

The Effect of COVID-19 on Supply Chain Management: Pre and Post-COVID-19: Case Study of CVS Pharmacy, Inc.

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Abstract

Throughout the COVID-19 crisis, everyone has observed many disruptions in the pharmaceutical supply chain. Indeed, this global and complex supply chain is vulnerable, especially when it must face a sudden rise in global demand. To adapt to the increasing demand and the numerous shortages, the United States White House has suggested several recommendations (The White House, 2021). Three of them will be detailed in this report:

boosting local production, building an emergency capacity, and promoting international cooperation. With more than 10,000 locations and retail stores in the United States and with the competition of large retail stores like Target and Walmart, CVS has continued to enhance its supply chain by rolling out vendor technological portals designed to facilitate its supply chain programs and models. Most of CVS's generic products and retail merchandise are manufactured outside the United States. To ensure the sustainability and efficiency of their models, integrated planning, internal and external collaborations, and dissemination of forecasting models with suppliers help them to predict and manage demand uncertainties. CVS is digitally connected to give people more options by using their artificial intelligence platform, thereby harnessing the power of digital technology and the Omni channel sourcing to ensure that their customers are reached/served whenever, and by whatever means possible. During the COVID-19 pandemic, CVS faced three major issues related to the distribution of common drugs between patients with chronic illnesses and patients with COVID-19 pneumonia, a high volume of customer calls, and high procurement costs of medicines from suppliers due to shortages. This led CVS to implement temporary mitigation measures that set it apart from its competitors and helped serve more patients in an orderly fashion. Based on the learnings from CVS, this report presents a set of short-term solutions that can be implemented by CVS to insulate it from future shortages until the long-term solutions are implemented in collaboration with the FDA and drug suppliers.

Keywords: COVID-19, Supply chain management, Pharmaceutical products, CVS, FDA, and Drug suppliers

1. Introduction

Every day, many patients must purchase drugs to recover from a virus, injury, or ailment. Everyone expects that the medicine will be on the shelf, and nobody should expect that they would need to wait several days before receiving the drugs. However, this is the current reality. This situation creates unacceptable consequences since a drug shortage is likely to further deteriorate a patient's condition. The COVID-19 crisis brought these pre-existing issues to light. To deal with these issues, the United States White House published a report in June 2021 that suggests multiple recommendations for the pharmaceutical industry. Our project's goal is to pick some of these recommendations, analyze the pharmaceutical supply chain, and verify if one can implement these suggestions in CVS pharmacy's supply chain.

2. Process Mapping of the Pharmaceutical Supply Chain

The supply chain for pharmaceutical products is broken down into five distinct pieces to arrive at a final product. As with all manufactured goods, the process starts with raw materials. These raw materials are brought together and/or refined to make fine chemicals. These fine chemicals are ultra-pure, high-quality chemicals that typically are only used for pharmaceutical purposes. The fine chemicals are then used in chemical processes to create active pharmaceutical ingredients (APIs). These are the active ingredients that are listed on medication packaging. The APIs are combined with inactive ingredients and packaging materials to produce the final dosage form (FDF). Lastly, the FDF is shipped to the market, including pharmacies, hospitals, and retail locations.

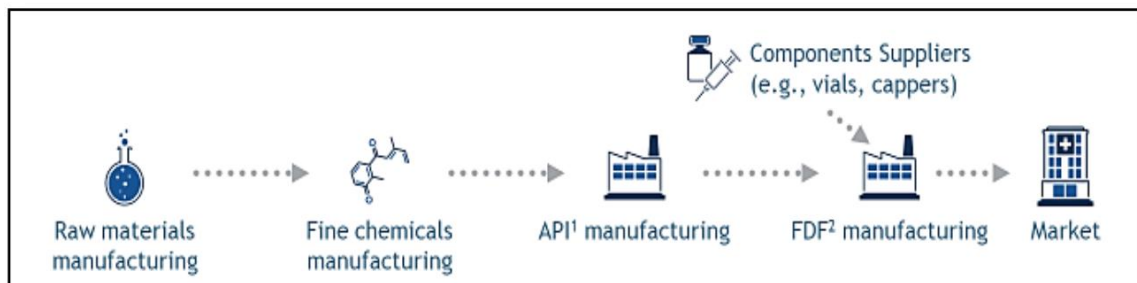


Figure 1. Pharmaceutical Supply Chain

Raw materials are typically commodity products that are widely available from many suppliers. These materials include petroleum products, organic materials, minerals, etc. Under normal circumstances, there would be low uncertainty about the demand and supply of most of these products. Producers of fine chemicals would efficiently treat the raw materials to reduce their costs as much as possible. Moving along the chain into fine chemicals, products start to get more specialized and differentiated. Many of the fine chemicals are still widely available and can be treated in an efficient manner similar to the raw materials. Some manufacturers of fine chemicals have proprietary products and processes that cannot be imitated or substituted by a competitor. When this is the case, supply uncertainty begins to increase. Manufacturers of APIs have to rely upon one supplier for inputs into their process.

APIs are separated between patented and generic. Only one manufacturer can supply the

ingredient to the market for patented APIs. This is beneficial to the manufacturer but makes the entire downstream supply chain dependent on one manufacturer for the ingredient. With only one manufacturer the supply uncertainty grows. Generic ingredients on the other hand can be produced by multiple manufacturers meaning that the supply chain is not reliant on one supplier. These generic manufacturers focus primarily on competing on price which can lead to quality issues arising more often. The FDA sets forth strict manufacturing practices for API producers to ensure the products sold in the United States meet quality standards. These regulations put additional pressure on manufacturers to err on the side of caution in quality control. The abundance of caution leads to even more supply uncertainty for downstream buyers.

FDF manufacturers are in the last stage of production for a pharmaceutical product. FDFs are often a combination of one or more active ingredients with inactive ingredients and packaging material. The FDA standards for API production also apply to FDF production for inactive ingredients as well as the APIs. Over the last 15 years, there has been a trend of API and FDF manufacturers' offshoring production to countries with lower costs of labor, namely China and India. This situation is attractive to manufacturers since wages in these countries are only about 8-10% of wages in the United States. The costs of land and facilities in these countries are also cheaper. As of March 2021, 52% of FDF and 73% of API manufacturing facilities that were registered with the FDA were located outside the United States. The number of facilities located outside the US producing generic drugs is even higher at 63% for FDF and 87% for API facilities. The locations are broken down further in Appendix 2.

Another method that all of the pharmaceutical supply chains use is to maintain lower costs in just-in-time manufacturing. This practice is used to keep inventory costs low but with the tradeoff of being less responsive to changes in supply or demand. As already discussed, supply uncertainty can be high for all points in the supply chain. When changes occur, availability is quickly disrupted. The COVID-19 pandemic was a major disruption to both supply and demand since workers were prevented from gathering at their workplace and demand for particular products skyrocketed.

Even before the pandemic, experts were giving warnings that this model would not be sustainable if something were to interrupt the global supply chain. A testimony by Janet Woodcock (U.S. Food and Drug Administration, 2019), the director of the Center for Drug Evaluation and Research, in October 2019 lays out how the current supply chain would pose a threat to national security if there were to be a disruption.

3. Analysis of CVS Supply Chain

1) Corporate Strategy of Health and Medicine products categories

The strategy of CVS is to provide outstanding service and value to their customers – while meeting their healthcare needs and making their overall shopping experience as easy as possible. Having the products, the customers want in stock is a large part of the organizational strategy.

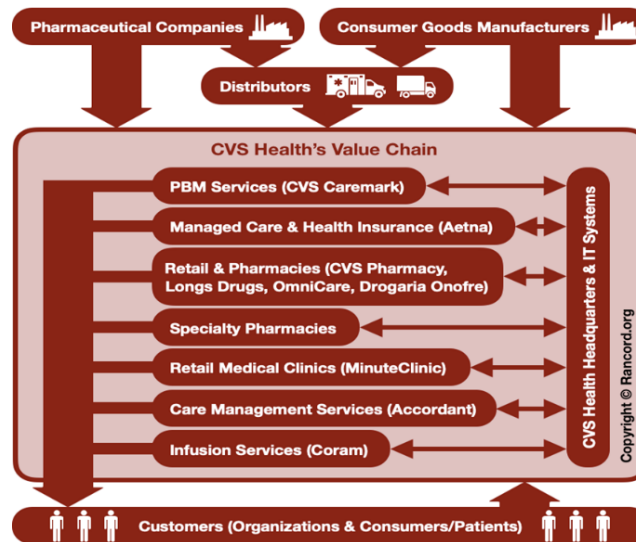


Figure 2. CVS Value Chain

These channels are digitally coordinated to give people more options by using digital technology to coordinate their supply chain. This Omni channel sourcing model ensures that all stakeholders will be able to access the CVS model from any part of the world.

This model was also established to reduce costs during sourcing and appraise suppliers accordingly. It is also used to communicate and share inventory and forecast information with supplies to help predict demand and supply. The model also helps in their integrated planning and internal/external collaboration among all parties.

Table 1. Characteristics of supply in uncertainty

Supply Characteristics	
Stable	Evolving
Fewer quality problems	Potential quality problems
Stable and higher yield	Variable and higher yields
More Supply sources	Limited Supply sources
Reliable Suppliers	Unreliable Suppliers
Flexible	Non Flexible.

Table 2. Characteristics of demand in uncertainty

Demand Characteristics	
Functional	Innovative
High demand Uncertainties	Low demand uncertainties
Very predictable demand	Difficult to forecast
Long product life	Short Selling Season
Low inventory Cost	High Inventory Cost
High Volume per SKU	Low volume per SKU
Low-profit margin	High-Profit Margin

Demand Uncertainties

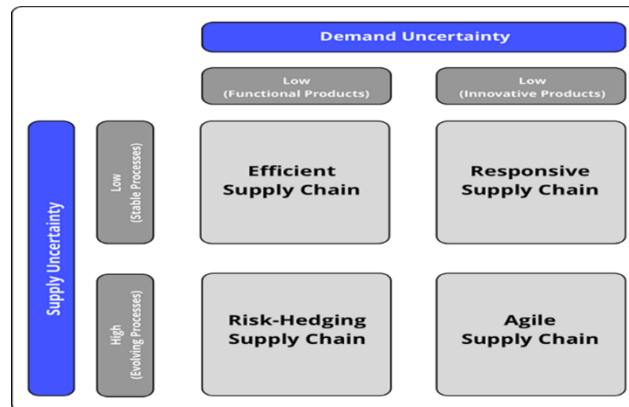


Figure 3. Inventory strategy matrix

The Health and Medicine product category from CVS is high uncertainty/innovative products thereby making their supply chain responsive, making optimal use of their resources while at the same time remaining sensitive to meeting customers' needs and demands.

1) CVS history (CVS Health Corporation, 2022)

As a pharmaceutical and prescription management enterprise, CVS Caremark has rapidly grown into a major corporation, coming second in the United States.

They provide a variety of healthcare services which can be broken down into the following segments, retail or long-term care, healthcare benefits, pharmacy services, and others. Retail and long-term care services include the selling of prescription drugs and other merchandise. The healthcare benefit segments offer traditional voluntary and consumer-directed health insurance, other products, and related services including pharmacy, dental, and other medical capabilities.

The Pharmacy angle offers pharmacy benefits solutions to clients.

They are currently the largest company in the retail pharmacy industry with almost 10,000 stores across the country with 256,500 employees across the locations.

2) CVS strategies, innovations, and digital services

Along with expanding their retail and primary care capabilities, they are harnessing the power of digital technology to help people schedule care, connect with physicians and get the quality and affordable care they deserve.

They have also moved beyond a traditional drug store model by optimizing their retail locations to serve as community health destinations for all kinds of services while enhancing their Omni channel health experience.

They have also digitally connected their pharmacy capabilities to give people more options by using artificial intelligence to streamline the members' experiences and position the company as a premier health and wellness destination for all.

3) Comparison before-after COVID

Before the pandemic, cost reduction, process improvements, and enhancement of productivity was the driving force behind supply chain management. All these factors are important, but the chaos caused by COVID-19 threatened the competitive position of every thriving business. Lots of pharmaceutical companies discovered that they cannot meet customers' needs and expectations. This forced companies to shift their focus on innovation and restructuring to ensure business continuity by building flexibility and resilience around their processes. The continuity needed to be balanced by continuing to offer the best products and services to meet their patients' and customers' every need on their healthcare journey.

CVS has more than 100 million customers and 10,000 stores. To serve their patients, especially the ones living with chronic or complex illnesses, they must ensure that their medication supplies are not interrupted in any way. With the pressure the pandemic put on the US healthcare system, CVS's responsibility was to ensure that their customers have affordable access to their medication and to be delivered when and where it was needed. COVID-19 has pushed all companies' supply chains to be more responsive and effective. Their supply chain models help them to monitor carefully all prescription availability, predict demand vs supply uncertainties, establish performance metrics for their suppliers, and communicate and share forecasting models with all stakeholders to help predict demand and supply.

With the model, they can stay abreast and ahead of utilization trends to ensure that customers have access to medication needed to manage their health and avoid costly implications. CVS uses predictive analytics to monitor prescription drug usage and adopt supplies of medications as needed. These models were not only used to ascertain the demand and supply trends but also to manage the distribution and logistics associated with their supply chain. The focus was placed on countries like India, China, and Italy which are the core of the pharmaceutical supply chain since the majority of their generic products are manufactured outside of the United States. Conclusively, CVS is optimizing its retail locations to serve as community health destinations, but not all non-prescribed product sales are final, because of COVID-19, some cannot be returned. Only prescriptions damaged or opened may be returned but those ordered online cannot be returned.

4. Overall Risks Assessment

Supply chain strategies are ever-evolving concepts that adapt in real-time as new challenges emerge. The term supply chain management has been known for a long time, but it became one of the most popular terms during the pandemic when people learned the importance of supply chain management in industries that were stable for a long time, such as healthcare.

The healthcare industry in the US is one of the world's largest with total spending reaching \$4.1 trillion in 2020 or \$12,350 per person (CMS, 2021). Due to such an exorbitant cost, a cheaper supply chain helps keep the cost of medicine as low as possible. The below table aptly summarizes the practices of the supply chain before the pandemic and the risks associated with them.

Table 3. Pre-pandemic Supply Chain Strategy & Risks

Supply Chain Node	Strategy	Risk
Warehouse Inventory	Reduce as much as possible	Reduces ability to cope with sudden increases in demand
Raw Materials	Dual sources from the cheapest suppliers far from the primary market	Increased reaction/shipping time if the supplier is located far away
In-store Units	Reduce as much as possible	Stock outs
Production	Move offshore	Relies on government treaties and relationships between host and consumer countries

During the COVID-19 pandemic, one of the biggest lessons that the world learned was that supply chain resilience is one of the principal factors to combat a pandemic on a global scale. The resilience of a supply chain system for a product helps companies to sustain the production of that product under uncertain times and can help absorb uncertain spikes in the demand.

One of the major industries that were affected during the pandemic was the healthcare industry due to the unexpected influx of a large number of patients admitted to hospitals across the country. This led to an acute shortage of staff as well as several essential goods such as drugs, medical equipment in ICUs, essential medical supplies, etc. Apart from the hospitals becoming overwhelmed, the pharmacy stores were equally affected by the increased demand and constrained supply chain of drugs.

1) *Shortage of Drugs & Drug Delivery Devices*

Based on a report from the White House (The White House, 2021), drug shortages were one of the top risks due to the supply chain crisis. Although drug shortages are a common phenomenon in the healthcare industry, the number of new drug shortages has been declining since 2011. Due to the unexpected demand for drugs needed to treat COVID-19 patients, simple essential drugs and drug administration devices, such as syringes, were in short supply. CVS, in particular, experienced shortages of essential medicines and medicines that were available over the counter to treat stand-alone symptoms of COVID-19 such as cough and cold. Apart from the drugs needed to treat COVID, the CVS and other pharmaceutical stores were out of COVID-19 testing kits that were used to identify if a person has the virus or not.

Shortages not only impacted the capacity of the hospitals to treat patients but also led to a significant increase in the cost to procure medicines. Based on the federal report, the hospitals in New York City competed against one another to procure medicines from one of the primary wholesalers.

2) *Limited Resilience*

The supply chain for many of the essential, as well as non-essential, drugs, is complex and involves multiple production/packaging facilities before they reach the shelves. However,

there are a few countries that have a high concentration of factories that produce drugs than other countries. Based on the federal report, out of 118 medications that are deemed essential by the FDA’s 2020 essential medicines list, around 50% of drugs do not have domestic manufacturing sites as seen from the analysis below.

Of 120 critical medicines, roughly only half have domestic API manufacturing sites (relative volume domestic vs. foreign being researched)

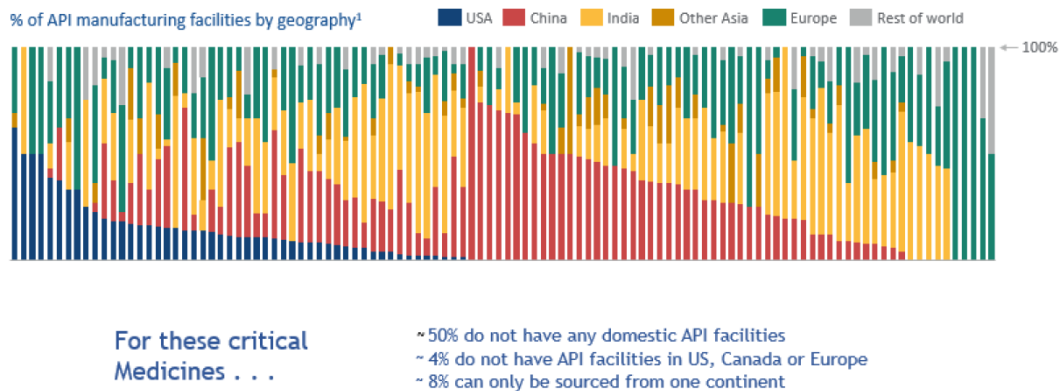


Figure 4. API Manufacturing Facilities by Geography (The White House, 2021)

Due to a high concentration of manufacturing sites located outside of the US, it was difficult to import drugs from those countries to the US due to lockdowns of countries, stoppage of production due to an outbreak of COVID-19 in a facility, and export bans of drugs since the country of production needed the drugs for domestic use. This led to a severe shortage of critical drugs that were used to sedate COVID-19 patients in the ICU. To mitigate this shortage, FDA used emergency powers to authorize imports of non-approved drugs from manufacturers to provide temporary relief to the industry. This type of import also increases the risk of low-quality drugs administered to patients and increases the risks of severe side effects.

3) *Just-In-Time Inventory Practices*

Lastly, the amount of inventory in the US and the storage costs played a huge role in shortages as well. The pharmacies such as CVS have warehouses located across the US that import and store drugs that are later distributed to local pharmacies. Based on the federal report (The White House, 2021), over 90% of drugs prescribed to Americans are produced outside of the US to reduce labor and manufacturing costs. Due to high storage costs and limited shelf lives of drugs, the inventory is usually limited to mitigate small fluctuations in the demand and cannot cope with an extreme surge in demand as seen during the pandemic.

5. CVS Risk Assessment & Mitigation Strategies

During the COVID-19 pandemic, CVS faced three big issues that affected its ability to serve medicines to its customers.

1) *Common drugs*

One of the symptoms seen in patients with COVID-19 was pneumonia. The treatment in early 2020 for this was to use off-label drugs that are also used to treat the chronic condition in patients that do not have COVID-19 (CVS Health, 2020). To treat both types of patients, CVS devised a plan to limit the number of units of off-label medicine for patients with COVID-19 pneumonia, whereas they exempted the patients from any limit rule who have been using this medicine for the treatment of chronic illnesses.

2) *Volume of calls to the pharmacy and in-person visits*

Due to extreme shortages of medicines in the market, which was mainly due to an exponentially greater demand compared to supply, as well as due to hoarding of medicines by many people to cope with uncertainty, there was an extremely high number of calls and in-person visits to the pharmacy. In addition to that, CVS was losing staff due to various issues related to work stress and the possibility of COVID-19 infection. CVS mitigated this issue by extending previously approved prior authorizations for medicines set to expire before June 30, 2020 (CVS Health, 2020). This reduced the number of calls and customers who used to come to extend their medications.

3) *High procurement cost*

The analytics team of CVS was monitoring the changing trend of medicine consumption and identified new patterns in the prescription of medicines (CVS Health, 2020). This helped them to gain a head start in combating the upcoming supply chain crisis. CVS also helped its suppliers and the market by not stockpiling medicines since it would have increased the prices of the medicines even further.

6. Recommendations

1) *Boosting local production and fostering international cooperation*

This first objective is to improve the US supply chain resilience and the US partner's supply chain resilience as well. To this end, many investments will be required. That is why one could create a diverse group of stakeholders who will help advise private firms to strengthen domestic capacities and boost local production. The consortium will chiefly be tasked with identifying financial incentives and investments, devising a plan of action to integrate additional small and medium-sized companies, and suggesting some regulations regarding new technologies. Given the climate change situation, they will also have to take the environmental impact into account by identifying and mitigating risks. The working group will focus on drugs that are essential to US patients. The objective is to allow these medications to constantly be available during a plague or another emergency. Moreover, this incorporation of the supply chain in the US would mitigate supply chain risks that are likely to happen because of geopolitical or climate change issues.

Specifically, sterile injectables are at risk of shortage. To solve this problem, the US could increase the sterile injectable supply chain's resilience by fostering financial incentives to spur investment, updating reimbursement models, and offering procurement guarantees.

Afterward, another way to entice domestic production is to foster R&D that allows the development of innovative manufacturing processes and technologies that will tighten the supply chain resilience. For instance, the COVID-19 crisis led to an increase in pharmaceutical production on-demand. However, significant capital expenditures will be necessary to commercialize the production of these platforms.

Quality is the foremost concern in the pharmaceutical industry. However, quality issues caused 63% of the drug shortage from 2013 to 2017 according to the White House report. The report urges the pharmaceutical industry to implement a rating system to reward diligent manufacturers that offer mature quality systems and work on a continuous improvement process. The rating of the facilities could be published if the pharmaceutical companies would want to. This regulation would bolster quality transparency. The rating system would also benefit international partners, to foster their supply chain security and resilience.

Once a company undertakes improvements to a supply chain, they need to be able to monitor the performance of the new process. Thus, FDA urges stakeholders to use commercial data to pinpoint and offset supply chain risks. In addition, the US Government should collect additional supply chain data to improve surveillance, oversight, and supply chain resilience.

The short- and medium-term next steps are listed in Exhibit 1.

2) *Build emergency capacity*

Even though the US increases its supply chain resilience, it is more than likely that the US will face unexpected events that could hazardously impact the drug supply chain. Therefore, the pharmaceutical industry should be prepared and devise a particular strategy.

To do so, another recommendation is the creation of a virtual stockpile of APIs and essential drugs. This virtual stockpile will help mitigate the waste of drug products since some of them are fragile and cannot be stockpiled indefinitely. Therefore, they recommend a mechanism to cycle materials/drugs, based on how long they can be safely held in inventory.

In practice, HSS will have to list essential APIs and finished medicines which must be stockpiled as well as assess the benefits and risks of a virtual stockpile. In addition, HSS should consider the use of on-demand manufacturing during increased production in crises.

3) *Promote international cooperation and partner with allies*

Despite all the above recommendations, it is neither desirable nor realistic to believe that all the medicines needed on American soil will be available anytime. As a result, the White House recommends ratcheting up international cooperation with partners to ensure international harmonization and tighten supply chain resilience. Indeed, collaboration with allies should help identify the risks to the global supply chain and develop solutions. In addition, both the US and its partners should initiate complementary strategies to set up a certain amount of redundant production without useless duplication among allied nations. Also, they could undertake the development of a centralized API supplier database. Finally, international partners may want to map a global supply chain that would theoretically consist of domestic production, production inaccessible locations, and production in allied nations.

7. Conclusion

The recommendations for CVS can be divided into two categories – short-term solutions that can be implemented in a short time and long-term solutions which need to be charted out extensively.

Short-Term Solutions:

- 1) *Emergency Inventory:* Building up on the White House report (The White House, 2021), CVS should work with its suppliers to build up inventories at each stage of the supply chain to increase the resilience of the supply chain and distribute the increased cost of storage.
- 2) *Improved Prescription Refill:* To improve customer service during a pandemic, CVS should implement a survey-type prescription refill so that the patients know ahead of time if the provider has approved the extra dosage without the patient needing to visit a pharmacy.
- 3) *Trends:* CVS should work with healthcare providers and use Aetna's health insurance data to obtain the trends in current prescriptions and work with suppliers to reduce the risk of shortages.

Long-Term Solutions:

- 1) *Digital Supply Chain Visibility:* To mitigate future shortages, CVS should invest in resources to improve the visibility of inventory further up the supply chain. CVS is one of the largest healthcare companies, it would be able to work with suppliers to investigate and solve supply chain problems that might affect CVS's sales.
- 2) *Periodic Check-in with Suppliers:* Building up on the previous solution, CVS should also work periodically with suppliers by holding meetings to understand if there are issues with suppliers that are inhibiting them from building up inventories.
- 3) *Collaboration with FDA:* To incorporate some more drugs in the essential list based on any pandemic or outbreak that might happen in the future, CVS should work closely with the FDA to solve issues with the supply chain if the above solutions do not work.

References

Alicke, K. et al. (2022). How COVID-19 Is Reshaping Supply Chains. McKinsey & Company, Retrieved on 23 Feb. 2022 from <https://www.mckinsey.com/business-functions/operations/our-insights/how-COVID-19-is-reshaping-supply-chains>

CMS. (2021). *National Health Expenditure Data*. Retrieved on 15 Dec. 2021 from <https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical#:~:text=U.S.%20health%20care%20spending%20grew,For%20additional%20information%2C%20see%20below>

CVS Health Corporation. (2022). *Form 10-K*. Woonsocket, RI: CVS Health Corporation,

2020.

CVS Health. (2020). *CVS Health Helping Protect Supply of Medicines Potentially Useful for COVID-19 Treatment*. CVS Health. Retrieved from <https://www.cvshealth.com/news-and-insights/press-releases/cvs-health-helping-protect-supply-of-medicines-potentially-useful>

Estes, C. (2020). States Are Being Forced into Bidding Wars to Get Medical Equipment to Combat Coronavirus. *Forbes Magazine*. Retrieved from <https://www.forbes.com/sites/claryestes/2020/03/28/states-have-are-being-forced-into-bidding-wars-to-get-medical-equipment-to-combat-coronavirus/?sh=6841a7f51cde>

The White House. (2021). Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-Based Growth: 100-Day Reviews Under Executive Order 14017.

U.S. Food and Drug Administration. (2019). United States, Congress, House, Committee on Energy and Commerce, Subcommittee on Health. *Safeguarding Pharmaceutical Supply Chains in a Global Supply Chain*. Retrieved from <https://www.fda.gov/news-events/congressional-testimony/safeguarding-pharmaceutical-supply-chains-global-economy-10302019>

Abbreviations

API – Active pharmaceutical ingredient

DPA - Defense Production Act

HHS - US Department of Health and Human Services

PPP – Public-Private Partnership

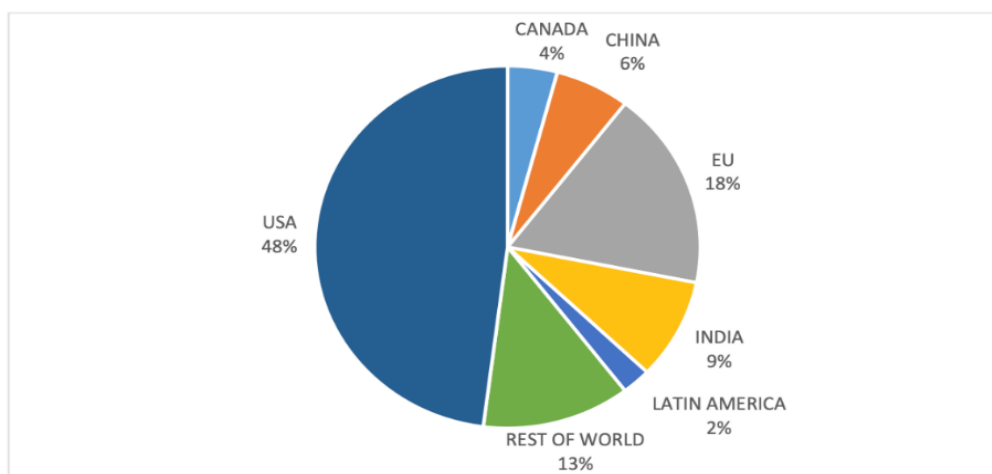
Appendix

Appendix 1. Boosting local production and fostering international cooperation

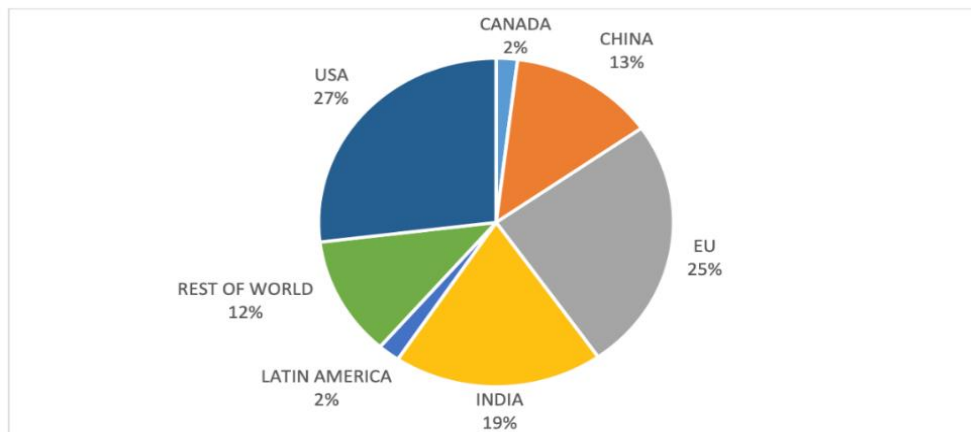
	<i>Short-term</i>	<i>Medium-term</i>
1. Investment and financial incentives to boost production	<ul style="list-style-type: none"> - HHS and the White House will sort out a high-level conference - The Assemble will create a consortium of public health experts to determine a list of the 50-100 most critical drugs that must be available at all times in the US - HHS will analyze the essential medicines than went into shortage as well as the root causes. 	<ul style="list-style-type: none"> - HHS will gather pharmaceutical supply chain experts to achieve a resilience framework based on analyses - HSS will map the supply Chain for the Critical Drug List - HSS will suggest if it is needed to ratchet up production or stockpile API for the Critical Drug List

	<ul style="list-style-type: none"> - HHS will leverage the DPA process to several financial incentives - HSS will establish a list of sterile injectables that must be subject to improved supply chain resilience 	<ul style="list-style-type: none"> - HSS will whittle down API supply risk by evaluating stockpiling strategies - The US government will update reimbursement models for key essential medicines
2. Invest in R&D	<ul style="list-style-type: none"> - Develop fully integrated and smaller-footprint platforms - HSS can gather experts that will be in charge of supporting the development, evaluation, and implementation of new manufacturing technologies and processes. 	/
3. Create Quality Transparency	<ul style="list-style-type: none"> - Establishing a quality rating system - FDA could start discussing with stakeholders to develop this rating quality management system 	- FDA will assess whether or not a new PPP is necessary to develop such a rating system
4. Improve information and data collection	<ul style="list-style-type: none"> - The industry and other non-governmental stakeholders should share insight into commercial data sources - Improving FDA and HSS's ability to collect information - Compel API and finish drug labels to identify original manufacturers 	

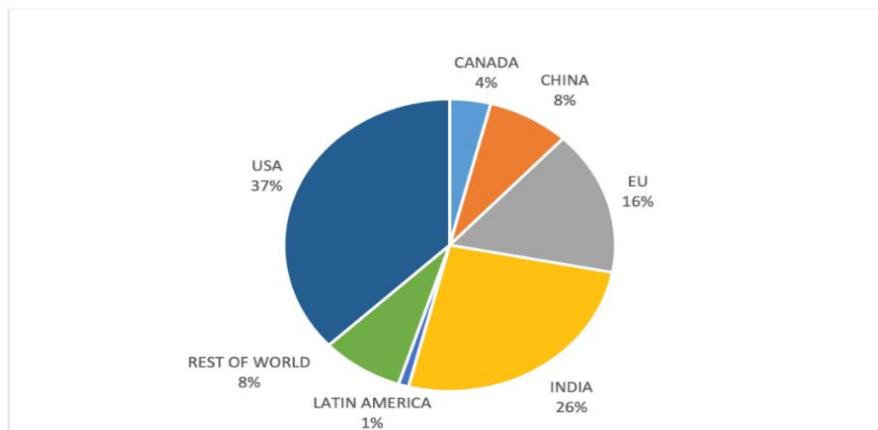
Appendix 2. Distribution of API and FDF manufacturing facilities worldwide (The White House, 2021)



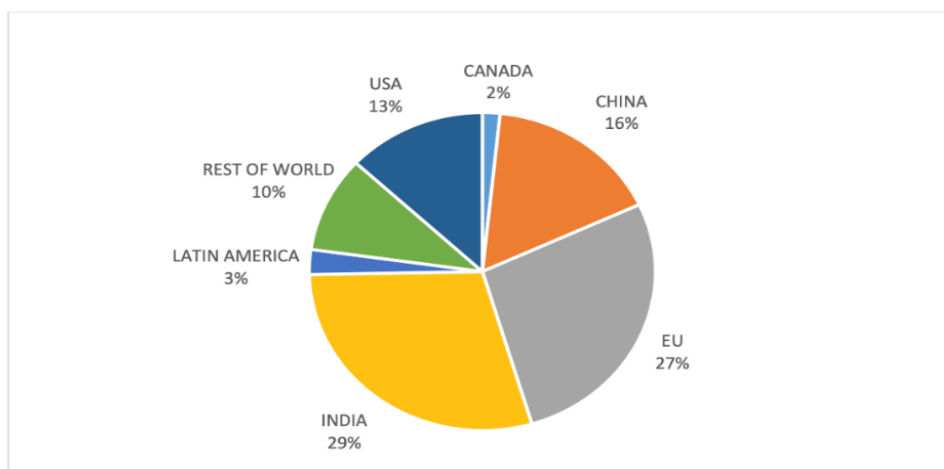
Appendix 2a. Percentage of FDF Manufacturing Facilities for All Drugs by Country or Region March 2021



Appendix 2b. Percentage of API Manufacturing Facilities for All drugs by Country or Region, March 2021

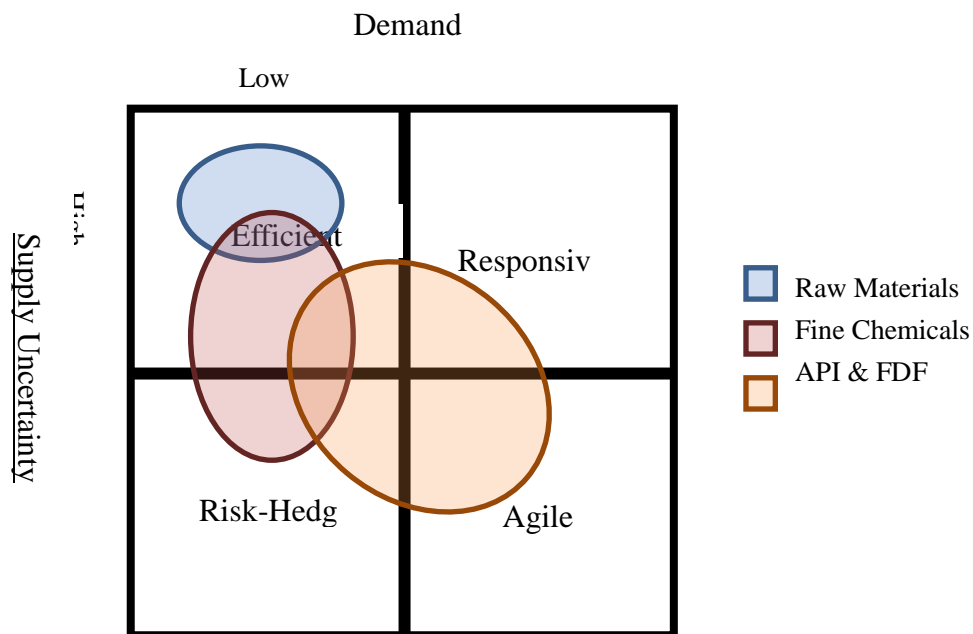


Appendix 2c. Percentage of FDF manufacturing Facilities for Generic Drugs by Country or Region, March 2021



Appendix 2d. Percentage of API Manufacturing Facilities for Generic Drugs by Country or Region, March 2021

Appendix 3. Demand and Supply Uncertainty for inventory along the pharmaceutical supply chain



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