilators in the roof.

2. **Challenge: Organizations do not always comply with WHO's Good Storage and Distribution Practices for pharmaceuticals.**

Solutions:

a) Prioritize simple yet effective QA measures such as visual inspections during product movement. Use tools like the WHO "Be aware" guide for visual inspection of medicines.

b) Follow good warehouse practices and implement the first-to-expire-first-out system to prevent distribution of expired products, waste, and subsequent environmental consequences.

c) Protect products from sunlight, chemicals, and physical damage by adhering to good storage guidelines including keeping them in designated packaging materials.

3. Challenge: Proficient monitoring and traceability take time to institutionalize due to lack of processes and sufficiently trained workers.

Solutions:

a) Use inventory management systems such as the Excel-based Pharma Inventory Tracker (PIT) and facility stock reporting tools for accurate reporting and traceability.

b) Strengthen reporting and investigation mechanisms, including establishment of clear procedures for reporting product quality issues. Conduct thorough investigations and implement necessary actions based on the findings.

c) Establish or enforce record keeping and data management to track products from source to destination.

4. Challenge: No quality assessments or follow-up on corrective and preventive action (CAPA).

Solutions:

a) Create a basic quality assessment framework that outlines standards, processes, and responsibilities.

b) Conduct quality assessments annually and follow-up on CAPA implementation continually. Consider asking management and financing colleagues to help close improvement gaps.

c) Conduct training on basic QA concepts and CAPA processes, and implement a monitoring system to track them.

5. Challenge: Lack of standard operating procedures (SOPs) and trained staff to manage risk and reality of counterfeit medical items.

Solutions:

a) Require Good Manufacturing Practices certificate from stringent authorities. Once products are in the warehouse, develop clear SOPs and train staff to establish regular processes for visual inspection and recall.

b) Implement technology-based authentication tools such as barcode scanning, RFID tags, and holograms on product packaging, which can help identify counterfeit products.

c) Educate health care providers, patients, and the community about the risks of counterfeit medical items. Develop a user-friendly reporting mechanism and encourage people to report suspected counterfeit products.

INVENTORY MANAGEMENT

Supply chain strategy is defined by the Association for Supply Chain Management as a plan for how the supply chain will function in its environment to meet the business goals of an organization. By extension, an inventory strategy describes how inventory will be used or managed to meet supply chain goals. It is the supply chain manager's responsibility to ensure that inventory policies are in place to support the organization's mission, goals, and objectives related to health in humanitarian and crisis settings.

1. **Challenge: Lack of integration of the supply chain across contracts and funding sources; managing the max-min levels according to financial source rather than need can introduce waste and stockouts.**

Solution:

a) Implement an integrated SCM approach that considers the actual need for supplies, regardless of funding source or contract. This will ensure efficient allocation and use of resources, leading to less waste and stockouts. Automate the alert system in the logistics management information system (LMIS) to signal when stock levels are below the minimum threshold. Automate these alerts to streamline the process further.

2. **Challenge: Lack of government guidelines for the disposal of expired products.**

Solutions:

a) Develop internal guidelines and protocols for proper disposal of expired products. Train staff on guidelines and ensure compliance with them. Separate expired products from regular stock, label them appropriately, limit access, and store them separately. Advocate for the development of government guidelines for the disposal of expired products to ensure standardized practices across the industry.

b) WHO has disposal guidelines that programs can reference. When developing guidelines, be sure to check local environmental regulations and establish a clear process for reverse logistics. This is also an opportunity to collaborate with the private sector, which may have access to high-fire incinerators or other appropriate methods for disposal.

3. **Challenge: NGOs lack supervisory authority for inventory management of donated health supplies in ministry of health MOH facilities.**

Solutions:

a) Collaborate closely with the MOH to establish clear roles and responsibilities for training and supervising donated inventory in MOH facilities.

b) Work with MOH staff to provide SCM support and training as needed. Ensure that both implementing partners and MOH staff have regular supervision and monitoring visits to maintain inventory controls and solve problems promptly.

4. **Challenge: Lack of proactive planning and budgeting to accommodate increased quantities and warehouse space.**

Solutions:

a) Anticipate the effects of increased demand due to rotation of health services, budget for increased warehouse space, and plan for SCM considerations. Conduct regular assessments to forecast future needs accurately, secure funds in a timely manner, and place orders promptly with suppliers, whether local or international.

b) Collaborate and partner with the private sector and other partners to find and understand possible options for temporary storage when more space is needed.

c) When warehouse space is limited, increase frequency of resupply instead of having fewer larger orders. If sufficient and efficient transportation is available, this can alleviate the need for more storage space.

5. **Challenge: Delayed shipments and stockouts due to global logistics challenges.**

Solutions:

a) Have a risk management plan in place to activate a response protocol. Establish communication channels and partnerships with international NGOs to request loans or support in case of emergencies.

b) Monitor closely the status of shipments and adjust the minimum stock levels, increasing buffer stocks if needed based on vendor reliability and prevailing global logistics challenges.

c) Collaborate with the global pharmaceutical unit for support and guidance.

d) Increase the number of potential suppliers to mitigate delays, possibly identifying qualified local and regional suppliers to reduce lead times.

6. **Challenge: Managing inventory control of donated health supplies and maintaining NGO-procured stocks within MOH-owned warehouses can be difficult.**

Solutions:

a) Build good relationships with MOH staff.

b) Support and train public health staff to ensure accurate inventory management practices. Collaborate closely with the public health centers to train staff and align processes, establish clear roles and responsibilities, and implement robust inventory control systems.

7. **Challenge: Difficulties managing bin location re-order level.**

Solution:

a) Use advanced electronic inventory tools with regular updates for real-time capability. Estimate need through monthly consumption data, PIT inventory tool register, coordination with health staff, and use of monitoring systems.

STORAGE AND WAREHOUSING

Supply chain managers must have an overall strategy for commodity warehousing, particularly in resource-poor environments in which warehousing can buffer against uncertainties and breakdowns within the supply chain. Managers must use warehouses as dynamic operations centers housing a range of distinct yet complementary activities that collect and hold products for delivery to where they are needed the most.

1. **Challenge: Security-related restrictions make it difficult to manage product shortages and travel and distribution to end users.**

Solutions:

a) Plan for temporary storage in a warehouse in a safer location. Distribute medicines across multiple warehouses to increase accessibility.

b) In unstable areas where adequate temperature is difficult to maintain, distribute medicines weekly when feasible and safe.

c) In unstable areas, distribute medicines to camps and health centers weekly, when feasible and safe, to avoid losses and ensure availability.

2. **Challenge: Fuel and energy shortages make product transport and cold chain storage difficult during times of conflict and political instability.**

Solution:

a) Plan to have reserve fuel available before political and security conditions worsen.

b) Move sensitive cold chain medicines from health centers to the nearest pharma warehouse with better storage conditions.

c) Transfer fuel from offices and health centers to pharma warehouses to maintain the cold chain.

3. **Challenge: In volatile security situations in crisis and disaster areas, warehousing and distribution of medical supplies to end-users are difficult.**

Solutions:

a) Maintain backup stock of essential medicines and distribute across warehouses strategically; adhere to Good Storage and Distribution Practices.

b) Collaborate with the private sector and other implementing partners. When using the private sector, include specific standards and KPIs in contracts.

4. **Challenge: Managing and reconciling in-kind donations, especially of drugs, is difficult.**

Solution:

a) Request storage condition reports for the past three months and manufacturer's certificate. Get approval from the QA team, then after approval, accept donations in the pharma warehouse, and record them on an inventory tracker such as PIT.

5. **Challenge: Inventory cycle count for pharmaceutical warehousing takes time and requires sufficient and trained staff to conduct spot checks.**

Solutions:

a) Instead of doing an entire physical count on a monthly or quarterly basis, consider spot-checking different portions of the inventory. Spot checks involve finance and program departments, conducted randomly within each month by different managers or a committee to secure accountability and transparency.

b) During cycle counts, several methods can be used. For example: 1) apply the Pareto principle, focusing on the top 20% of products that constitute 80% of the most expensive, attractive, and highly consumed inventory; and 2) use ABC classification based on annual value: usually Category A items include the costliest and are considered priority items—these may only account for a small percentage, perhaps 10 or 20%; and 3) VEN analysis based on classifying medicines according to their critical nature. Find more information in the JSI Supply Chain Manager Handbook.

6. Challenge: Moving supplies in conflict situations poses risks to products and staff.

Solution:

a) Have backup stocks (pre-positioning) of essential medicines; distribute strategically to warehouses to cover all health care facilities; and ensure one-month coverage of basic supplies during emergencies.

7. Challenge: Dealing with expired products and mitigating waste is difficult.

Solutions:

a) Focus on medicines with shorter expiration dates and request quantities based on real consumption or forecasting.

b) Involve health staff and supply chain team in the ordering process and prioritize essential medicines.

c) Review previous projects to avoid repeating challenges, and regularly monitor expiration dates for products with a shelf life less than 12 months.

d) Pre-position products to have a guaranteed amount available drawn from high rotation stock with sufficient shelf-life.

e) Resupply short shelf-life products more frequently.

8. Challenge: Improper medical kit handling can damage items. This can occur due to inadequate training and lack of awareness of proper storage and usage of kits.

Solution:

a) Provide comprehensive training on the proper handling, storage, and use of medical kits. This includes training health care workers on inventory management, cold chain maintenance, adherence to treatment protocols, and how to transition from health kits to individual PMCs.

9. **Challenge: Limited infrastructure, such as insufficient storage facilities, unreliable transportation, and lack of equipment for proper administration hinder the deployment and efficacy of medical kits.**

Solutions:

a) Work to improve infrastructure such as providing adequate storage facilities and reliable transportation systems. This may require increased budget allocations and collaboration with local authorities and NGOs to enhance capacity to handle medical supplies effectively.

b) NGOs may collaborate with the private sector to use its infrastructure. For example, hiring local taxi drivers in Liberia secured transport of personal protection equipment during the Ebola crisis. Niger has used local grocery stores to increase cold chain capacity during crises.

COLD CHAIN WAREHOUSING

The cold chain encompasses the entire process from manufacturing, storing, transporting, and distributing to reaching the end-user. Cold-chain pharmaceutical products refer to drugs, vaccines, and biological substances that must be stored and transported within a specific temperature range to preserve their quality, potency, and safety. There are health products that are highly sensitive to temperature fluctuations, and deviations can render them ineffective or even harmful.

1. **Challenge: Temperature excursions for cold chain health products.**

Solutions:

a) Monitor temperatures with digital temperature monitoring devices like log tags, FridgeTag (30-day temperature recorders), or remote temperature monitoring devices to effectively monitor and track potential temperature excursions. Establish SOPs for regular reporting of data and implement processes to address any excursions promptly.

b) Establish SOPs and written plans shared with all health facilities that clearly describe actions to take (e.g., using vaccine carriers or moving vaccines to a neighboring facility with cold chain equipment) when cold chain fails, and how to record temperatures and any action taken due to temperature excursions.

c) Establish SOPs for preventive maintenance for cold chain equipment such as cleaning, defrosting as needed, cleaning solar panels where available, and ensuring space between equipment and the wall for air flow.

d) Ensure proper transportation with vaccine carriers, ice bags, conditioned ice or gel packs, and digital temperature monitors.

2. **Challenge: Managing cold chain for products other than vaccines (e.g., maternity oxytocin and laboratory reagents) in the absence of cold chain equipment.**

Solution:

a) Use mobile unit boxes with ice and gel packs and temperature loggers.

3. **Challenge: Risks associated with electricity outages and maintaining the cold chain are complex to manage.**

Solution:

a) Implement measures to mitigate risks such as installing automated generators and backup power systems, and ensure surge protectors are in place and use. SOPs should explain how to minimize opening the door of a piece of cold chain equipment as the holdover time can be up to 8 hours, depending on the equipment. During holidays and special dates, train night-shift staff (security personnel) to monitor the temperature regularly. Install remote monitors that will alert staff to temperature excursions. Maintain accurate temperature records to verify that the cold chain is properly maintained.

LOGISTICS MANAGEMENT INFORMATION SYSTEMS

Supply chain management information systems are the heart of health supply chains and depend on the right combination of people, processes, and technology. An effective SCMIS depends on the right combination of people, processes, and technology. A logistics management information system collects, organizes, and reports data that enable people to make operational and strategic decisions and take informed action.

1. **Challenge: When integrating electronic LMIS with other platforms, the software is not always compatible and may cause operational problems.**

Solutions:

a) Develop a detailed assessment of processes when integrating LMIS with other platforms. This includes: 1) gathering process and system requirements; 2) conducting a technology scan or overview of all the options, whether open-source or proprietary and organizing a team of experts to select the best solution; 3) conducting a market survey to identify a technology partner that will provide dedicated ongoing support; 4) assessing organizational management capacities (people, funding, and processes) to implement the project; 5) planning entry and exit strategies to clarify the final product; and 6) developing clear time- and deadlines to keep momentum and motivation.

b) Design integration architecture that is scalable and adaptable to different systems and versions. This includes using application programming interfaces that facilitate integration and data sharing between systems.

c) Standardize data formats, terminologies, and protocols across systems to facilitate integration.

2. **Challenge: Version updates for DHIS2-stock management do not always facilitate end-to-end supply chain visibility or integration.**

Solutions:

a) DHIS2-RTS (real-time stock management system) is fully functional on mobile devices for recording and managing stock data. It can be used as a transactional system for warehouse management from the central level to the end user.

b) Plan for dedicated support such as a service-level agreement that will secure ongoing support when issues arise. DHIS2 can be integrated with multiple electronic LMIS or ERP systems such as mSupply, Medexis, OpenLMIS, and ORACLE. This facilitates triangulation of logistics and service data imported from other LMIS tools.

3. **Challenge: DHIS2 is not always able to manage data with offline functionality for updating stock data, especially in complex emergencies with intermittent power and internet connectivity.**

Solution:

a) The Android Capture app of DHIS2 is designed for offline use. Users can collect and view data while offline and synchronize data with the server once the network is back. DHIS2 is implemented in complex emergencies in Somalia, Nigeria, and DRC because it can handle such conditions. For more support, the DHIS2 community is available to discuss challenges and how other users handle them.

ENVIRONMENTALLY SUSTAINABLE SUPPLY CHAINS

In recent years, there has been increased focus on environmental sustainability in humanitarian supply chains. A sustainable supply chain is one that fully integrates ethical and environmentally responsible practices into a competitive and successful model. To help protect the environment and meet global climate change goals, humanitarian partners must find ways to reduce their carbon footprint and other environmental burdens stemming from supply chain activities. This includes reduced packaging and improved quantification accuracy to reduce waste and optimized distribution routes to cut fuel usage.

1. **Challenge: Humanitarian NGOs lack tools to assess their environmental impact and develop corrective actions.**

Solution:

a) Use tools like the NEAT + tool to assess every function (product selection, quantification, procurement, inventory management, warehousing, and transportation practices) and incorporate sustainable practices throughout the entire supply chain to reduce and mitigate environmental harm. Seek guidance and resources on inventory control management practices to improve sustainability.

2. Challenge: Incinerators for waste management in different countries are not mapped.

Solutions:

a) Collaborate with international partners, including USAID BHA, to leverage resources to map incinerators.

b) Establish contact with relevant stakeholders to access information and resources related to incinerators in different countries.

c) Engage in knowledge sharing and networking opportunities to enhance waste management practices, including access to incinerators.

3. Challenge: Finding alternatives to conventional plastics in humanitarian settings can be difficult.

Solution:

a) Alternative options are becoming increasingly viable, so continue to research them. Prepare and publish guidance notes on alternatives to plastic, considering the specific conditions and challenges faced in humanitarian contexts. If alternatives to plastics are not available, explore reusable instead of single-use materials.

4. Challenge: Promoting recycling initiatives and biodegradable materials in humanitarian contexts takes time, commitment, and financial resources, which are not always available concurrently.

Solutions:

a) Although recycling initiatives are often privately owned, some organizations and funder support such initiatives in certain countries. Include recycling, reuse, and biodegradable considerations in product selection, quantification, and procurement specifications and contracts. Advocate for increased support for recycling initiatives and incentivize more manufacturers to produce biodegradable materials. However, carefully consider the conditions for biodegradability, which may not be possible in humanitarian contexts.

b) Emphasize the importance of waste reduction at the source and encourage investment in recycling and reuse practices, particularly within the organization.

c) When developing product specifications, include a requirement to use brown cardboard material for packaging (it has less chemicals). Recognize the supply/demand dynamics in the cardboard market and the potential shift to brown cardboard if demand for white cardboard decreases. Advocate for the use of brown cardboard as the default material and support initiatives that promote its adoption.

5. **Challenge: Insufficient skills to advocate for investments in environmentally sustainable supply chains and funding for waste management practices.**

Solution:

a) Include waste management practices in the preparedness phase of projects and initiatives. Incorporate budgetary considerations for staff, processes, new materials, and implementation of waste management strategies. Advocate for securing sufficient funding and resources at higher levels within NGOs to support waste management efforts. Ask donors to fund and adopt environmentally sustainable waste management practices.

RISK MANAGEMENT

All activities and operations conducted in a humanitarian health supply chain are exposed to risk. In each function of the SCM cycle, staff work in procurement, storage, distribution, inventory management, and reporting to ensure that people in crisis and emergency settings receive the lifesaving medicines they need. The various problems that can interrupt these activities and the ability to provide products to people are known as supply chain risks. For example, sudden reduction in funding may limit procurement or slow down delivery operations.

1. **Challenge: Relying on a limited number of local suppliers may cause disruptions.**

Solution:

a) Expand the network of suppliers by engaging local, regional, and international suppliers. Coordinate with other partners and organizations working on the response to explore collaborative solutions such as joint market surveys and pooled procurement.

2. **Challenge: Accepting products with insufficient expiration dates increases the risk of expired products.**

Solution:

a) Establish a general rule of accepting products with expiration dates of 12 months or more. Negotiate with vendors to exchange products with longer expiry dates if stock levels are sufficient, and monitor consumption and accelerate distribution to health clinics with higher consumption rates to minimize the risk of expired products. Strive for zero tolerance of expired products.

3. **Challenge: Inadequate procurement processes compromise quality and cause delays.**

Solutions:

a) Strengthen procurement processes by emphasizing the use of pre-qualified suppliers and establishing robust and comprehensive product specifications. This will mitigate risks associated with receiving the wrong or substandard products.

b) Conduct regular analysis of consumption, review forecasts, and expiration dates to optimize procurement decisions and minimize waste and stockouts.

4. Challenge: Dealing with political situations that affect health supply chains.

Solutions:

a) Contact other NGOs to seek collective support and collaboration to handle political situations that affect procurement and distribution. Establish and maintain communication channels with MOH authorities to understand the situation and work together to find solutions.

b) Work through the cluster system (if activated) to ensure coordination and advocacy.

5. Challenge: Risk management is not a standardized organizational practice.

Solution:

a) Promote a proactive approach and culture of regular review of risk management plans for SCM within the organization. Encourage leadership commitment to risk assessment and mitigation by providing the necessary tools and guidance.

6. Challenge: Lack of analysis and understanding of suppliers' capacity and developing response protocols.

Solution:

a) During the preparedness phase, include a comprehensive threat analysis of suppliers' capacity to deliver on time. Use previous performance statistics, analyze the global supply chain, and consider special conditions within the country. Based on the risk level identified, develop a response protocol using a team-based approach to determine the most suitable course of action.

COORDINATION

Humanitarian organizations and governments responding to health crises use several coordination mechanisms to strengthen global, regional, and national/local humanitarian management and coordination systems. They diversify collaboration to build better sourcing strategies, effective and timely distribution, efficient inventory strategies to avoid expiries and waste, and warehousing and storage practices that comply with WHO standards. Coordination within each organization is essential to expedite processes and better serve populations in need.

1. **Challenge: Limited access to MOH annual supply plans challenges ability to maintain adequate stock levels.**

Solution:

a) Establish a collaborative relationship with the MOH to gain access to its annual supply plans. Emphasize the importance of sharing information to improve coordination and planning. Regularly communicate and coordinate with MOH to align procurement and supply chain activities to maintain adequate stock levels and implement effective inventory management and controls.

2. **Challenge: Navigating commodity security during volatility, insecurity, and political unrest hinders the ability to deliver health supplies.**

Solution:

a) Monitor the security situation through humanitarian access teams and the clusters system. Share information and work with local authorities to avoid insecure areas and plan accordingly.

3. **Challenge: Limited local manufacturing of pharmaceuticals and lack of coordination to conduct joint market surveys due to different calendars and timelines.**

Solutions:

a) Conduct local market assessments—ideally with other NGOs—by certified experts to ensure procurement from local suppliers that use best practices.

b) If local suppliers are unavailable, procure primarily from international suppliers and invest time in analyzing importation processes and requirements, mapping them and identifying roles and responsibilities to optimize lead times.

4. **Challenge: Administrative burdens in the government medical supply chain limit importation and distribution of health products.**

Solution:

a) Work with health authorities to pre-clear international orders and engage all levels of government for transportation permits to deliver health supplies where needed.

5. **Challenge: Limited local supplier collaboration and data sharing with humanitarian organizations hinders ability to identify qualified suppliers.**

Solutions:

a) Establish coordination committees or other forums for information sharing and problem solving. Explore coordination of International Association of Public Health Logisticians country chapters with humanitarian organizations to understand MOH challenges and how to strengthen coordination with NGOs supporting the humanitarian response.

b) Encourage suppliers and distributors to share product monitoring data to facilitate coordination and decision making. This collaboration helps identify and avoid quality problems.

c) Encourage suppliers and distributors to share temperature monitoring practices and other relevant information.

d) Standardize procedures for data sharing and reporting. Use digital platforms and communication channels to facilitate data exchange and improve coordination.

e) Hold regular meetings and establish communication channels to share SCM updates, challenges, and solutions.

HUMAN RESOURCES FOR SUPPLY CHAIN MANAGEMENT

Human resources are at the center of the SCM cycle. In humanitarian assistance, SCM requires skilled and committed personnel to ensure the functioning of the supply chain cycle and deliver health supplies in the right quantity, quality, and cost during every phase of the humanitarian response. By addressing Human resources management challenges and implementing these solutions, organizations can enhance the utilization of supply chain professionals in humanitarian settings, ultimately improving the efficiency and effectiveness of relief efforts.

1. **Challenge: Shortage of trained health care personnel hinders proper use of health supplies, including health kits. The lack of staff to administer treatments and educate patients on medicine usage can impact the overall effectiveness of the humanitarian response.**

Solutions:

a) Task shifting can alleviate the burden on health care professionals. Train community health workers or volunteers so that health care tasks can be decentralized, ensuring wider coverage and better use of health supplies.

b) Develop strategies for the deployment of supply chain professionals based on the specific needs of humanitarian operations. Ensure seamless integration into the overall structure to optimize their contributions.

2. **Challenge: SCM training is ad-hoc, diminishing humanitarian supply chain performance due to knowledge gaps.**

Solutions:

a) Set up a sustainable human resources system, emphasizing the need for structured and ongoing training programs, including on-the-job. Focus on building an HR system that can withstand external challenges and reduce/manage staff turnover.

b) Provide training and capacity-building programs for humanitarian organizations to enhance understanding of the role and importance of supply chain professionals. This can contribute to a more comprehensive use of their skills.

3. **Challenge: While there are supply chain professionals in most countries, not all work in the humanitarian sector. Their expertise may not be fully recognized or understood in the context of humanitarian settings, hindering their involvement in critical decision-making processes.**

Solutions:

a) Encourage collaboration and coordination between humanitarian organizations and supply chain professionals. Foster a more collaborative approach to use their skills across sectors and organizations.

b) Advocate for the recognition of supply chain professionals as essential contributors to humanitarian efforts. Emphasize their role in ensuring the efficient and timely delivery of aid.

4. **Challenge: The People that Deliver Step 2.0 Program, which can mitigate SCM challenges, is expensive and not yet implemented in many countries. The program combines traditional learning with on-the-job training to give health supply chain managers guidance in people management, problem-solving, communication, project management, and professional development competencies.**

Solution:

a) Efforts are being made to secure funding from organizations like USAID, the Global Fund, IPFW Foundation, and the GAVI Vaccine Alliance. The PtD implementation event in Thailand in 2024 will convene multiple countries and organizations to discuss challenges and solutions.

5. **Challenge: Health and education workers in refugee camps face safety risks, including theft and harm to female workers.**

Solution:

a) Talk with workers to understand their security concerns and design interventions that respond to them. Promote an inclusive worker-centric strategy.

6. **Challenge: Lack of optimization for distribution of SCM human resources across health interventions in humanitarian settings. There is concern that SCM resources are prioritized in silos instead of an integrated approach to meet primary health care needs.**

Solution:

a) Develop a SCM professionalization strategy using tools like capabilities mapping and cutting across health programs to ensure a more holistic and equitable distribution of human resources to manage PMCs.

7. **Challenge: Humanitarian organizations face resource constraints that make it hard to allocate personnel including supply chain professionals.**

Solution:

a) Secure additional resources for humanitarian organizations to overcome constraints in deploying and using supply chain professionals. This may involve seeking external funding and reallocating existing resources more effectively.

ANNEX D. TOOLS AND MANUALS

The following lists contain an overview of quantification and eLMIS tools, respectively. They are updated on an ongoing basis and housed in the Humanitarian Commodities Logistics Community of Practice resource library.

Quantification Tools: 20 forecasting and quantification tools and manuals for conducting quantification exercises.

eLMIS Tools: More than 45 eLMIS tools for those looking for SCM systems and software solutions.

ANNEX E. IAPHL AND THE HCL COMMUNITY OF PRACTICE

During its first phase, the Building Capacity to Improve Pharmaceutical and Medical Commodity Management in Humanitarian and Emergency Settings program created the Humanitarian Commodities Logistics (HCL) Community of Practice (COP) as a sub-group within the International Association of Public Health Logisticians (IAPHL). Membership is free and anyone interested in learning more about health logistics in humanitarian settings can join. First, join IAPHL, then request access to the HCL sub-group.

The HCL COP includes individuals from country governments; international and local nongovernmental, IP, and United Nations organizations; and funders, among others. As of January 2024, it had over 800 members from more than 90 countries. The community participates in discussions and posts with the larger IAPHL group and has access to the HCL resource library, which has over 170 resources on LMIS, quantification, procurement, inventory management, warehousing, storage, distribution, SCM assessments, green logistics, sustainable supply chains, waste management, and more.

ANNEX F. LITERATURE SEARCH ON SUPPLY CHAIN MANAGEMENT INNOVATIONS FOR PHARMACEUTICAL AND MEDICAL COMMODITIES IN HUMANITARIAN CRISES OR FRAGILE SETTINGS

INTRODUCTION

This literature search focused on supply chain management advances and innovations for pharmaceutical and medical commodities in humanitarian crises or fragile settings. The goal was to examine how supply chain management strategies have addressed health and medical supply chain challenges brought about by recent emergency and crisis situations around the world. By looking at examples of innovative approaches to supply chain management, this search also uncovered practices and technologies that will likely be used in the future to manage supply chain disruptions.

The search included literature from March 2020 onward. During this period, much of the research related to health supply chain management focused on the COVID-19 pandemic and its effects, and pandemic-related documents therefore dominate the list of articles. The list includes peer-reviewed publications, journal articles, gray literature, and other supply chain and logistics literature. The following search terms were used to find relevant sources:

- Coordination to deliver health products
- COVID-19
- Disruptions in supply chain
- Emergencies
- Forecasting
- Green logistics
- Humanitarian disaster
- Humanitarian crisis/crises
- Health supplies
- Importation
- Information systems
- Inventory control strategies
- Logistics
- Logistics innovation
- Logistics management information system
- Pharmaceutical and medical commodities
- Risk management
- Quality assurance methods
- Reverse logistics
- Temperature control
- Transportation to the last mile
- Transportation during crisis
- Last mile delivery
- Remote management
- Availability of supplies in refugee camps
- Migration and emergency response
- Medical needs-assessment
- Quantification of needs
- Supply chain management
- Supply planning
- Supply chain visibility
- Humanitarian development nexus + logistics

ARTICLE SUMMARIES

Abdul Rahman NA, Ahmi A, Jraisat L, et al. 2022. **Examining the trend of humanitarian supply chain studies: pre, during and post COVID-19 pandemic**. *Journal of Humanitarian Logistics and Supply Chain Management*, 12 (4) 594-617. https://doi.org/10.1108/JHLSCM-01-2022-0012

This article covers publication trends of humanitarian supply chains before, during, and after COVID-19 by using bibliometric analysis. The authors used the Biblioshiny app, a shiny app for the Bibliometrix R package that decodes humanitarian supply chain data extracted from the Scopus database from 2006 to early 2022. The article goes into significant technical detail about the Biblioshiny tool and how it was used to analyze 644 Scopus articles. The results are distilled into figures showing top keywords, most productive sources, top publishing institutions, top publishing countries, most productive authors, and top cited articles. Based on analysis of those data points, there are three thematic areas among the papers: humanitarian logistics, humanitarian organizations, and humanitarian operation, with humanitarian logistics being the largest theme. There is also a comparison between leading themes in 2006 and those during and post-COVID-19 with the number of main themes moving from nine to eight as the decision support system theme in 2006 was absorbed into several new categories. The authors note that there are a few limitations of the study including the existence of previous bibliometric analyses of supply chains in certain industries like automotive, green, agriculture, and technology, but they vary widely in the databases they searched and the tools they used to analyze the data. The authors also note that policy perspectives are missing from this study and that this is an area that warrants further study. The article concludes with suggestions for future research.

Ahmadi, E, Mosadegh, H, Maihami, R et al. 2022. **Intelligent inventory management approaches for perishable pharmaceutical products in a healthcare supply chain**. *Computers & Operations Research*, 147. https://doi.org/10.1016/j.cor.2022.105968

This article describes intelligent inventory management (IIM) approaches for managing perishable pharmaceutical products in a health care supply chain. Managing inventory of these commodities is extremely challenging because of their perishable nature, consumer need, uncertain market conditions, storage requirements, and price. New IMM approaches are needed because existing inventory policies fail to account for various real-world issues including random demand and the nature of perishables. The authors propose a machine learning model that can mitigate some of these problems with its flexibility. Their design uses two algorithms to determine near-optimal inventory policies and compares them with existing methods. The article goes into detail about the mathematical formulas used and the reasoning behind them. Part of this study includes implementation of the design and training processes. Results of the implementation indicate that the IIM approaches can lead to lower costs and less risk of stockouts.

Akpan I, Udoh P, and Adebisi B. 2020. **Small business awareness and adoption of state-of-the-art technologies in emerging and developing markets, and lessons from the COVID-19 pandemic**. *Journal of Small Business & Entrepreneurship*, 34. https://doi.org/10.1080/08276331.2020.1820185

This article outlines new technologies, including internet and telecommunications, which small- and medium-scale businesses (SMEs) in emerging markets and developing economies can use to increase their market share and improve their business models. Many of the technologies are not new, but have been out of reach of these SMEs due to technological and/or monetary constraints. Larger businesses and more advanced economies switched to online technologies as soon as the pandemic started, but SMEs were unable to capitalize on the new internet space because of a lack of infrastructure. Now that the pandemic has waned, SMEs can begin to use technologies that will allow them to compete in the upcoming fourth industrial revolution (industry 4.0 or I4.0) like internet, artificial intelligence (AI), internet of things, cloud computing, big data analysis, and blockchain. The special issue, of which this article is a part, contains four articles that describe different technologies. The first article discusses financial innovation like ATMs, point of sales, internet banking, and mobile money tools, and how they can improve productivity. The second article introduces an algorithm for weighing different maintenance practice innovations and how they can improve resource management. The third article looks into process innovation and determines that it is the most important area for attaining high growth in startups. The last article investigates how effective innovative technology transfer is based on data from over 1,100 manufacturing firms in Africa. The conclusion is that countries should look inward for innovation rather than relying on help that may never appear. SMEs in emerging markets and developing economies face several challenges to development and implementation of new technologies including lack of infrastructure, money, government interest, technical capacity, decision-making, and education.

Alani AH, Miller L, Waweru I, et al. 2023. **Lessons learned from implementing the Non-Communicable Diseases Kit in a humanitarian emergency: An operational evaluation in Sudan**. *BMJ Global Health*, 7 (Suppl 5). https://doi.org/10.1136/bmjgh-2023-012077

This article evaluates the use of the WHO Non-Communicable Diseases Kit (WHO-NCDK) in primary health care settings in Sudan. The WHO-NCDK is a health system intervention aimed at providing supplies to manage NCDs in emergency settings, allowing for continuity of care during supply chain disruptions. Researchers applied this toolkit in Sudan to evaluate its effectiveness and to identify contextual factors that may influence the ability to apply this tool in crisis settings and situations. This study identified several key factors that influence the kit's effectiveness: local communities' unfamiliarity with health care facilities, the national integration of NCDs into primary health care (PHC), and the existence of monitoring and evaluation systems. For the kits to be most effective, health facilities must have adequate staff and resources. Researchers concluded that the WHO-NCDK can be a useful tool in crisis settings where health care resources are limited as long as these contextual factors are taken into account and addressed before the kit is implemented.

Atek S, Bianchini F, De Vito C, et al. 2023. **A Predictive Decision Support System for Coronavirus Disease 2019 Response Management and Medical Logistic Planning**. *Digital Health* 9. https://doi.org/10.1177/20552076231185475.

This article describes examples of logistics planning from the Earth Cognitive System for Coronavirus

Disease 2019 project. This project consisted of a decision support system created to support health care institutions in monitoring and forecasting activities by using artificial intelligence (AI), social media analytics, and geospatial data. This system was able to use machine learning and AI to predict factors such as the number of emergency room visits and to identify high risk regions.

Beasley, K. 2022. **Covid-19 Altered The Supply Chain—Does Your Forecasting Strategy Reflect The New Reality?** *Forbes Innovation (blog)*. July 14, 2022. https://www.forbes.com/sites/forbestechcouncil/2022/07/14/covid-19-altered-the-supply-chain-does-your-forecasting-strategy-reflect-the-new-reality/?sh=2e95f2875e24

This article explores the COVID-19 pandemic's impact on the use of predictive analysis in supply chains. The pandemic caused stockouts of supplies around the globe, leading to a major increase in corporations' analytics spending to prevent future over- and under-stocking. Manufacturers also pivoted during the pandemic to reflect supply and demand trends, with many factories producing personal protective equipment (PPE) in place of their usual products. The author recommends four strategies for companies to adapt to changes in the supply chain: expand data sets to include external sources; build contract agreements directly with suppliers; look for non-traditional suppliers; and leverage technology to support data and analytics.

Brody B. 2020. **4 high-tech tools Johnson & Johnson is using to get products to you during the pandemic**. *Content Lab* (U.S). https://www.jnj.com/innovation/johnson-johnson-supply-chain-technology-during-coronavirus

This news update from Johnson & Johnson (J&J) describes the company's innovative practices to ship their products to consumers during the pandemic. The first measure J&J took was to start running plants around the clock and to focus on reducing complex formulations for simpler ones that would help the most people. The company also employs algorithms that flag anomalies in ordering levels so that they can be investigated. In order to manage varying staffing levels due to employee illness, J&J used an automated risk simulation to predict worse-case scenarios and then planned to mitigate them. Another issue exacerbated by the pandemic was product delivery. J&J used track-and-trace sensors to continually monitor where each shipment was and track timeline and delays. The last thing J&J did in the face of no international travel was to employ smart glass technology so that engineers could actually see what workers were seeing anywhere in the world and keep production running.

Budd J, Miller BS, Manning EM, et al. 2020. **Digital technologies in the public-health response to COVID-19**. *Nature Medicine*, 26 (8), Article 8. https://doi.org/10.1038/s41591-020-1011-4

This review captures digital innovations that emerged during COVID-19 along with their barriers to implementation and the technology limitations in regard to public health. The technologies discussed include machine learning, survey apps, and websites; wearable sensors and other devices; smartphone apps and phone-location data; social media and search engines; and teleconferencing. The authors outline each public health need, the technology that can help fulfill it, examples of where it has been used, and the limitations of the technology. Machine learning can help with epidemiological surveillance by pulling data from apps and websites, wearable sensors and other devices can help with case identification, apps and location data can help reduce area transmission, social media and search engines can help with public communication, and teleconferencing can help with telemedicine. Some limitations include the inability to sync data from all the different platforms, over-reliance on digital information which can be misleading, lack of consistent up-to-date data, and selection bias. The authors conclude that system owners and technology companies need to be involved in preparedness and alignment with international strategies to prevent future pandemics.

Cárdenas AM & Roger-Dalbert C. 2022. **Learning from Agility, Partnership and Innovation During the Covid-19 Pandemic: A Perspective From Industry**. *Frontiers in Cellular and Infection Microbiology*, 12. https://doi.org/10.3389/fcimb.2022.838565

This article examines the effects of the COVID-19 pandemic on the medical technology/device industry. It discusses the rapid changes and adaptations that took place so that certain workers in this industry could work from home, as well as accommodations made to physical workplaces to reduce the spread of the virus for employees whose jobs required them to be in-person. The authors identify three key areas of importance in this field as agility, partnership, and innovation. The article found that by utilizing those three skills, the industry was able to rapidly adapt to address the changing industry landscape brought on by the pandemic. However, work still needs to be done to better communicate to the public how and when they should be using different types of COVID-19 tests. Further strengthening of partnerships between different health stakeholders, including health care providers, academics, and public health agencies will help monitor infectious diseases and improve the outcome of future events.

de Rubalcava A de NG, Piñeiro OS, Jiménez RM, et al. 2023. **Modeling Population Movements under Uncertainty at the Border in Humanitarian Crises: A Situational Analysis Tool**. *arXiv* (arXiv:2303.15614). https://doi.org/10.48550/arXiv.2303.15614

This article describes the development of a situational analysis tool that helps predict the flow of populations crossing borders in humanitarian emergencies. The tool is specifically designed to work with the United Nations High Commissioner for Refugees (UNHCR) model by predicting the number of migrant and forcibly displaced populations during crisis events. This tool was developed and applied in the context of the Venezuela-Brazil border crisis, when the border between these countries was closed due to the

COVID-19 pandemic. This event showcased the need for a tool to estimate what size populations might be expected to cross the border during crisis events. The tool consists of three main components: a collection of real-time data of potential indicators of interest in crossing the border; a model to predict how many people might cross the border based on past crossings and other indicators; and an interactive simulation tool that models the flow of people crossing the border to predict the needed shelter capacity. The authors of this study hope to continue to improve this tool for use in future crisis settings and ultimately expand its use to forced displacement contexts as well.

Dubey R. 2022. **Design and management of humanitarian supply chains: Challenges, solutions, and frameworks**. *Annals of Operations Research*, 319(1), 1–14. https://doi.org/10.1007/s10479-022-05021-7

This article examines 44 articles on the topic of humanitarian supply chains and synthesizes the results to note gaps in the current research and recommend areas for future studies. It describes the recent rise of the field of humanitarian supply chains to address disasters, beginning with the poor response to the 2004 Indian Tsunami, and provides a brief summary of the key topics found in the articles included in the review. The author argues the need for a multi-methods approach and points out the gap in the literature surrounding this topic, including coordination between organizations, technology and human interaction, innovation, and crisis leadership.

Elrha. 2021. **Field Ready: Making humanitarian supplies in the field**. https://www.elrha.org/project/field-dready-scale/

This source summarizes the Field Ready project, which aims to improve humanitarian logistics and supply chains by using technology, specifically 3D printing. It explains that using additive manufacturing in the form of 3D printing directly in the field reduces costs and wait times for communities to receive needed supplies. The project aims to further scale up this approach by moving these manufacturing processes to areas where they are most needed and by providing training to others to use these skills and technologies.

Falagara Sigala I, Kettinger WJ, and Wakolbinger T. 2020. **Digitizing the field: Designing ERP systems for Triple-A humanitarian supply chains**. *Journal of Humanitarian Logistics and Supply Chain Management*, 10 (2), 231–260. https://doi.org/10.1108/JHLSCM-08-2019-0049

This study's goal was to determine the design principles needed in enterprise resource planning (ERP) systems for humanitarian organizations to optimize supply chains. The introduction notes that humanitarian organizations often work in complex and unpredictable environments, and that supply chains must be able to adapt quickly to meet these needs. However, their current systems and technology are often not capable of meeting these standards. The optimal supply chain is one that displays agility, adaptability, and alignment (Triple-A). ERP systems can help humanitarian organizations achieve these three components and lead to successful humanitarian relief efforts by enhancing integration, communica-

tion, and decision-making. The authors of this paper conducted a case study in which they engaged in ERP design for the humanitarian organization Medecins Sans Frontieres (MSF) and monitored the results of the design and implementation process. The study found that ERPs need to be designed as unique systems to meet the needs of specific humanitarian organizations. Each organization has different needs and faces different challenges, particularly related to field-level work, and standard ERP packages do not meet these needs. One key challenge was the decentralized nature of humanitarian organizations that often have offices or locations around the world and in remote locations that require both the ability to connect between systems and the ability for systems to work autonomously. The authors ultimately recommend that humanitarian organizations looking to implement ERPs review their own specific needs and processes and consider using unique design principles to develop their software system, rather than using an existing ERP package.

Flynn B, Cantor D, Pagell M, et al. 2020. **From the Editors: Introduction to Managing Supply Chains Beyond Covid-19 - Preparing for the Next Global Mega-Disruption**. *Journal of Supply Chain Management*. https://doi.org/10.1111/jscm.12254

This article summarizes a special issue of the Journal of Supply Chain Management focusing on the importance of effective supply chain management in light of the COVID-19 pandemic and how the field can move forward to prepare for the next major disruption. The authors state that this issue features essays that discuss learnings from the COVID-19 crisis, such as the fact that the disruption of global supply chains for an extended period of time highlighted the need for renewed supply chain risk management strategies. They also note that some articles focus on how the pandemic led to certain improvements that can be leveraged going forward, such as rapid adoption of communication and sharing technologies, reduced time and costs spent on travel, and expanded production of life-saving medicines by pharmaceutical companies. Together, the articles in this issue provide an overview of the field of supply chain management in the wake of COVID-19 and suggest areas for future research.

Foster T, Patel P, and Skiba K. 2021. **Four ways pharma companies can make their supply chains more resilient**. https://www.mckinsey.com/industries/life-sciences/our-insights/four-ways-pharma-companies-can-make-their-supply-chains-more-resilient

This article outlines four ways that pharmaceutical companies can make their supply chains more resilient as they become increasingly global and complex. The authors explain that the potential for disruption that comes with operating at such a large scale puts companies at risk for major losses. The first way to increase supply chain resilience is end-to-end transparency. Companies should have a clear picture of all of the small moving parts that make up their supply chains in order to identify potential risks and vulnerabilities. The second way to increase resilience is routine stress-testing and reassurance, which can be done by using scenario planning and modeling to simulate the impact of potential issues and plan for solutions. The third is reduced exposure to shocks, such as by expanding the network of suppliers, improving physical assets to withstand natural disasters, and preparing for quick changes and rerouting in case of issues with one supplier or site. The final recommendation for increasing resilience is having

supply chain resilience on the executive agenda. Organizations should use existing forums to conduct risk assessments or create a specific committee or working group dedicated to assessing and managing supply chain risks.

Gao Y, Gao H, Xiao H, et al. 2023. **Vaccine Supply Chain Coordination Using Blockchain and Artificial Intelligence Technologies**. *Computers & Industrial Engineering* 175 (January). https://doi.org/10.1016/j.cie.2022.108885

This article examines the use of blockchain and artificial intelligence (AI) technology in vaccine supply chains to address issues of vaccine reliability and accessibility. Blockchain technology tracks shipments across the supply chain and traces items as they move through the production and distribution process. The use of blockchain technology in vaccine supply chains can ensure that vaccines are safe and have not been tampered with at any point, thus addressing the issue of vaccine reliability. AI can quickly analyze large amounts of data and provide recommendations based on the results. This technology can be applied to vaccine supply chains in many ways, such as by analyzing the efficiency of the supply chain and by looking at data outside of the supply chain to predict future supply and demand. The authors conclude that these technologies can improve transparency, safety, and efficiency in vaccine supply chains.

Goodarzian F, Taleizadeh AA, Ghasemi P, et al. 2021. **An integrated sustainable medical supply chain network during COVID-19**. *Engineering Applications of Artificial Intelligence*, 100, 104188. https://doi.org/10.1016/j.engappai.2021.104188

This article describes the development of a mathematical formulation called Sustainable Medical Supply Chain Network aimed at addressing the urgent need for sustainable supply chains brought to light by the COVID-19 pandemic. This formula takes into account three key components of sustainability: economic, environmental, and social effects. It aims to maximize positive features of supply chain development such as job creation and economic development while minimizing costs such as transportation and carbon emissions. The authors tested this formula using three meta-heuristic algorithms with different parameters. They then assessed the results of each algorithm to determine which displayed the most successful result.

Harland C. 2021. **Discontinuous Wefts: Weaving a More Interconnected Supply Chain Management Tapestry**. *Journal of Supply Chain Management*, 57(1), 27–40. https://doi.org/10.1111/jscm.12249

The author of this study proposes that to tackle future crises similar to the COVID-19 pandemic, the field of supply chain management (SCM) should take a more interconnected approach by considering supply markets, public procurement, humanitarian SCM, network and systems thinking, and global stewardship. The introduction points out that even countries that were relatively well-prepared for a pandemic event prior to COVID-19 still were not able to implement their plans fully and effectively. The idea of interconnectedness as a key factor in supply chain resilience is not new, but has not yet been integrated into existing

systems. The article then discusses four sub-topics regarding the role of supply chains in the COVID-19 crisis: the lack of knowledge of supply markets early on in the pandemic, the lack of research on public sector SCM, the current focus on firm-based decision-making, and whether it is feasible to form a global supply chain response to address future crises. The author argues that humanitarian supply chains are already adept at handling complex networks of organizations and resources, particularly during times of crisis, and that the broader field of SCM should look to humanitarian supply chains for guidance on how to increase interconnectedness.

Heckmann A. 2022. **Industry Innovation: Turning Supply Chains into Hot Spots for Meaningful Change**. SAP News Center.

This article summarizes three of SAP's recent projects in the SCM field. The first is the SAP Information Collaboration Hub for Life Sciences, a network that allows pharmaceutical companies to share product information across different levels of the supply network. The goal of this network is to reduce the existence of counterfeit drugs by ensuring that medications are traceable and verifiable across the supply chain. The second project is the SAP Intelligent Clinical Supply Management solution. This project aims to address the barriers present in traditional supply chain structures by providing accurate information on demand and stock levels at different sites, allowing for faster supply cycle times and fewer inventory overages. The third project is the SAP Multi-Bank Connectivity solution that works to improve relationships between companies and banks. This digital system provides a channel between banks and companies, allowing them to transfer data and payments remotely, increasing efficiency and transparency.

Hu H, Xu J, Liu M, et al. 2023. **Vaccine Supply Chain Management: An Intelligent System Utilizing Blockchain, IoT and Machine Learning**. *Journal of Business Research* 156 (February). https://doi.org/10.1016/j.jbusres.2022.113480

This article describes a new system for managing vaccine supply chains that addresses the three major issues in the field: vaccine quality, demand forecasting, and trust among stakeholders. Their system tackles these problems by using blockchain technology, the Internet of Things (IoT), and machine learning. The authors note that this system is original and no other vaccine supply chain management in the literature uses multiple digital technologies. Blockchain technology and the IoT address issues of vaccine quality by tracking products with real-time data as they move along the supply chain. The system also uses machine learning to predict demand and improve distribution, transportation, and inventory management. The authors conclude that combining multiple digital technologies into one system helps to solve the three major issues in vaccine supply chain management.

Hu Z, Sarfraz M, Khawaja KF, et al. 2022. **The Influence of Knowledge Management Capacities on Pharmaceutical Firms Competitive Advantage: The Mediating Role of Supply Chain Agility and Moderating Role of Inter Functional Integration**. *Frontiers in Public Health*, 10. https://doi.org/10.3389/fpubh.2022.953478

This article examines how knowledge management (KM) capacities can improve pharmaceutical companies' supply chain agility, making them more competitive in the field. KM is defined by the authors as "a set of dynamic capabilities of a firm to gather valuable information and then send it across the units of the firm to improve operations internally." The study examines several KM capacities: absorptive capacity, transformative capacity, and inventive capacity. The authors then attempt to identify the influence of these three capacities on overall competitive advantage. They determined that having these KM capacities gives a company more supply chain agility and allows them to quickly respond to changes in the market, which thereby gives them greater competitive advantage. The study concludes that KM is an essential resource for a pharmaceutical firm's competitive advantage and overall success. The more a firm invests in their KM capacities (absorptive capacity, transformative capacity, and inventive capacity) the better their performance and supply chain agility will be.

International Medical Corps. 2022. **Pharmaceutical Innovation Is Making a Difference in South Sudan**. https://internationalmedicalcorps.org/story/pims-south-sudan/

This article examines the use of the Pharmaceuticals Information Management System (PIMS) in South Sudan. PIMS is a software system that allows medical and pharmaceutical staff to manage supplies and equipment to improve supply chains. At the Juba camp for internally displaced persons (IDP), PIMS allowed the pharmacy facility to shift from manual record keeping and paper records to electronic records management. PIMS also automated this pharmacy's inventory records and prescription refills. Pharmacy staff reported that this change greatly improved the quality of pharmacy services as it allowed staff more time to interact directly with patients and less time spent manually updating records. While this system is currently used in pharmacies, hospitals, and health care centers, International Medical Corps is planning to expand the use of PIMS to humanitarian agencies and other organizations going forward.

International Rescue Committee. N.d., retrieved January 4, 2024. **Medicine Bank**. https://airbel.rescue.org/projects/medicine-bank/

Medicine Bank is a supply chain management solution that allows low-income patients with chronic illnesses to purchase medications at a discounted price. This project, currently in the prototype stage, works by connecting pharmaceutical producers directly with local pharmacies to sell medications with an approaching expiration date for a discounted price. Pharmacies can then provide these discounted medications to their low-income clients at a reduced price. This is also beneficial for producers as they would have to pay to get rid of the expired medications, whereas they can instead profit from them. This project will initially be piloted with medications that treat chronic illnesses as demand for these tends to be more predictable, but a similar system could be applied to other medicines or supplies in the future.

Ivanov D. 2021. **Supply Chain Viability and the COVID-19 pandemic: A conceptual and formal generalisation of four major adaptation strategies.** International Journal of Production Research, 59 (12), 3535–3552. https://doi.org/10.1080/00207543.2021.1890852

This study describes four major strategies to maintain supply chains during future pandemics: intertwining, scalability, substitution, and repurposing. It also introduces a model to analyze the results of deploying these four strategies and describes case studies where these adaptations were implemented. The authors note that, since the COVID-19 pandemic, many papers have been published that attempt to explain the effects of the pandemic on global supply chains and suggest solutions for future crisis events. However, there is a research gap around using the four adaptation strategies together and measuring their results. The article provides examples of several case studies that utilized one or more of these strategies effectively during COVID-19. For example, Amazon displayed scalability by increasing their workforce, opening new grocery pick up locations, and prioritized stocking and delivering essential items such as medical supplies and groceries to meet increased demand. Johnson & Johnson also used scalability by drawing from their past experience providing supplies in disaster settings and using simulated scenarios to predict potential challenges and determine solutions, which allowed them to ensure stock of high-demand items. AGRO corporation, an agricultural equipment manufacturer, used substitution by adapting risk management strategies they had employed during previous supply chain disruptions, for example using unconventional delivery methods or routes to ensure timely delivery. Noting the shortage of protective equipment for health workers, Ford repurposed some of its manufacturing capacity to produce PPE such as mylar face shields. The authors conclude that using a combination of these four strategies in an integrated framework of viability can help mitigate future supply chain disruptions.

Karabacak Z and Saygili MS. 2022. **Green Practices in Supply Chain Management: Case Studies**. *Journal of Business and Trade*, 3 (1), Article 1.

This article evaluates the effects of using green practices in supply chain management by examining the literature around the topic as well as several case studies. Recent research has shown that some companies have switched to using green practices reactively in order to comply with legal requirements. However, those that change their practices proactively to mitigate their effect on the environment find that there is a direct link between their ecological performance and their economic performance. Companies using green supply chain management often see reduced costs for operations and logistics and increased customer satisfaction. Implementing green practices can require upfront investment, which may be manageable for larger companies but can be difficult for smaller organizations. The authors describe several ways that green practices can be incorporated across supply chains, including in production, marketing, packaging, transportation, and more. The article looks at case studies of several companies that have implemented green supply chain management and how this has affected their business. For example, IKEA took several steps to become greener, including recycling old products into raw materials and using recycled materials to manufacture new products. Correlating with these changes, the company has seen a rise in sales, possibly demonstrating that using green practices increases customer satisfaction with the brand. Other companies saw a reduction in their energy consumption and water use after changing their supply chain processes. The authors conclude that although implementing green supply chain management requires upfront investments, companies that make these changes reduce their

costs over time, increase their efficiency, and gain a competitive advantage, in addition to improving their impact on the environment.

Koç E and Türkoğlu M. 2022. **Forecasting of Medical Equipment Demand and Outbreak Spreading Based on Deep Long Short-Term Memory Network: The COVID-19 Pandemic in Turkey.** *Signal, Image and Video Processing* 16 (3): 613–21. https://doi.org/10.1007/s11760-020-01847-5.

This study presents a tool to forecast the demand for medical equipment during the COVID-19 pandemic based on a long short-term memory network. Researchers fed a set of COVID-19 data from the beginning of the pandemic into the system to train it to predict demand. They had the system predict the number of COVID-19 cases, beds in intensive care, and respiratory supplies for a specific period, and then compared the predictions to the real figures. In all three cases, the number the system predicted was very similar to the real-life numbers, showing that the model is highly accurate. This system is one of the first of its kind and has promising implications for demand forecasting in future crisis scenarios.

Kovács G and Falagara Sigala I. 2020. **Lessons learned from humanitarian logistics to manage supply chain disruptions**. *Journal of Supply Chain Management*. https://doi.org/10.1111/jscm.12253

This article notes the shared characteristics between pandemic supply chains and humanitarian response supply chains, including unpredictable demand, lack of resources, and poor infrastructure, and describes lessons learned from humanitarian supply chain contexts that could be applied to mitigate future supply chain disruptions in other sectors. Neither governments nor industries were adequately prepared for the disruptions caused by the COVID-19 pandemic, and the author notes that pandemics are not the only type of event that can cause these large-scale interruptions. Humanitarian supply chain management offers a wealth of experience in managing these issues and adapting quickly during times of crisis. One key element is preparedness, not just by stocking adequate resources, but by training and modeling crisis events and responses ahead of time across every level of the supply chain. Agility and the ability to quickly make decisions is another important factor: humanitarian supply chains strive to move with urgency while also using needs assessment tools to determine the most effective course of action. They are also willing to think outside the box and come up with innovative solutions to meet unexpected challenges, such as in the case of manufacturers diverting their resources to make PPE and other medical supplies during the COVID-19 pandemic. Companies also need to collaborate across sectors and between the public and private sectors to improve their response to future crises. The author stresses the importance of being prepared for future supply chain disruptions that could come from a number of sources, including climate change, political conflict, financial crises, and more.

Kumar P, Singh RK, and Shahgholian A. 2022. **Learnings from COVID-19 for managing humanitarian supply chains: Systematic literature review and future research directions**. *Annals of Operations Research*, 1–37. https://doi.org/10.1007/s10479-022-04753-w

The authors of this article examine the existing literature on lessons from COVID-19 for managing humanitarian supply chains and suggest directions for future research. The findings from their literature show several of the major challenges created by COVID-19 and how those were mitigated using humanitarian supply chain strategies. Some of the major challenges identified in their review include lack of planning and preparedness, extended shortages, inadequate lab capacity, lack of supply of vaccines, and low vaccine uptake. The pandemic provided several learnings for managing humanitarian supply chains going forward. One of the most critical is the importance of preparedness and planning in supply chains. Another learning was the need for prepositioning relief items and ensuring adequate supply. Coordination and collaboration among and across different stakeholders is also a key component of effective supply chain management. The article identifies several areas in need of further research, including how data analytics can be used to predict future pandemics or other disruptive events, and how to use emerging technologies more effectively to better manage humanitarian supply chains.

Kwapong Baffoe BO and Luo W. 2020. **Humanitarian Relief Sustainability: A Framework of Humanitarian Logistics Digital Business Ecosystem.** *Transportation Research Procedia*, 48, 363–387. https://doi.org/10.1016/j.trpro.2020.08.032

This study uses a literature review to develop a Humanitarian Logistics Digital Business Ecosystem (HLDBE) framework that can address common challenges that humanitarian supply chains face and sustain their logistics operations. The authors describe several common challenges in humanitarian logistics, including lack of funding, duplication of efforts, information availability, transparency, and coordination. A digital business ecosystem is a concept that involves businesses acting like biological ecosystems by creating a collaborative network that works together and shares resources and information. The authors propose applying a similar approach to humanitarian logistics to form an HLDBE, which would leverage data analytics and bring together humanitarian logistics stakeholders and business stakeholders and foster collaboration. The paper proposes several ways that such a structure could benefit disaster relief efforts, but also notes that there is no empirical evidence to support this claim. The authors suggest future studies could be done to test this framework and prove the effectiveness of an HLDBE.

Lal A, Lim C, Almeida G, et al. 2022. **Minimizing COVID-19 disruption: Ensuring the supply of essential health products for health emergencies and routine health services**. *The Lancet Regional Health – Americas*. https://www.thelancet.com/journals/lanam/article/PIIS2667-193X(21)00125-3/fulltext

This article argues that supply chains should use multi-country procurement in order to increase access to essential medicines and health supplies and to respond to future health emergencies like the COVID-19 pandemic. The authors examine the results of the Pan American Health Organization's (PAHO) Strategic Fund to show that partnerships between companies across different countries can minimize supply chain disruptions by reducing the effects of stockouts. As of 2021, PAHO had agreements with 50 countries, territories, and public health institutions, making it uniquely positioned to provide a diverse range of services and support to its members. The strategic fund delivers on five key areas: technical cooperation, pooled procurement, capacity-building, quality assurance, and innovative financing. The article

concludes that multi-country pooled procurement systems like PAHO's Strategic Fund can help countries maintain supply chains during future disruptive events, including pandemics, creating a more resilient and sustainable global system.

Lin Q, Zhao Q, and Lev B. 2020. **Cold chain transportation decision in the vaccine supply chain**. *European Journal of Operational Research*, 283 (1), 182–195. https://doi.org/10.1016/j.ejor.2019.11.005

This paper examines the connection between vaccine distributors' decisions to use cold chain in transportation and retailers' inspection processes upon arrival. The authors examine the existing literature on the subject to develop a basic model that describes the conditions that may cause a distributor to choose to adopt cold chain transportation or not. Factors that affect this decision include cost of implementing cold chain throughout transportation, potential loss due to a vaccine-related adverse event, and potency of the vaccine. This model reveals that having a retailer perform an inspection of the product at the end of the transportation process increases the likelihood of the distributor using cold chain. The authors then compare the effectiveness of a one-step versus two-step inspection by the retailer. The study concludes that the one-step inspection has a stronger influence on the distributor's decision to use cold chain.

Liu P. 2020. **Intermittent Demand Forecasting for Medical Consumables with Short Life Cycle Using a Dynamic Neural Network during the COVID-19 Epidemic**. *Health Informatics Journal* 26 (4), 3106–22. https://doi.org/10.1177/1460458220954730

This study describes a model that forecasts intermittent demand for medical consumables by taking into account seasonal factors that influence demand. Products like medical consumables have a very short life cycle, making it difficult to predict demand using typical factors such as historical sales data. Researchers tested various models using dynamic neural networks to determine the optimal model structure. They concluded that while this model is useful in predicting intermittent demand, the format of forecasted sales values (decimal or integer) in small data sets led to different results. While this is not an issue in large data sets, more research is needed to optimize a forecasting model for intermittent demand.

Marbouh D, Abbasi T, Maasmi F, et al. 2020. **Blockchain for COVID-19: Review, Opportunities, and a Trusted Tracking System**. *Arabian Journal for Science and Engineering*, 45 (12), 9895–9911. https://doi.org/10.1007/s13369-020-04950-4

This paper reviews potential opportunities and applications of blockchain-based tracking systems in combating the COVID-19 pandemic. Many companies, both in the technology sector and in health care, have developed contact tracing apps to track the spread of COVID-19, but this data may be imperfect or unreliable due to the potential for it to be hacked or manipulated. Using blockchain technology in this type of data tracking could allow for more reliability and accuracy. One potential use case is in clinical trial management, where blockchain could aid in recording clinical data from trial participants, ensur-

ing accuracy and transparency. Another major area for use is in supply chain management, where blockchain technology can connect stakeholders in one network and help move operations along more quickly. Blockchain can also be used in several ways to track the spread of the virus, including in contact tracing through mobile apps and in databases that store up-to-date news and information, ensuring that fraudulent data cannot be added. The authors propose and evaluate a blockchain-based tracking system for logging data related to COVID-19 that would collect information from various web sources, including WHO, the Centers for Disease Control and Prevention, and the Institute for Health Metrics and Evaluation. They provide a cost analysis and security analysis of this system, highlight the benefits as well as the challenges associated with it, and propose that future research might focus on improving specific functionalities of the system.

Onyango G and Ondiek JO. 2022. **Open Innovation during the COVID-19 Pandemic Policy Responses in South Africa and Kenya**. *Politics & Policy* (Statesboro, Ga.), September. https://doi.org/10.1111/polp.12490

This article explored how the governments in South Africa and Kenya have used open innovation to address four aspects of the COVID-19 pandemic: economic recovery, logistics and supply chain, digital healthcare partnerships, and collaboration. In addition to several other innovations, the government of Kenya adopted transport modeling sensors to track vaccine temperatures across the supply chain. Kenya Airways invested in updated pharma warehouses and repurposed passenger flights to ship COVID-19 essentials. The South African government invested heavily in digital technologies that allowed for greater visibility and traceability in their supply chains. Both governments have increased their use of and funding for open innovation strategies in response to the pandemic.

Papalexi M, Bamford D, Nikitas A, et al. 2022. **Pharmaceutical supply chains and management innovation?** *Supply Chain Management*, 27 (4), 485–508. https://doi.org/10.1108/SCM-12-2019-0456

This study evaluates the effectiveness of innovative programs in pharmaceutical SCM to improve service provision. Innovations in pharmaceutical SCM could result in reduced waste, improve inventory control, and enhance the quality of health services. However, the complexity of pharmaceutical SCM and the fact that they tend to operate independently makes it difficult to implement innovative approaches and solutions. The researchers conducted interviews and used questionnaires in hospital and community pharmacies to assess the impact of innovations in pharmaceutical SCM environments. Responses highlighted the complexity of communication and knowledge sharing in these organizations, and their technology systems are typically not integrated. Participants also noted the difficulty of introducing new and innovative processes into a system that is currently inefficient. These findings led the authors to create the Innovative Pharmaceutical Supply Chain Framework. This framework would act as a guide to pharmacies and provide information on how to develop supply chain strategies to reduce waste and enhance service quality.

Patil A, Madaan J, Shardeo V, et al. 2022. **Material convergence issue in the pharmaceutical supply chain during a disease outbreak**. *The International Journal of Logistics Management*, 33 (3), 955–996. https://doi.org/10.1108/IJLM-11-2020-0425

This article explores the issue of unsuitable and inappropriate donations in pharmaceutical supply chains during disease outbreaks and strategies that can lessen the negative results of this material convergence problem. Material convergence problems cause a number of issues in supply chains, including wasted resources, congested networks, and delays. Unsuitable pharmaceuticals also have their own unique set of problems, as they can become an environmental hazard if not disposed of properly and can also be resold in unsafe ways. This study examines the literature on this topic to develop a problem-solving framework for pharmaceutical supply chains facing drug convergence issues. The authors used simulation modeling to explore several ways to implement circular economy principles in pharmaceutical supply chains to address these issues and improve performance. They also identify seven learnings related to inappropriate donations and seven actions to relieve these effects. The learnings and simulations described in this study can be used by decision-makers to identify interventions tailored to their specific needs.

Raj A, Mukherjee AA, Lopes de Sousa Jabbour AB, et al. 2022. **Supply chain management during and post-COVID-19 pandemic: Mitigation strategies and practical lessons learned**. *Journal of Business Research*, 142, 1125–1139. https://doi.org/10.1016/j.jbusres.2022.01.037

This article examines the supply chain challenges that manufacturers have faced as a result of the COVID-19 pandemic, focusing specifically on the context of India. Based on a literature review, the authors identify ten major challenges: uncertainty of demand, inconsistency of supply, scarcity of material, delay in delivery, suboptimal substitute adoption, scarcity of labor, suboptimal manufacturing, constraint in capacity, vehicle unavailability and delays, and last-mile delivery challenges. They rank the most prominent challenges in order to determine which issues need to be addressed most urgently, noting that inconsistency of supply and suboptimal manufacturing were the two most prominent challenges facing manufacturers. The study describes mitigation strategies based on these challenges, breaking them into short-term and long-term strategies. The authors suggest that future similar studies could be conducted in other countries to see if their challenges are similar or different. They also note that while this study focused on the context of manufacturing, other studies could be done to identify challenges in the service industry.

Rakhimova G and Spiller D. 2021. **WFP's COVID-19 Fast Track: Sourcing humanitarian innovation at speed and scale**. *Medium*. https://wfpinnovation.medium.com/sourcing-humanitarian-innovation-at-speed-and-scale-wfps-covid-19-fast-track-f4012369fb37

This article describes the World Food Programme's (WFP) COVID-19 Fast Track innovation challenge, which took place in South Sudan in response to high rates of food insecurity caused by supply chain disruptions. After identifying food insecurity as a major issue, the WFP put out an open call for innovations, requesting solutions that involved humanitarian supply chain elements and could be quickly implemented. This resulted in three innovative pilot projects: Retail in a Box, Cockpit, and Rainmaker. Retail in a Box, which has successfully run in Mozambique, brings pop-up retail stores to communities in need, combatting store closures and delivery delays in food supply chains caused by COVID-19. Cockpit provides data analysis

about WFP's school meal program, allowing for accurate and timely decision-making. Rainmaker noted South Sudan's pre-existing conditions for food growing, including long sunlight hours and large amounts of agricultural land, and tapped into this by installing solar-powered water pumps and sensor-driven drip irrigation systems in villages around the country.

ReliefWeb. 2023. **Ethiopia's First Long-Range Medical Drone Network Established**. https://reliefweb.int/report/ethiopia/ethiopias-first-long-range-medical-drone-network-established

Ethiopia has established its first medical drone network to deliver medical supplies, including vaccines, to remote and hard-to-reach areas. The 30-day project consisted of 44 total flights to six different communities. The drones fly along pre-planned routes which have been mapped out in advance to avoid any physical obstacles. For the most remote locations, the project established a battery-swap hub, allowing the network to reach as far as 240 km from the distribution center. The drones can also be used for two-way delivery, meaning that communities can use the drones to send samples back to more centrally located labs. Based on the success of this effort, the project has been extended to run for an additional 90 days in early 2024.

Sarigol I, Ozdemir RG, and Sarigol EB. 2022. **Covid 19 vaccine order allocation: An optimization model with substitution**. *Journal of Humanitarian Logistics and Supply Chain Management*, 13 (2), 125–139. https://doi.org/10.1108/JHLSCM-09-2021-0094

This paper examines the issues of supplier selection and order allocation in vaccine supply chains in the context of the COVID-19 pandemic with the aim of determining ways to minimize the postponement of vaccination plans. Governments need to consider several factors when determining the type and quantity of vaccines to order, such as vaccine effectiveness, storage conditions, supplier reliability, and community preferences. The authors of this article developed an optimization model for governments to choose vaccine plans that uses a weighted-sum approach to make decisions about vaccine orders and substitutions to avoid postponement of these plans. The three objectives included in the model are purchasing costs, postponed vaccinations, and ineffectively vaccinated people. The authors explore how this model might be used in optimum, most-likely, and pessimistic scenarios. This tool can be used by governments in their decision-making process to determine the best possible vaccine plan in different contexts while minimizing the possibility of postponement.

Sawik T. 2022. **Stochastic Optimization of Supply Chain Resilience under Ripple Effect: A COVID-19 Pandemic Related Study**. *Omega* 109 (June). https://doi.org/10.1016/j.omega.2022.102596

The COVID-19 pandemic caused several major disruptions to supply chains, including increased demand for health care products, shortage of material supplies, reduced availability of workers, and delays in transportation and distribution. These disruptions led to an increase in research on supply chain resil-

ience strategies, as well as a higher level of analysis known as supply chain viability. This is defined as the ability of supply chains to survive in difficult situations by reacting to challenges that arise and adapting to meet changing environments. The ripple effect refers to the fact that during the pandemic, disruptions persisted for a long period and spread through the entire supply chain. The study proposes a decision-making model for supply chains facing a similar situation.

Sayol I. N.d., retrieved September 21, 2023. **Humanitarian logistics: At the heart of every emergency**. https://ignasisayol.com/en/humanitarian-logistics-at-the-heart-of-every-emergency/

This article provides an overview of humanitarian logistics and its role in emergency and crisis response. The author explains that one major difference between humanitarian supply chains and commercial supply chains is the difficulty in forecasting for the latter due to the unpredictable nature of the setting it is working in. This makes adaptability and innovation extremely important in developing humanitarian logistics strategies. The author describes three recent technological innovations and how they are being implemented in this field: 3D printing, drones, and blockchain. As supply chain disruptions become the new norm due to factors such as climate change and pandemics, humanitarian logistics strategies will need to become increasingly adaptable to meet these challenges quickly and efficiently.

Schmalz F. 2020. **The coronavirus outbreak is disrupting supply chains around the world—Here's how companies can adjust and prepare**. *Business Insider*. https://www.businessinsider.com/covid-19-disrupting-global-supply-chains-how-companies-can-react-2020-3

This article describes the supply chain challenges caused by COVID-19 and the unique and innovative ways companies have addressed these issues. One solution is for larger companies to build regional supply chains, segmenting their production so if one location is not functioning, others may remain in operation. A solution for smaller companies that are not able to employ this approach is to lean on technology, specifically using 3D printing and smarter warehouse information systems. The author discusses the need for companies to look to the future and develop long-term strategies that take into account efficiency and resilience.

Siriwardhana Y, De Alwis C, Gür G, et al. 2020. **The Fight Against the COVID-19 Pandemic With 5G Technologies**. *IEEE Engineering Management Review*, 48 (3), 72-84. https://doi.org/10.1109/EMR.2020.3017451

This paper discusses the use of 5G and internet of things related technologies in combatting the effects of the COVID-19 pandemic. The authors describe several examples of how these technologies have been used in innovative ways across several different industries. One is through telehealth, where 5G technology allows for the transfer of health data from patients' wearable devices for smartphones directly to health care professionals. It can also be used to conduct virtual clinical services with high-quality audio and video. 5G technology has also been effectively used in contact tracing and monitoring self-isola-

tion. Internet of things technology has been used to electronically tag products, helping with supply chain management. While there are several promising examples of how these technologies have streamlined processes in multiple sectors, they come with challenges, including privacy and security issues, scalability issues, and connectivity issues. The authors propose potential solutions to each of these challenges, but note that further research may be needed to effectively address these concerns.

Spieske A, Gebhardt M, Kopyto M, et al. 2022. **Improving resilience of the healthcare supply chain in a pandemic: Evidence from Europe during the COVID-19 crisis**. *Journal of Purchasing and Supply Management*, 28 (5). https://doi.org/10.1016/j.pursup.2022.100748

This article examines evidence from Europe to suggest strategies for improving future resilience of health care supply chains based on experiences from the COVID-19 pandemic. The authors look at this issue through the framework of the Resource Dependence Theory, which states that no organization is self-sufficient and that organizations form relationships with others to access critical resources. Because these relationships cause dependence on an outside party, they become a source of risk for the organization. Therefore, companies, including those in the health care industry, need to manage their dependence on outside partners to reduce vulnerabilities. The authors examined several case studies from the COVID-19 pandemic to determine the circumstances that led to these inter-organizational dependencies and how various companies have dealt with problems that arose from these relationships. Two types of strategies were typically used to combat these issues: buffering, by which companies reduce their exposure to a partner to reduce dependency, and bridging, by which companies establish stronger bonds with a partner to increase their influence over them. Some of the strategies used in the case studies included establishing central warehouses for medical supplies, exchanging medical supplies between regions with different levels of demand, and securing medical supplies from suppliers outside their typical networks.

Stark. 2022. **Pharma Supply Chains of the Future**. *EYGM*. http://ey.com

This article reviews ways in which the pharmaceutical supply chain industry dealt with disruptions caused by the COVID-19 pandemic, gathering insights from 17 companies that are members of the Pharmaceutical Manufacturing Forum. Following the pandemic, there have been several policy changes from the US, the EU, and China aimed at rebuilding and strengthening supply chains to ensure that pharmaceutical and medical products are available during future crises. Prior to the pandemic, pharmaceutical supply chains were becoming increasingly globalized, but we are now seeing a trend toward localization and a greater focus on developing regional supply chain networks. The authors suggest that localization combined with other policy changes and strategies may be the best solution moving forward. They also identify five criteria for supply chain resilience: reliability, time to innovate, agility, risk exposure, and efficiency. The article argues that localization needs to be considered from a variety of angles and may not look the same across different regions and contexts.

Tickle M and Hannibal C. 2022. **The Use of Technological Innovations in Promoting Effective Humanitarian Aid: A Systematic Review of the Literature**. *International Journal of Technology and Human Interaction*, 18 (1), 1-14. http://doi.org/10.4018/IJTHI.293204

This article examines how technological innovations, specifically in information and communication technology (ICT), can be applied to humanitarian supply chains during relief efforts following a disaster. Some possible benefits from using ICT in humanitarian supply chains include reduced costs, improved coordination, increased donor awareness, and increased agility. The study also found that ICT improved data collection and storage, increasing visibility and transparency. These tools also allowed organizations to share information with other organizations, increasing awareness of issues in the supply chain. Although the authors found several benefits to using ICT, there are also barriers, including incompatibility between different systems, volume of data, lack of familiarity with technologies, lack of funding, and security concerns. The article suggests several innovative uses of ICT that could offer the most benefit to humanitarian supply chains: tracking goods and services, a database containing information on past disaster relief efforts, satellite technology to enable internet access in remote areas, and Web 2.0/social media.

UNICEF. 2022. **Six ways UNICEF is innovating to respond to the pandemic and build stronger health systems**. *UNICEF Office of Innovation*. https://www.unicef.org/innovation/six-innovative-ways-pandemic-response-health-systems

This article from UNICEF describes six ways the organization has used innovative solutions to address issues caused by the COVID-19 pandemic. The first is the development of a rapidly deployable health emergency facility that can provide screening, isolation, and care during future disease outbreaks. The second is the Real-Time Vaccination Monitoring and Analysis (RT-VaMA) app that can be used to track the usage, coverage, and waste of vaccines. The third is Vaccine MicroArray Patches (VMAPs), a prototype patch device that is adhered to the skin and delivers vaccines through microneedles, eliminating the need for traditional syringes and removing the risks of needle waste and disposal. The fourth is UNICEF's use of data, including the platform MagicBox, to understand the needs of vulnerable populations and monitor the spread of the pandemic. The fifth is UNICEF's involvement in several projects that strengthen oxygen systems around the world. The final innovation is UNICEF's commitment to supporting future innovations by putting out a call for applications through the UNICEF Venture Fund for startups that are using AI, machine learning, or data science technologies to address health needs.

USAID Global Health Supply Chain Program. 2021. **Digitalization of COVID-19 Commodities Supply Management Strengthens Health Delivery in Bangladesh**. https://www.ghsupplychain.org/news/digitalization-covid-19-commodities-supply-management-strengthens-health-delivery-bangladesh

This article discusses the development of a comprehensive electronic logistics information management system (eLMIS) for COVID-19 commodities management under USAID's Medicines, Technologies, and Pharmaceutical Services (MTaPS) program in Bangladesh. At the onset of the COVID-19 pandemic, MTaPS developed a basic online system to track the stock of emergency commodities on a daily basis. As the

pandemic progressed and information needs became clearer, MTaPS upgraded the reporting system into an eLMIS that included a quantification tool to display stock availability in real time. This information was critical for making decisions around procurement, distribution, and restocking of COVID commodities. The use of eLMIS demonstrates the importance of a centralized inventory management system to improve decision-making in the field of supply chain management.

Zhang J, Pathak HS, Snowdon A, et al. 2022. **Learning Models for Forecasting Hospital Resource Utilization for COVID-19 Patients in Canada**. *Scientific Reports* 12 (1), 8751. https://doi.org/10.1038/s41598-022-12491-z

Researchers in this study developed a machine-learning model that can predict five quantities related to the COVID-19 pandemic: the number of hospital beds, ICU beds, ventilators needed, COVID-19 cases, and COVID-19 deaths. Researchers created a temporal convolutional network (TCN) model and compared it to other models to determine its accuracy. The TCN model's forecasts were consistently more accurate than other models across the entire forecasting period, illustrating its effectiveness as a decision-making tool. The TCN model can examine predictive patterns, meaning that it can look at the relationship between inputs and outputs, which other models cannot. The creators of this model hope to expand its use by inputting other COVID-19-related data to increase the type of information that the tool can predict.

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