UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

SUPPLY CHAIN DISRUPTIONS DURING THE COVID-19 PANDEMIC IN THE PHARMACEUTICAL INDUSTRY IN CENTRAL EUROPE

Ljubljana, June 2024 Mitja Ergaver

AUTHORSHIP STATEMENT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

sl. -Slovene

3PL – (sl. Tretji ponudniki logistike); Third party logistics providers

AI – (sl. Umetna inteligenca); Artificial intelligence

API – (sl. Aktivna farmacevtska učinkovina); Active pharmaceutical ingredients

CAGR – (sl. Letna stopnja rasti); Compound annual growth rate

CEO – (sl. Glavni izvršni direktor); Chief executive officer

COVID-19 – (sl. Koronavirus); Coronavirus disease 2019

CT – (sl. Računalniška tomografija); Computed tomography

EUR – (sl. Evro); The Euro

GPO – (sl. Skupinska nabavna organizacija); Group purchasing organization

IoT – (sl. Internet stvari); Internet of Things

IT – (sl. Informacijska tehnologija); Information technology

JAZMP – (sl. Javna agencija Republike Slovenije za zdravila in medicinske pripomočke); Agency for medicinal products and medical devices of the Republic of Slovenia

OTC – (sl. Zdravila brez recepta); Over the counter

PPE – (sl. Osebna varovalna oprema); Personal protective equipment

PSC – (sl. Farmacevtska oskrbovalna veriga); Pharmaceutical supply chain

R&D – (sl. Raziskave in razvoj); Research and development

SCM – (sl. Upravljanje oskrbovalnih verig); Supply chain management

SCRM – (sl. Upravljanje tveganj oskrbovalnih verig); Supply chain risk management

USD – (sl. Ameriški dolar); The United States Dollar

WHO – (sl. Svetovna zdravstvena organizacija); World health organization

1 INTRODUCTION

The supply chain plays an important role in the firm's business processes and can be defined as a network of various entities, that are part of an upstream and downstream movement of goods, services, and information. A common goal of such networks is fulfilling the needs of the final consumer by following the objective of being as efficient as possible (Mentzer et al., 2001). Usually, there is a set of firms, through which products or services go through. Such set of firms can be referred to as supply chain (La Londe & Masters, 1994). When supply chains are managed in any way, we are discussing the concept of supply chain management (SCM). This concept covers all end-to-end steps, that are needed to meet the customer's demand (Cooper et al., 1997).

Supply chain risks are unpredicted scenarios that occur and impact the state of the whole supply chain and make companies more vulnerable to different types of challenges (Kleindorfer & Saad, 2005). Generally, there are two main groups of supply chain risks, which are: operational risks and disruptional risks. Operational risks are mainly about poor supply and demand management and coordination within the company, due to inadequate internal systems, which makes such risks much more controllable (Bhattacharyya et al., 2010). On the other hand, disruptional risks are much less controllable, since they originate from natural disasters, for instance, hurricanes, pandemics, economic crises, and even man-made disasters, like labor strikes and terrorist attacks (Parast & Shekarian, 2019). Such risks can become a big deal for the companies, hence companies must have good supply chain risk management, which includes assessing and implementing strategies to minimize the impact of possible disruptions (Craighead et al., 2007).

It was in early 2020 when the World Health Organization declared Coronavirus disease 2019 (COVID-19) a global pandemic. We could see worldwide strict measures imposed by the governments, trying to limit the spread of the virus. Thus, it is no wonder that those restrictions significantly impacted various industries, including the pharmaceutical industry, which was of key importance to battle through the pandemic.

At the time of the pandemic, I was working a student job in one of the multinational pharmaceutical companies, located in Slovenia. With this work, I gained a lot of experience in how to work in a crisis, where decisions need to be made quickly. I could experience on my own what changes on a large-scale mean, like moving a couple of hundred employees to work remotely overnight. This motivated me to write this thesis, which allowed me to dive deeper into the functioning of the pharmaceutical supply chains (PSC) in the time of COVID-19 pandemic.

The purpose of my master's thesis is to understand the relationship between the COVID-19 pandemic and supply chains in the pharmaceutical industry in the region of Central Europe in general, and in particular, in the case of Slovenia. I want to examine whether

pharmaceutical companies experienced any disruptions caused by the pandemic and how the industry reacted to the world health crisis. Additionally, I would like to research the state of medicine supply during and after the pandemic of COVID-19. Therefore, my research aims to provide pharmaceutical companies with the knowledge and information on navigating through uncertain events, such as the pandemic, to fulfill the goal of supplying medicine to patients.

The goals of my master's thesis are:

- To analyze how the world health crisis impacted the supply chains in the pharmaceutical industry within Central Europe, and in particular, Slovenia
- To analyze how companies responded to the world health crisis
- To analyze shortages of medicine during and after the COVID-19 pandemic
- To provide recommendations for the companies for the future

With my thesis, I am going to address the following research questions:

- What was the impact of the COVID-19 pandemic on supply chains in the pharmaceutical industry in Central Europe, and Slovenia in particular?
  - Which links of the pharmaceutical supply chain were impacted most significantly?
  - How did governmental measures impact the operations of pharmaceutical companies?
  - How significant were the shortages in the supply of raw materials, and in consequence shortages in the supply of medicines for patients?

- How did pharmaceutical companies from Central Europe and Slovenia respond to the pandemic?
  - What were the response priorities for pharmaceutical companies when the pandemic began?
  - How can pharmaceutical companies be better prepared for the possible future disruptions?
  - What are the current weaknesses of the supply chains in the pharmaceutical industry and how can companies address them?

- Are pharmacies in Slovenia having any supply shortages of medicine?
  - How do pharmacies respond, in case there is a shortage of medicine?
  - What is the impact of supply shortages on patients?

My research focuses on Central Europe, which is home to numerous important pharmaceutical companies, including Novartis, Sandoz, Roche, and Bayer, whose supply chains extend throughout the whole Central European region and beyond. Through secondary sources, I was able to determine the impact of the COVID-19 pandemic on pharmaceutical industry in Central Europe. Furthermore, I looked into how companies

responded to disruptions and how the region's medicine supply was affected. Here I learned that most pharmaceutical companies denied any issues with shortages of medicine (Grom, 2022; Zalar, 2021). In contrast, there were several reports from different Central European countries, who expressed concerns with regards to shortages of medicine in pharmacies (Ahmed, 2022; Cerar, 2023; Martuscelli, 2023; Hungary Today, 2022). This discrepancy motivated me to dig deeper. While I focused on the context of Central Europe, my empirical work used Slovenia as a case study to determine the state of medicine supply in Slovenian pharmacies, as relevant stakeholders, who are located in the supply chain between pharmaceutical companies and patients. Additionally, this gave me insights into how Slovenian pharmacies are affected by supply chain disruptions and how they are dealing with the issues.

The secondary data for my thesis was collected using literature review as a research method, which allowed me to get an overview of the research subject. For the primary data collection, I used a non-standardized, semi-structured interview, allowing me to be more flexible in the research process.

My thesis is structured as follows. In the first chapter I make an introduction to the thesis. The second chapter presents a comprehensive overview of supply chain concepts. The third chapter focuses on supply chain management in the pharmaceutical industry. In this section, I describe the links, risks, and disruptions that occur in pharmaceutical supply chains. Chapter four focuses on the pharmaceutical industry in Central Europe. The fifth chapter analyses pharmaceutical supply chains during the COVID-19 pandemic, where the main focus is on the pandemic's impact and the industry's response. The first five chapters presented me with important data, which helped me gain a strong understanding of the research subject. In chapter six, I outline the methods I used for data collection and analysis. The findings are presented in chapter seven, and discussed in the last chapter eight, along with recommendations and research limitations and future research.

2 UNDERSTANDING CONCEPTS

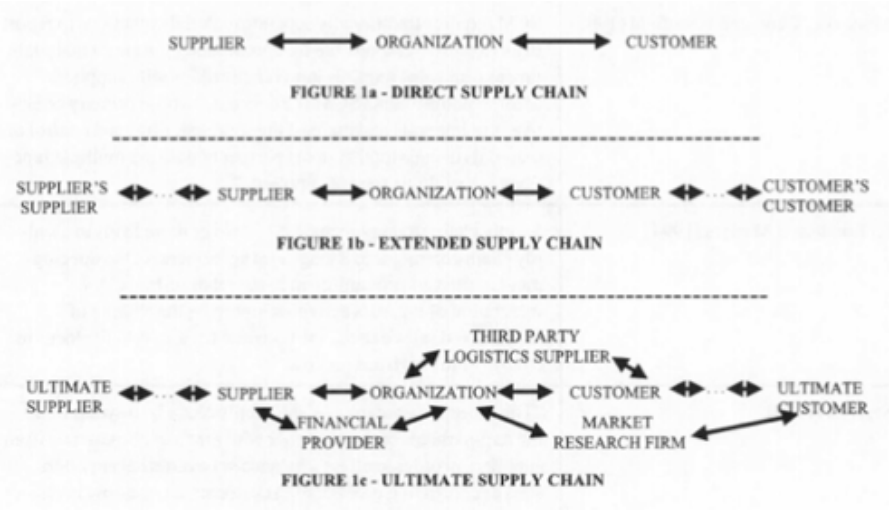
2.1 Supply chain

The supply chain is a network of various entities that contribute to the upstream (i.e., supply) and downstream (i.e., distribution) movement of goods, services, and information, with a shared goal of fulfilling the final customer demand (Mentzer et al., 2001). Organizations within the supply chain are dependent upon each other and need to collaborate to meet the market's demand (Christopher, 2011). The supply chain is, therefore, an integrated system that connects all business processes, with the goal of being as efficient and profitable as possible to increase the competitiveness of the firm and supply chain as a whole (Min et al., 2019).

Nowadays, a final consumer or industrial product is not only manufactured by one single firm, but rather a set of independent firms, that pass the raw materials, semi-finished products, and services among each other to assemble the final product. A simple example of this would be where one firm provides raw materials to the second firm for production. The second firm then manufactures a component, which is sold to a third firm that produces the final product. The next firm in line is then a wholesaler, who sells the product via the retailer to the ultimate consumer. Such a network of independent firms can be referred to as a supply chain (La Londe & Masters, 1994).

According to Mentzer and others (2001), there are three levels of supply chain complexity: a) direct supply chain, where a firm has a supplier and a customer; b) extended supply chain, which includes a supplier of the supplier and a customer of the customer and c) ultimate supply chain, which adds also the third-party logistics providers (3PL) and financial providers in the chain among other organizations. It is worth mentioning that whether supply chains are managed or not, they still exist as business phenomena. But once organizations in supply chains are in any way managed, then we are shifting to a concept of supply chain management.

Figure 1: Levels of supply chain complexity



Source: Mentzer et al. (2001).

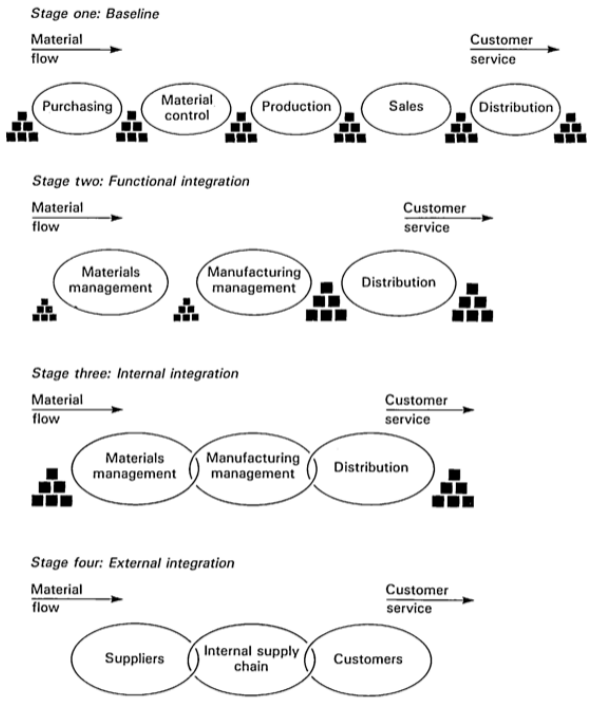
2.1.1 Supply chain management

In the 1970s and early 1980s, there were many firms that were primarily focused only on the goals of functional areas and not on the supply chain as a whole. This led to a large information imbalance across the chain, making it inefficient. As a solution, companies tried to reduce the impact of imperfect information with the use of excessive inventory and production capacities, resulting in even higher costs (La Londe & Masters, 1994; Stevens, 1989).

Companies started to implement different strategies to manage the flow of material and information within the company in a more systematic way, trying to improve efficiency and effectiveness. It soon became clear that firms need to integrate the supply chain not only within the firm but also between all organizations within the supply chain (La Londe & Masters, 1994).

Stevens proposed a basic three-level framework on how to build an integrated supply chain. The strategic level covers a wider view and includes the objectives, guidelines, and location of the supply chain. The tactical level encompasses different ways of achieving strategic objectives, it transforms them into operational and functional goals and helps finding the right tools, systems, and resources to reach them. Lastly, the operational level deals with systems and procedures that are needed to achieve an efficient and effective supply chain. Each level within the firm can be centralized or decentralized, it all depends on the organization itself, but the important thing is that people, systems, facilities, and finances within the organization work in harmony (Stevens, 1989). Furthermore, four stages of supply chain integration have been proposed for the companies as shown in Figure 2.

Figure 2: Stages of supply chain integration



Source: Stevens (1989).

In the baseline stage, the departments of the company are separated, and independent, without any information being exchanged between them, leaving supply chains fragmented (Stevens, 1989).

The functional integration stage focuses primarily on the inbound flow of material, services, and information. The outbound flow of finished products is decoupled from the inbound

flow, meaning there is poor demand visibility, which puts a large burden on the planning and manufacturing part. As a result, firms are just getting the right things done, but not in the most efficient way (Stevens, 1989).

The internal integration stage guides companies to include also the outbound flow. With the help of controlling, planning, and information exchanging systems, firms manage to achieve internal visibility from end-to-end. At this point of integration, firms start to work efficiently (Stevens, 1989).

In the final stage of external integration, firms achieve full supply chain integration by including suppliers and customers. To comprehend the customer's demand, a shift from product to customer orientation is required. On the other side, suppliers need to be involved in product development from the very beginning. With that, the cooperation of all organizations in the supply chain is needed to reach the goals of being efficient and effective (Stevens, 1989).

Supply chain integration is the starting point of the supply chain management. A company first needs to achieve internal integration to harmonize the internal processes. The next step is then external integration, where collaboration and coordination of people, processes, and information happen between companies (Pagell, 2004).

Furthermore, when there is a proactively managed two-way movement of goods, services, and information within the supply chain, we are discussing the concept of SCM. This concept is responsible for the coordination of activities and processes within the supply chain (Monzcka et al., 2016).

SCM's main goal is to manage and integrate material flows and systems from the supplier end to the customer end (Monczka et al., 1998). The objective is to have the customer's demand synchronized with the whole supply chain, which helps companies deliver the final product or service to the customer most efficiently and effectively (Stevens, 1989).

In order to lower the overall costs of the chain, decision making in the SCM needs to be highly strategic (Houlihan, 1988). Each activity in the chain is interdependent, hence collaborative approach is required among the members to achieve the goals of efficient and effective supply chains (Monczka et al., 1998). Firms need to form long-term relationships, where they share computer databases to exchange sensitive information about sales, demand, and inventory data. A high level of trust among the companies is required to ensure visibility in the chain. Such an approach will lead to benefits for every member of the supply chain, such as service improvements, and cost reductions and the chain as a whole will be more competitive compared to others (La Londe & Masters, 1994).

2.1.2 Supply chain risks and disruptions

In the literature, there are many definitions of risk and uncertainty, but often they are used interchangeably. Generally, uncertainty is defined as the possibility of experiencing an unwelcome event, which results in financial or other losses. Such an event cannot be measured, or calculated and the outcome cannot be predicted (Wang & Jie, 2020). Risk on the other hand is when there is deviation in the outcome from the expected one, resulting in disruptions, with negative consequences (Chen et al., 2013; Wagner & Bode, 2006). Both terms are connected, since uncertainty is the one that triggers risks. This means that the higher the uncertainty, the more likely it is for the risks to occur. Because people even with the help of technology and different forecasting models, cannot predict future events, there is a risk that the outcome will differ from the one that is planned (Wang & Jie, 2020).

There are numerous definitions of supply chain risk, but they all focus on a specific area within the supply chain, and not across the chain as a whole. For example, supply risk is defined as a chance of individual or group suppliers failing to deliver the material to the manufacturer, who as a consequence cannot deliver the final product to the customer (Zsidisin, 2003). Furthermore, there is also information, material, and product flow risk from the primary supplier to the end customer, leading to a mismatch of information between the supply and market demand (Jüttner et al., 2003). Hence, supply chain risk is defined as the probability and severity of an unwanted event, that negatively affects the state of the whole supply chain and makes companies more vulnerable on operational, tactical, and strategic levels (Ho et al., 2015).

Generally, supply chain risks can be divided into two main categories. For instance, Tang (2006) suggests that there are disruptional and operational risks. Similarly, Ho and others (2015) conceptualize supply chain risks as macro-risks and micro-risks, while Sodhi and others (2012) categorize them into catastrophic risks and operational risks. For the purpose of this paper, we will refer to the categorization of disruptional and operational risks, provided by Tang (2006).

When speaking about unexpected events and conditions, that occur external to the company and have a negative impact on the supply chain, we are referring to disruptional risks. This category of risk is further divided into natural risks, which include for example hurricanes, floods, earthquakes, pandemics, economic crises, and man-made risks, such as political uncertainty, war, and terrorist attacks. Contrary, operational risks originate from failures in internal processes and operations of the companies within the supply chain, leading to poor supply-demand coordination. Furthermore, there are four subcategories of operational risks, which are: manufacturing risk, supply risk, demand risk, and infrastructural risk. Manufacturing risk includes events that hinder firms' ability to produce the products and services. Supply and demand risks are related to the issues of companies in the upstream and downstream parts of supply chain. Lastly, disruptions in technology, financial, and transportation systems can largely impact the operation of the whole chain, and they are

referred to as infrastructural risks (Ho et al., 2015; Parast & Shekarian, 2019; Wu et al., 2006).

It is important to note, that disruptional risks are less controllable, mainly because they originate from natural disasters. While on the other hand, operational risks are more controllable, as long as the company collects and analyzes the data to foresee unwanted events in the future (Bhattacharyya et al., 2010; Patrick, 2007).

2.1.3 Supply chain risk management

Nowadays, companies are facing more and more supply chain risks, therefore it is important for them to have an established supply chain risk management (SCRM), which ensures that companies stay profitable and in operation, despite disruptions. SCRM can be defined as collaboration within and between every member of the supply chain, with a common goal of avoiding and mitigating both disruptional and operational risks (Tang, 2006). Jüttner and others (2003) defined SCRM as a process of identifying the risks for the supply chain and managing them through a common approach from all of the partners in the supply chain, to reduce the impact of disruptions. A similar definition was provided by Norrman & Jansson (2004), who highlighted the importance of collaboration of supply chain members when dealing with uncertainties. With the use of quantitative and qualitative risk management methods, SCRM aims to identify, asses, mitigate and monitor the unwanted events, which may negatively affect the company or supply chain as a whole. Hence, the main objective of SCRM is to reduce the possible adverse impact of disruptions (Ho et al., 2015; Jaberidoost et al., 2013).

Generally, SCRM includes four different elements: (1) risk identification; (2) risk assessment; (3) risk mitigation, and (4) responsiveness to risk incidents. The very first step is to identify the possible risks that can occur at some point in the future and that can impact the operations within the supply chain (Kleindorfer & Saad, 2005). To minimize the possible negative effects of disruptions, the company needs to discover and acknowledge the risk in the earliest phase possible (Chowdhury & Quaddus, 2017). As a result, Wieland & Wallenburg (2013) suggest that data collection within the company and information sharing across all members of the supply chain is crucial to identify future risks.

When risk is identified, the next step is then to perform the risk assessment, where you evaluate in which possible cases the risk can occur and what is the potential impact (Ho et al., 2015; Kleindorfer & Saad, 2005). The goal is to understand why risky events happen, what are the probabilities for such events to occur, and what are the negative consequences and severity of such disruptions impacting the supply chain. Identified risks are then categorized based on the potential disruption and likelihood of occurring (El Baz & Ruel, 2021; Manuj & Mentzer, 2008).

The main objective of risk mitigation is to define a strategy through which a company minimizes the probability of disruption unfolding, meaning that such event is prevented from happening. But in case a risk event happens, then we are already talking about the fourth step, which is responsiveness. At this stage, SCRM aims to provide a contingency plan to help an organization respond in the most effective manner. Many authors highlight the importance of cooperation between all members of the supply chain, combined with the organization's internal SCRM processes since this is one of the most effective ways of dealing with supply chain disruptions (El Baz & Ruel, 2021; Kleindorfer & Saad, 2005; Manuj & Mentzer, 2008; Wieland & Wallenburg, 2013).

2.2 Supply Chain Management and Logistics

Recently, the terms logistics and supply chain management are often used interchangeably, hence it is important to clearly define the meaning of these two different concepts (Blume Global, 2019). Logistics is responsible for planning, implementing, and controlling forward and reverse flows of materials, information, and services from the originating point to the consumption point, with the objective of fulfilling the customer's demand. The goal of logistics is to manage these flows in the most efficient and effective way (CSCMP, n.d.).

The main responsibility of logistics is transporting materials along the inbound and outbound supply chain members. This includes managing the movements of goods, parts, and semi-finished products from and to manufacturing plants, warehouses, and finally to consumers. (Zijm et al., 2019).

Logistics can be seen as one of the business processes, which are covered by the broader concept of supply chain management. SCM manages all supply operations, including procurement, manufacturing, and distribution. SCM connects the demand and supply by managing relationships among all organizations within the supply chain, including suppliers, manufacturers, distributors, third-party service providers, and at the end, the final customer. Logistics is usually responsible only for a specific segment of the supply chain, while supply chain management encompasses the whole end-to-end process that is needed to deliver the products or services to the customer (Zijm et al., 2019; Blume Global, 2019; Christopher, 2011).

3 PHARMACEUTICAL INDUSTRY SUPPLY CHAIN MANAGEMENT

3.1 Pharmaceutical industry in general

The pharmaceutical industry is an industry comprised of different organizations and processes, that contribute to discovery, development, and production of pharmaceutical

drugs, which are then distributed to patients in need (Goodarzian et al., 2020). This is an industry, which helps people live longer lives. Research and development (R&D) is one of the most important parts of this industry. Through R&D, the pharmaceutical industry discovered a variety of medicines to treat various diseases, hence it is no surprise, that this is also one of the most research-intensive industries. This is also one of the reasons, why there are many collaborations between pharmaceutical companies and universities, especially in the first phases of product development, which usually takes a lot of time (McGuire et al., 2007).

Overall, there are two segments of the pharmaceutical market. The first segment is the prescription pharmaceuticals, where medicine is available only via prescription by the healthcare professional. This segment is then further divided into two parts. The first part is where pharmaceutical companies invest large amounts of money and time into discovering new, innovative medicine. In such cases, the probability of failure is high, but in case of success, the reward is much higher. The second part is the so-called generics pharmaceuticals, where the products are based on the current patents and only the patent holders or licensee can manufacture such drugs. The main difference of this part is that it doesn't require a company to invest in R&D, because the products have already been developed, which also means that the drugs are sold for a lower price. Furthermore, when the patent expires after 20 years, other companies can also start manufacturing those drugs. Prescription medicine is primarily marketed to healthcare professionals, who then prescribe drugs to the patients. The second segment is the so-called» over the counter« (OTC) market, where you find medicines for less serious diseases and where safety is of no concern. This means that you can buy such drugs without a prescription, and the marketing target are the patients (McGuire et al., 2007).

To put in perspective how big the pharmaceutical industry is, here are some numbers. In the year 2022, the total revenue of the worldwide pharmaceutical industry was nearly 1.50 trillion USD. This is the amount that is spent to purchase medicine from the manufacturers. In the next years, total revenue is expected to grow at compounded annual growth rate (CAGR) 3-6%, reaching 1.90 trillion USD in 2027 (IQVIA, 2023).

The global OTC pharmaceutical market in 2022 received a total revenue of 333 billion USD, with an expected growth of 5% CAGR in the following years (Hubner, 2023).

Similar growth is expected in the generic pharmaceuticals segment, where total worldwide revenue in 2020 was 74 billion USD and is anticipated to grow up to 100 billion USD by 2026 (Evaluate Pharma, 2021).

3.2 Pharmaceutical supply chain

As we have seen in the previous chapter, the supply chain is a network of different entities that take part in the inbound and outbound flows of information, material, and services, with

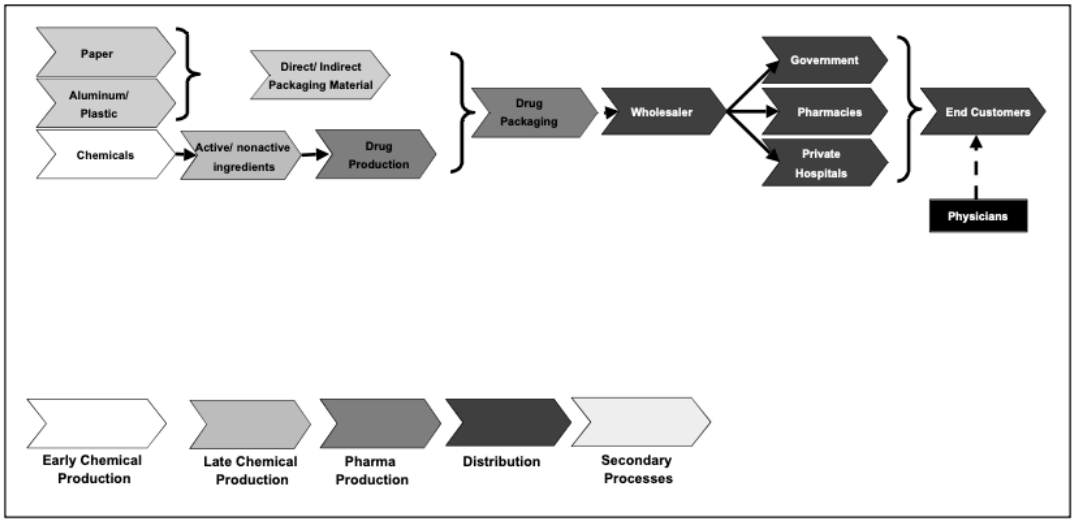
an objective to deliver the product or service to the final customer (Mentzer et al., 2001). Furthermore, the same definition applies when we are talking about PSC, which is basically an integration of all processes and organizations that are needed to transform raw materials into medicines, which are then delivered to the patient. In short, PSC is comprised out of three groups of entities. The first group are the producers, where we find pharmaceutical companies, suppliers of raw materials, medical surgical product companies, universities, and others. The second group are purchasers, which includes pharmaceutical wholesalers, pharmacies, independent distributors, group purchasing organizations (GPOs). And finally, third group are the providers which are usually healthcare providers, like hospitals. Among all of these entities, there are of course also regulatory and governmental bodies making sure products are in line with the regulation and are safe to use. Interactions within the PSC network are known to be complex and crucial since the patient's well-being is on the line. Hence, the whole healthcare system is very much dependent on the effectiveness of the PSC (Narayana et al., 2014; Uthayakumar & Priyan, 2013).

Main objective of pharmaceutical supply chain is to deliver the medicine to the patient in the right quantity, quality and on time, as this is one of the crucial ways for patients to fight with diseases. Any disruption in the PSC can cause major delays in production and delivery of drugs to the final consumer. But not only that, delays can also endanger the lives of people. Therefore, PSC is one of the most sensitive chains, which needs to be managed in the most efficient and effective way possible, since it has a very high responsibility for the whole healthcare system (Goodarzian et al., 2020; Uthayakumar & Priyan, 2013).

Standard pharmaceutical supply chain includes the following stages: (1) primary manufacturing; (2) secondary manufacturing; (3) warehouses and distribution centers; (4) wholesalers and (5) healthcare centers. Primary manufacturing is responsible for production of active pharmaceutical ingredients (API), which usually means use of chemicals and sophisticated chemical procedures to produce the ingredients for the final product. This step is considered to be highly complex and time-consuming, because the ingredients pass through many stages of transformation. Nowadays, many big pharmaceutical companies opt to outsource this activity to the contractors, since this allows the companies to shift focus on the research and other important areas. But at the same time, this adds the complexity to the PSC, which can cause problems among the chain. In the following stage of secondary manufacturing, manufacturing companies add excipient materials to API, and together with packaging produce the final product. Due to globalization, many companies have geographically dispersed secondary manufacturing plants, due to reasons such as price optimization and location of being closer to the final consumer. This is also the reason why companies have more secondary manufacturing plants, than primary. Next, we have warehouses and distribution centers, through which wholesalers distribute the finished pharmaceutical goods to the hospitals and healthcare centers, from where finally the drugs are delivered to the patients (Shah, 2004).

A similar definition of pharmaceutical supply chain was proposed by Kaufmann and others (2005), who divided the chain into four main segments, which are: (1) early chemical production; (2) late chemical production; (3) pharma production, and (4) distribution. In the early stage, it all begins with producing or extracting raw materials, like basic chemicals, out of which in the second stage, companies produce ingredients for the final product, such as liquids, solids, and active and non-active ingredients. These are all crucial parts of the pharmaceutical drug since they trigger the chemical reaction once the drug is consumed. In the pharma production stage companies manufacture and package the drug to be ready for distribution, which is the final stage of PSC, being responsible for delivering the product to the final consumer.

Figure 3: Example of pharmaceutical supply chain



Source: Kaufmann et al. (2005)

3.2.1 Upstream pharmaceutical supply chain

The whole pharmaceutical supply chain can be divided into two segments. The first segment is the upstream supply chain, which includes all organizations and processes that are needed for the pharmaceutical company to start the production. The aim is to provide the manufacturer with all needed materials, such as chemicals, active and non-active ingredients, and packaging materials. There are several departments that are the key players of the upstream supply chain. First being is the procurement, who is responsible for selecting the optimal suppliers, who offer high quality materials and reliable deliveries. Then, there is logistics department that needs to make sure that the whole inbound transport is effective and efficient, including the warehousing and inventory management. And finally, there is quality management department, who ensures that the inbound material is meeting all of the high quality standards. Altogether, they need to follow the objective of materials being delivered on time, in the right place, in the right quantity and quality (Kaufmann et al., 2005).

3.2.2 Downstream pharmaceutical supply chain

The second segment of the pharmaceutical supply chain is the downstream supply chain, which includes organizations and processes that are needed to deliver the finished pharmaceutical product to the end consumer. Of course, as with the upstream supply chain, there are also a few departments, which play an important role when it comes to reaching the goal of delivering the final products on time, in the right place, in the right quantity and quality. The main players are the marketing or sales department, logistics department, and quality management. For instance, the sales department needs to market the products in such a way, that the company maximizes the profits. Then there is outbound logistics, which is responsible for dispatching the orders and delivering them to the right customer on time and in the right condition. The quality management department must not be ignored, since it plays one of the more responsible roles in the whole downstream PSC. Its objective is to make sure that all finished pharmaceutical products are of prime quality and safe to use. The main challenge for the downstream segment of the supply chain is demand forecasting, mainly due to the lack of information from wholesalers to the manufacturing companies (Kaufmann et al., 2005).

3.3 Pharmaceutical supply chain risks and disruptions

As with any supply chain, also PSC is impacted by risks, which disrupt supplying drugs in the right quantity, quality, and time, threatening patients', by making drugs less accessible (Jaberidoost et al., 2013). In recent years, pharmaceutical companies are facing more and more challenges, which have an impact on the pharmaceutical supply chain. For instance, risks are coming from the regulation authorities, who may often change legislation. Similarly, customers and fierce competition in the market can also trigger risks for the company (Enyinda et al., 2010).

Generally, pharmaceutical supply chains face risks in terms of product discontinuity, shortages of the product, poor performance, safety concerns of the product, technological errors, which can cause stock shortages and counterfeit medicines. A common negative impact of such risks is that drugs can be delivered with a delay, putting patients' lives in danger (Breen, 2008).

Research conducted by Breen (2008) proposes the following risks as the top ten risk identified by the pharmaceutical supply chain stakeholders: (1) fragmentation of supply chain; (2) poor visibility of stock; (3) unexpected increase in demand; (4) demand versus capacity; (5) poor information flow; (6) poor forecasting; (7) availability of raw material; (8) not able to respond to the demand; (9) insufficient buffer stock; (10) contracting treated as a commodity. Risks were then further divided into three distinctive groups: supply chain structure, controllability, and strategy.

When it comes to the structure of the supply chain, the number one issue is the fragmentation and disconnectedness of all supply chain members. Those risks were marked as top priority, since they have a huge impact on the whole chain, often resulting in financial loss. Usually, PSC has a lot of members and due to fragmentation, it often happens that decisions are not harmonized. To deal with this issue, the possible solution is to have a responsible body, that coordinates and interconnects members of the supply chain (Breen, 2008).

In the second group, in controllability there are risks, which are more related to the operational and functional level within the company. For example, poor visibility of stock and poor information flow can cause delays and issues along the whole supply chain. Companies should emphasize more on such risks, since they are much more controllable by the companies, and they should minimize them as much as possible. Especially since there are also less controllable risks, like natural disasters, which companies cannot influence. In the strategy group, the main risk is the lack of coordinated strategy among the members of the supply chain, which overlooks the whole supply chain (Breen, 2008).

Jaberidoost and others (2013) reviewed the literature about the pharmaceutical supply chain risks and identified the most common risks in the industry. As we can see in the Table 1, risks were divided into seven groups.

Table 1: Identified risks

Name of the risk	**Description**	
Supply and suppliers' issues	-supply and supplier issues -partnership with supplier -raw material quality -fragmentation -timely delivery	-flexibility of supplier -technology level -delivery reliability -ordering cycle time
Organization & Strategic issues	-inventory management -operation issues -R&D -planning issues	-information flow -skill of workers -production cost -visibility of stock
Financial	-currency rate -financial risks -cash flow	-interest rate -tariff policies changes
Logistic	-counterfeit	-transportation
Market	-market -consumer taste	-demand
Political	-natural disasters -political issues	-sanction
Regulatory	-regulation	

Source: Own work based on Jaberidoost et al. (2013).

Most risks were identified in the supply and suppliers' issues group, followed by regulatory issues and organization and strategic issues. As the Table 1 is showing, there are more internal risks, which are related to failures of business processes and mismanagement of the firm and of the supply chain as a whole. Such risks can mostly be managed by the correct mitigating strategy. Contrary, there are fewer external risks, which are harder to mitigate (Jaberidoost et al, 2013).

3.3.1 Challenges in pharmaceutical supply chains

Nowadays, pharmaceutical companies are facing more and more challenges, especially in the supply chain part, due to its complexity and responsibility of delivering the medicine on time to patients. Managing such supply chain is of great importance, since good supply chain management can be one of the competitive advantage a company has towards competition. But being successful in PSC management is not an easy task, mainly because of complex environment with constant changes in trends, short product life cycles, globalization and outsourcing of the business processes. Furthermore, pharmaceutical industry is also characterized by high costs, time consuming activities and high uncertainties in demand planning. On top of that, there are global quality standards, healthcare reforms and patent expiries, which are forcing pharmaceutical companies to be as strategic as possible, to deal with those challenges (Singh et al., 2016). According to Shah (2004), challenges in pharmaceutical supply chains can be divided into operational issues and strategic and design issues. Both categories will be discussed in the following section.

3.3.2 Operational issues in pharmaceutical supply chains

Business processes are crucial for pharmaceutical industry to have more responsive and agile supply chain. Some most important processes are inventory management, both primary and secondary manufacturing and outsourcing. Pharmaceutical drugs are mostly produced out of chemicals or organic compounds, meaning that degradation can occur in case the drugs are not stored properly. For the inventory management team this is an important task, to keep the finished drugs in optimal conditions. In addition, inventory levels must be sufficient for any unexpected rises in demand, which is highly complex, due to many stochastic variables. It is essential for the companies to be able to fulfill the customer demand, hence high inventory levels are required, resulting in high costs for the company (Shah, 2004; Singh et al., 2016).

Looking at the manufacturing stages, pharmaceutical companies face the challenge mainly in the primary manufacturing stage. This stage is essentially a »push« process, which is based on historic data and demand prediction models. Since this stage usually requires a lot of time to produce the ingredients, the responsiveness is rather low, which means that any change in demand can cause negative effects that are then seen even in the secondary manufacturing stage. Poor responsiveness can be seen as a large limitation for the

pharmaceutical company, because this prevents the company from responding to any short-term opportunities. For instance, if a competitor runs out of supply, company cannot simply step in and produce the medicine for the market (Shah, 2004).

One of the key business processes is logistics, for which company can choose to have it as internal activity or as an outsourced activity. Outsourcing means to transfer activity from the inside of the firm, to the outside provider, who then takes full responsibility and decision making for the process (Shah, 2004). In order to be more competitive on the market, many pharmaceutical companies opt to outsource logistics activities to specialized providers, such as third-party logistics providers (Aktas et al., 2011). Main positive effect of outsourcing activities is that the pharmaceutical company can then cut costs, but also this allows to speed up the innovation process, since the company can focus more on the research (Graf & Mudambi, 2005). On the other hand, Harris and others (1998) propose that outsourcing can cause loss of control over the activities, leakage of information and knowledge to supplier, who can then also emerge as a competitor.

3.3.3 Strategic and design issues in pharmaceutical supply chains

When it comes to strategic and design issues, pharmaceutical companies face important decisions from various areas, most significant being capacity planning, supply chain network design, and manufacturing plant design. Besides those, pipeline and development management is additional area that requires attention, since this is where the company needs to decide which medicine will be developed and how it will be developed (Shah, 2004). Some of the main issues in this category are uncertainty in demand and capacity planning, which results in difficult and unreliable production plans. Furthermore, there is also a question of which drug in development will be successful, making it nearly impossible to plan the production, until you know the trial results. In terms of supply chain design, the issues originate mainly from the questions of how a company should design the supply chain network to be as effective and efficient as possible. The main dilemma here is based on what criteria a company should design the network. For instance, a company can decide to have a global supply chain network, often from the countries with lower taxes, but at the same time it needs to take into account that in such case, there are more potential logistics issues, compared to having supply chain more localized (Shah, 2004; Singh et al., 2016).

3.3.4 High priority issues in pharmaceutical supply chain management

The following Table 2 shows ten important and high priority issues for pharmaceutical supply chain management to deal with.

Table 2: High priority issues in pharmaceutical supply chain management

Issues in pharmaceutical supply chain	Definition
Lack of coordination	Fragmented supply chain system, which needs better coordination to achieve higher efficiencies
Inventory management	Due to uncertainty and lack of accurate information, companies don't know how big inventories should be
Demand information	Procurement departments have little or no demand information
Human resource dependency	High workloads combined with poorly trained personnel results in poor performance of the supply chain
Order management	Poor demand information and poor shipment visibility make it hard to know if healthcare providers are supplied properly
Shortage avoidance	Strategies such as frequent ordering, frequent replenishment and large buffer stocks should be implemented to avoid shortages of supply
Expiration	Due to unpredicted demand, higher inventory levels are needed, coming with a risk of medicine expiring
Warehouse management	Poor storage, low capacity and poor organization can lead to wrong order fulfillment and product expiry
Temperature control	Temperature inconsistency in storage or transportation can cause medicine to expire, resulting in financial losses
Shipment visibility	Lack of whereabouts of the shipment is causing delays in production and distribution

Source: Own work based on Privett & Gonsalvez (2014).

3.4 Pharmaceutical supply chain risk management

As we have seen in the previous section, pharmaceutical supply chains are facing numerous risks and challenges, and good pharmaceutical supply chain risk management is required to minimize the impact of those risks and to enable seamless production and delivery of medicines to patients. By implementing plans and strategies, risk managers can achieve better performance of the supply chain, and at the same time they can reduce supply chain vulnerabilities and uncertainties (Moktadir et al., 2018).

Supply chain risk management is receiving more attention, since it can also offer sustainable competitive advantage for the company. Furthermore, good risk management helps to reduce surprises in the future, it helps company to make better decisions and it creates a balance between threat and reward. For the risk managers the hardest thing is to first identify the risk, then to prioritize the risk according to the importance and finally, to put in place mitigation strategies (Enyinda et al., 2010).

Due to the complex structure of PSC, risk managers must overlook the whole supply chain, and not just one part of it. It needs to include the network of suppliers and buyers. This is of big importance, since modern pharmaceutical supply chains are highly fragmented. Hence, it is important to implement a way of identifying and understanding the risks in the whole pharmaceutical supply chain and adopting the strategy to effectively manage them (Breen, 2008).

4 CENTRAL EUROPE

The definition of Central Europe differs among different organizations and authors. According to definitions provided by Britannica Kids (n.d.) and Collinsdictionary (n.d.), the following countries are considered to be part of Central Europe: Germany, which is also the largest, Switzerland, Slovenia, Austria, Czech Republic, Hungary, Slovakia, Poland, and Liechtenstein, which is also the smallest country. For the purpose of this paper, we will use the aforementioned definition of Central Europe. In the following Figure 4, the highlighted countries represent the countries of Central Europe.

Figure 4: Map of countries in Central Europe

Source: Own work based on Britannica Kids (n.d).; Collinsdictionary (n.d.).

In Table 3 we can see some basic data of the countries in Central Europe.

Table 3: Data of Central European countries

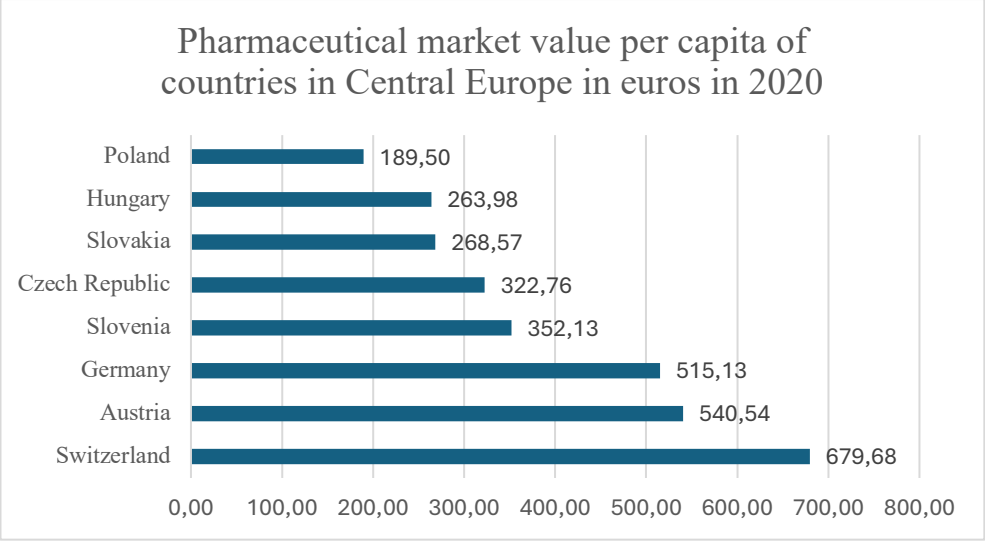
Country	Population (in millions of inhabitants)	Area in km2	GDP in million EUR	Currency	Member of EU
Germany	83.4	357 376	3,570,620	EUR	Yes
Austria	8.93	83 879	403,370.4	EUR	Yes
Slovenia	2.11	20 273	52,020.2	EUR	Yes
Czech Republic	10.5	78 868	238,714.2	CZK	Yes
Poland	38.2	312 679	570,206.6	PLN	Yes
Hungary	9.69	93 011	153.536.7	HUF	Yes
Slovakia	5.44	49 035	97,122.5	EUR	Yes
Liechtenstein	0.039,196	161	5,362.9	CHF	No
Switzerland	8.71	41 290	687,110.4	CHF	No

Source: Own work based on WorldData (2024).

4.1 Pharmaceutical industry in Central Europe

Figure 5 is showing the market value of pharmaceuticals per capita in each country from year 2020, where we can see that Switzerland comes on first place, with nearly 680 euros per capita, followed by Austria with 540 euros per capita and Germany with 515 euros per capita. Slovenia comes in fourth place, with 352 euros per capita, while Poland comes last with 189 euros per capita (EFPIA, 2022).

Figure 5: Pharmaceutical market value per capita of countries in Central Europe

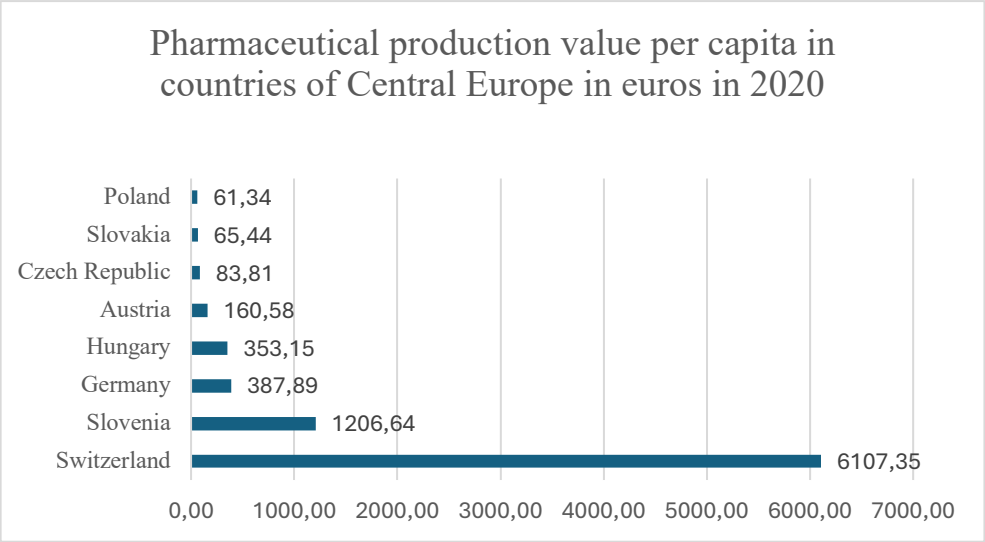


Source: Own work based on EFPIA (2022).

The discussed figure 5 includes pharmaceutical sales, which are calculated from the sales in each country through all distribution channels, such as pharmacies, doctors, hospitals, supermarkets, including prescription and non-prescription drugs (EFPIA, 2022).

In the following figure 6 we have the data for the value of production per capita in each country from Central Europe in year 2020. Production value is the value of ex-factory prices, which is the price when the product leaves the company and it includes all medicines produced in the country. It is clearly seen that Switzerland is one of the most important countries for pharmaceutical manufacturing, as it comes in first place, with production value per capita of 6107 euros, followed by Slovenia with value of 1206 euros per capita, while on third place comes Germany with a value of 387 euros per capita (EFPIA, 2022).

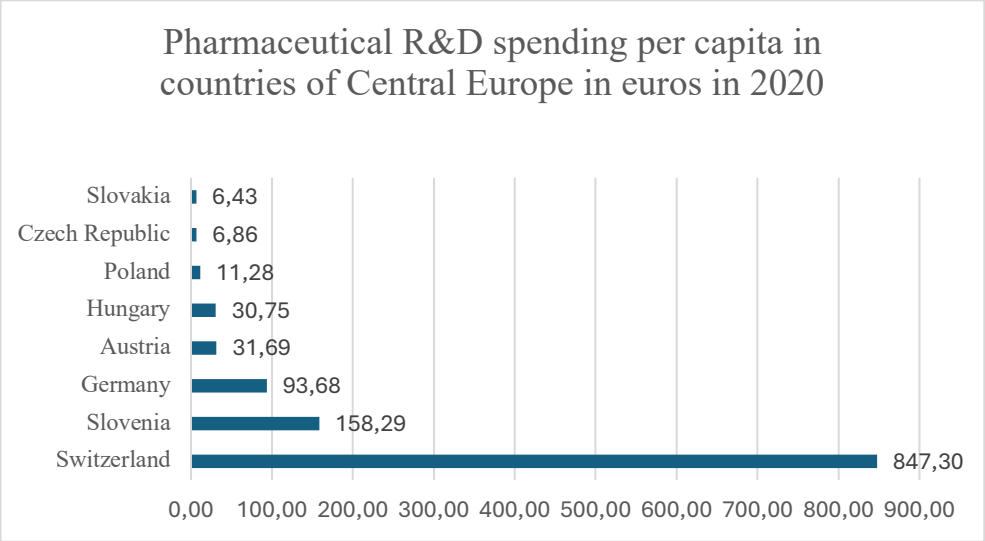
Figure 6: Pharmaceutical production value per capita in countries of Central Europe



Source: Own work based on EFPIA (2022).

Figure 7 is showing how much countries spent for pharmaceutical research and development per capita in year 2020. Again, Switzerland comes on top, with 847 euros per capita invested in R&D, followed by Slovenia with 158 euros. On third place is Germany, with 93 euros per capita, while Slovakia and Czech Republic come last, with just over 6 euros per capita. It is worth mentioning, that when looking at the absolute numbers, Germany comes on top, with over 7.8 billion euros invested, followed by Switzerland with 7.3 billion euros invested, while Slovenia invested 334 million euros (EFPIA, 2022).

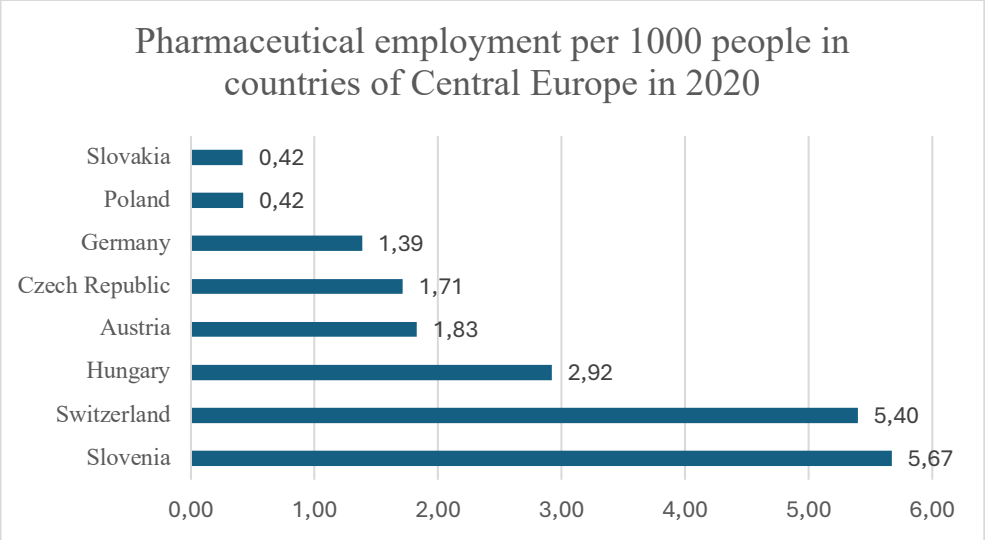
Figure 7: Pharmaceutical R&D spending per capita in countries of Central Europe



Source: Own work based on EFPIA (2022).

Figure 8 is showing the number of people employed per 1000 people by the pharmaceutical industry in each country in Central Europe in year 2020. We can see that Slovenia is the top employer, by employing 5,67 people for every 1000 people with Switzerland following closely with 5,4 people per 1000. Some studies have also shown that the pharmaceutical industry creates up to three times more employment indirectly than directly, along the whole upstream and downstream chain. It is also worth mentioning, that pharmaceutical industry is employing a large number of highly educated and skilled workers, which can help with reducing the brain drain from the countries (EFPIA, 2022).

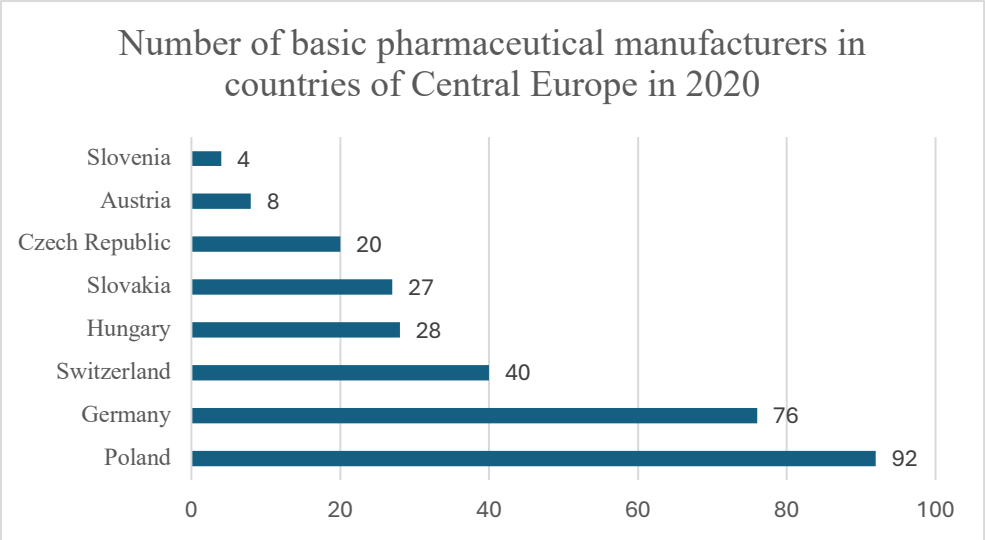
Figure 8: Pharmaceutical employment per 1000 people in countries of Central Europe



Source: Own work based on EFPIA (2022).

Figure 9 is showing number of companies in Central Europe, who are manufacturing basic pharmaceuticals. As we can see, Poland comes on top with 92 companies, followed by Germany with 76 and Switzerland with 40. In last place, there is Slovenia with 4 manufacturing companies (Eurostat, 2023).

Figure 9: Number of basic pharmaceutical manufacturers in Central Europe



Source: Own work based on Eurostat (2023).

4.2 Pharmaceutical industry in Slovenia

Slovenia is one of Central Europe's smallest countries, but it remains a major player in the pharmaceutical sector. Slovenia has two significant pharmaceutical companies: Lek and Krka. They both employ around 11000 people across multiple production sites in Slovenia. In 2022, Lek and Krka both made around 1.7 billion EUR in revenue, with Lek having a profit of 163 million EUR and Krka having a profit of 348 million EUR (GVIN, 2024a & GVIN, 2024b).

Over the last decade, total pharmaceutical sales on the Slovenian domestic market, depending on retail price, have steadily increased from 450 million EUR in 2012 to 679 million EUR in 2022 (OECD, 2024). In year 2021, Slovenia manufactured 3.4 billion EUR worth of pharmaceuticals, with the majority of products exported (EFPIA, 2023 & ITA, 2024).

Novartis AG sold Sandoz AG in 2023, resulting in Lek splitting into two separate entities, Sandoz Slovenia, and Novartis Slovenia. Along with Krka, Slovenia today has three major pharmaceutical businesses that compete in the market. The presence of two major foreign pharmaceutical companies demonstrates that Slovenia is very appealing for international investments, particularly in the pharmaceutical sector. This could be attributed to highly educated individuals who are leading specialists in their industry and lower wages in

Slovenia, compared to other countries from Central Europe. This allows companies to produce high quality products for lower cost. As Slovenia's pharmaceutical industry continues to grow, the demand for expertise in this sector is increasing. As a result, long-term solutions for obtaining the necessary labor are urgently required (Zavrtanik, 2024).

5 ANALYSIS OF PHARMACEUTICAL SUPPLY CHAINS DURING COVID-19 PANDEMIC IN CENTRAL EUROPE

In December 2019 first cases of an unknown disease were discovered in Wuhan, China. Soon after, the virus spread globally, leading to the declaration of a pandemic by WHO (Lotfi et al., 2020; Pan et al., 2020; Wu et al., 2020).

According to Worldometer (2024) on the 13th of April 2024, there were a total of 704.753.890 confirmed COVID-19 infections and 6.010.681 deaths related to the infection.

5.1 Response to the pandemic

As soon as the virus started to spread across different parts of the world, many countries imposed various measures and restrictions with a goal to stop the virus from spreading. Most countries, including countries from Central Europe, took severe actions, like declaring full lockdowns and imposing severe control measures, such as travel restrictions, travel bans, closings of schools, non-essential businesses and churches, prohibition of public gatherings, and order to people to stay at home. It is important to note that some countries chose to have less strict lockdowns, while some other countries chose much more strict lockdowns, where freedom was limited. Along with restrictions, different preventative actions were put in place, such as face masks, gloves, and frequent hand washing (Gianino et al., 2021).

One of the key questions was the incubation period of the virus, which is the main determinant of the length of the quarantine, which differed across countries (Ciotti et al., 2020).

It was on March 11th, 2020, when WHO declared an outbreak of COVID-19 as a worldwide pandemic (Cucinotta & Vanelli, 2020). A race for vaccine development began since the vaccine was one of the most promising ways to end the lockdowns and restrictions imposed by the countries (Haque & Pant, 2020).

World Health Organization has advised the global public to get vaccinated to get protection from the most severe symptoms of COVID-19. It is important to note that one can still get infected despite being vaccinated, but there is a much lower risk of having severe symptoms or even death in worst cases. Until the 8th of April 2022, WHO has approved ten vaccines, which met all the safety criteria. Those vaccines are AstraZeneca/Oxford vaccine, Johnson and Johnson, Moderna, Pfizer/BionTech, Sinopharm, Sinovac, COVAXIN, Covovax,

Nuvaxoid, and CanSino (WHO, n.d). As of the 26th of November 2023, there have been a total of 13.6 billion vaccine doses administered (WHO, 2023a).

Along with vaccination, WHO also provided some basic guidelines for the public to increase protection from the disease, such as having physical distance of at least one meter from other people, avoiding large crowds in closed spaces, wearing face masks, frequently washing hands with alcohol-based soap, covering mouth and nose when coughing and sneezing. Furthermore, instructions to self-isolate when people develop symptoms or test positive were also given (WHO, 2023b).

5.2 Socio-economic impacts of the COVID-19 pandemic

Inevitable strict governmental measures, which were imposed to limit the spread of the virus left a huge impact on social and economic aspects, with the healthcare system being the most affected. The following section provides an overview of impacts on different sectors.

Primary sector includes industries, which are responsible for the production or extraction of raw materials, such as agriculture, energy, metals, and mining (Nicola et al., 2020). Those industries were mainly impacted by very low demand, which pushed prices extremely low. In some cases, due to overproduction, companies had to even destroy the products (Delardas et al., 2022).

Secondary sector, which includes manufacturing industry, experienced a 20% decline in global output, caused by governmental measures to stop the pandemic. Most manufacturing companies were hit by supply chain disruptions, which caused delays in deliveries of raw materials and semi-finished products. Contrary to some industries which faced lower demand, the electronics industry faced high demand, resulting in production shortages (Delardas et al., 2022).

The retail industry within tertiary sector faced challenges with delivering goods to stores and keeping shelves full, mainly due to lockdowns and border closures. Additionally, they faced more pressure from the consumers, who were buying more products for having stock at home. Looking at fintech companies and e-commerce businesses we see that they had a great increase in demand from the beginning of the pandemic (Delardas et al., 2022).

Quaternary sector, which includes the educational sector, was severely disrupted, impacting the learning process of more than 1.5 billion students worldwide, who lost class engagement and motivation. In addition, many reported having different health issues, such as anxiety (Delardas et al., 2022). While online learning with interactive educational tools allowed some flexibility, it also put financial stress on schools and families to provide the necessary devices (Miyah et al., 2022).

With regards to psychological impacts, restrictions to stop the virus from spreading, such as lockdowns, disrupted social life of many people. This caused people to have more stress, anxiety, depression, and disorders. On top of that, many lost their jobs, putting even more stress on their mental health (Miyah et al., 2022).

Contrary to all negative effects, there were some positive side-effects. For instance, global environmental pollution decreased significantly, mainly because of lower energy consumption and reduced use of transportation. Additionally, greenhouse gas emissions were reduced, and air quality has increased (Miyah et al., 2022).

5.3 Effect of COVID-19 pandemic on pharmaceutical industry in Central Europe

5.3.1 Risks and disruptions of the COVID-19 pandemic

Once the virus of SARS-CoV-2 started to spread globally and governments started to impose various restrictions and measures to stop the virus, it immediately caused disruption along the pharmaceutical supply chain by having an impact on supply of active pharmaceutical ingredients, shipping, procurement, and delivering finished products to patients. On top of that, workers' migration and transportation activities were also hindered, causing additional delays along the supply chain (Sharma et al., 2020). At the time, the biggest risk for pharmaceutical companies was having delays in delivering urgent and essential pharmaceutical products to patients, which is one of the main objectives of pharmaceutical supply chains (Balfour, 2021).

5.3.2 Impact on pharmaceutical supply chains

At the start of the pandemic, pharmaceutical industry was impacted by two interesting phenomena's, which showcased high dependency of supply chain members in pharmaceutical industry. On one side, hospitals were facing a rapid increase of hospitalized patients, which resulted in high demand for pharmaceutical products. For instance, demand for generics skyrocketed, since they are widely used in hospitals for treating various diseases, including COVID-19. Additionally, home consumers and even governments were stockpiling different pharmaceutical products, putting more pressure on pharmaceutical manufacturers. As a response, pharmaceutical companies had to increase the production, which put pressure on their suppliers. On the other side, pharmaceutical companies faced poor supply of materials and ingredients, which are needed to produce the medicines. Disruptions in supply mainly originated from governmental lockdowns, travel bans, and production restrictions, due to social distancing. Supply was furthermore impacted by the closure of manufacturing sites of active pharmaceutical ingredients in China and India, which are two of the largest manufacturers in the world (Balfour, 2021; Spieske et al., 2022).

It is no secret, that Central European pharmaceutical companies are dependent on supplies from China and India. For instance, China is one of the largest global manufacturers of active pharmaceutical ingredients, which is the primary ingredient of pharmaceutical drugs. Furthermore, we also have India, which also exports API and is also dependent on China. Since China was the first country to impose lockdowns, this caused severe impacts on the supply of API. Reduced production in China pushed India to protect supplies for their domestic production, which further restricted the exports of API to Europe. As a result of all the above actions, Central European pharmaceutical companies faced lower supplies of active pharmaceutical ingredients, putting additional pressure on the production (Balfour, 2020).

Research conducted by Spieske and others (2022) confirms the aforementioned impacts on pharmaceutical supply chains. The authors found out that European manufacturers were highly affected by their suppliers, who were unable to fulfill the orders of various materials, personal protective equipment, and ingredients for pharmaceutical drugs. Some of the companies stated, that they were having temporary supply shortages, due to their suppliers being affected by local lockdowns, meaning they were not able to deliver the goods.

An interesting point of view was provided by the authors of the study "Impacts of the COVID-19 pandemic on EU industries", who state that shortages of pharmaceutical products and equipment were mainly caused by distribution issues, due to closed borders and travel restrictions. Along with stockpiling and supply chain issues, this led to shortages of supply in some of the European countries, especially in terms of protective equipment (De Vet et al., 2021).

5.3.3 Impact on pharmaceutical companies

Since the beginning of the pandemic, pharmaceutical industry professionals are worried about pharmaceutical supply chains and the disruptions caused by COVID-19, especially with regard to sourcing of active pharmaceutical ingredients and generics. As already mentioned before, China and India are leaders in the market of APIs, with around 60% of total API production in the world. Due to restrictions, production capacities in China and India were limited, increasing the risk of having shortages in supply in Germany and other Central European countries (GTAI, n.d.).

It is worth mentioning, that in the peaks of the pandemic, major pharmaceutical companies from Central Europe were able to fulfill the demand for urgent medicines, which were needed for treating COVID-19 patients. For instance, Amit Nastik, who has one of the leadership roles at Novartis stated that they were able to push through the pandemic with relatively low supply chain disruptions (Grom, 2022).

Sandoz, which was a division of Novartis for generic pharmaceuticals experienced similar challenges as other companies. At the start of the pandemic, they had a rapid increase in

demand from hospitals, governments, and home patients. Over the year 2020, demand stabilized and due to many measures even decreased for some pharmaceutical products. According to the CEO of Sandoz, Richard Saynor, Sandoz was more or less able to fulfill the demand, mainly because of well-functioning and robust supply chains in Slovenia and other European countries (Zalar, 2021).

Furthermore, Bayer, who is a German pharmaceutical giant also noted that they were able to provide their medicines without any major interruptions during the first COVID-19 wave. They believed that the industry reacted quite well (Access Accelerated, 2020).

In contrast to others, some companies were hit harder by the pandemic. For example, Swiss company Roche, which is one of the largest pharmaceutical companies in the world faced severe shortages of supply of their drugs back in 2021. Their drug Actemra/RoActemra, which was used to treat patients with critical or severe symptoms of COVID-19 experienced unimaginable demand, in some regions well above 400% of before COVID levels. Company officials explained that due to too high demand and limited worldwide production capacities of raw materials, they were not able to cope with the demand (Healthcare Purchasing News, 2021).

Companies, who are manufacturing pharmaceutical equipment, such as CT scanners, blood gas systems, diagnostic devices, ventilators, and various test kits faced challenges mostly on the supply side. Some companies reported that their suppliers were not able to fulfill the demand for various materials and components, which are needed for medical devices. Furthermore, they stated that suppliers lacked financial stability, which prevented the supplier from increasing the production capacities. In some cases, suppliers were also providing incorrect capacity data, causing issues along the supply chain. Moreover, pharmaceutical equipment manufacturers often had to pay higher prices, due to lack of alternative supply, showcasing high dependency on their primary suppliers. On top of poor supplier capacities, additional delays were caused by logistic services, which capacities were highly restricted, due to border closures. In addition, number of passenger and cargo flights was reduced, which allowed logistics service providers to increase the price of the service. Furthermore, due to lower levels of supply, pharmaceutical equipment manufacturers faced severe competition. For instance, manufacturers were competing for materials and parts needed for assembling medical devices. Also, they had to compete with global authorities, who had public tenders for CT scanners, ventilators, personal protective equipment, and test kits (Spieske et al., 2022).

5.3.4 Impact on hospitals

Hospitals and patients, who are at the end of the supply chain, faced numerous challenges with supplies of products related to COVID-19. Firstly, manufacturers and suppliers of ventilators, personal protective equipment (PPE), test kits, and other products, were not able to match the demand. Secondly, suppliers increased prices for the products, despite

previously negotiated contract terms. And thirdly, suppliers shared incorrect delivery data. These challenges pushed hospital procurement departments to find new supply solutions. Similarly as manufacturers, hospitals too faced competition with purchasing PPE, disinfectants, and ventilators. Moreover, they had to face global authorities, who were stockpiling COVID-19-related products (Spieske et al., 2022).

5.3.5 Supply shortages of medicines

According to comments from big pharmaceutical players from Central Europe, they were able to provide a supply of urgent medicines for treating patients, despite the pandemic. But still, there are reports from different countries, highlighting the supply shortages of various medicines. In the section below I take a look at those reports and try to find the cause of the shortages.

For example, German pharmacies are facing shortages of different medicines. Many pharmacies are experiencing a high demand for drugs to deal with fever and pain, caused by COVID-19. As a result, pharmaceutical companies face high demand. On top of that, German news media reported issues with supply chains and deliveries to German pharmacies. This triggered panic-buying from the general public, who stockpiled medicines and caused additional pressure on the supply chain (Kinkartz, 2022). In recent months there is also higher demand for children's medicine, such as antibiotics, diabetes drugs, cough syrup, and painkillers. A pharmacist from Berlin stated that they have around 300 medicines, which are currently unavailable (Ahmed, 2022).

Switzerland is dealing with similar challenges as Germany with supply shortages of medicines, like fever-reducing syrups, cancer drugs, and various vaccines (FOPH, n.d.; Reuters, 2022).

As further research showed, Germany and Switzerland are not the only countries affected by the supply shortages. Since the end of 2022, Central European countries along with other parts of Europe, have faced severe supply shortages of medicines, especially antibiotics, cough syrup, ibuprofen, penicillin, and cholesterol medicines (Martuscelli, 2023; Hungary Today, 2022; Smith, 2022; JAZMP, 2023).

5.3.6 Reasons for supply shortages of medicines

As manufacturers experience high demand, their response is dependent on three main segments. First is the size of the supply of raw materials and active pharmaceutical ingredients. Second is the production capacity and third is the logistics capacity and reliability of distribution channels. As we already know, restrictions and lockdowns put in place worldwide severely hindered the operations of pharmaceutical companies.

Additionally, there was a shift of focus in production, from general, not COVID-19-related medicines to COVID-19-related medicines, such as vaccines (JAZMP, 2023).

According to industry professionals, shortages are due to a poor supply of raw materials and a lack of skilled workers in pharmaceutical companies, who are unable to make on-time deliveries (Kinkartz, 2022). Based on the comments from the German Federal Institute for Drugs and Medical Devices, the reason for supply shortages is high dependency on countries like China and India, which produce around 80% of generic pharmaceuticals for Germany. Restrictions and lockdowns in China and India are the cause for the delays in deliveries and as a consequence, supply shortages of medicine (Ahmed, 2022).

A similar opinion was shared by Swiss officials, who stated that such bottlenecks and delivery delays are mostly due to disrupted supply chains, originating from China. Furthermore, they are stating that additional vulnerability comes from the fact that there are few centralized production sites, on which a lot of countries are dependent. Along with unpredictable demand and lean inventory management of supply chain partners, this leads to the shortages of supply for patients (FOPH, n.d.; Reuters, 2022).

Essentially, on one side there is reduced supply due to aforementioned reasons, and on the other side, there is surprisingly increased demand due to seasonal infections, which could be caused by a weaker immune system. Countries are seeing a rapid increase in patients with respiratory diseases, which were less present during the peaks of the pandemic, because of the restrictions. As a response, pharmaceutical companies reduced production for such medicines and shifted focus to COVID-19-related medicines. Unfortunately, now, due to the rapid and surprising increase in demand, pharmaceutical companies were caught unprepared with low levels of stock (Martuscelli, 2023; Peseckyte, 2023).

5.4 Response of pharmaceutical industry to COVID-19 pandemic in Central Europe

As we've seen in one of the previous chapters, most pharmaceutical companies from Central Europe were able to provide and support patients with medicines needed for treating COVID-19. The following section provides details on how companies reacted to the pandemic.

Sandoz, who is one of the largest generic pharmaceutical companies, was able to deal with worldwide health crises and supply chain challenges without any major shortages of supply. They immediately saw and recognized a rapid surge in demand for their products. Thanks to their proactive approach, they soon increased inventory levels of their antibiotics and respiratory medicines, which were potential drugs for treating novel coronavirus. As a response to an increase in demand, Sandoz increased production capacities in all of their production facilities, which was possible due to hard-working employees and their willingness to work and collaborate in new innovative ways. On top of that, in February

2020, Sandoz ensured that their prices for medicines to deal with COVID-19 would remain stable (Sandoz, 2020).

Another pharmaceutical giant, Novartis, who is based in Basel from Switzerland was also able to follow their goal of delivering medicines to their patients on time without major disruptions, despite all the challenges along the supply chain imposed by the pandemic. Soon after the pandemic was declared, they established task force team with around 50 employees from different functions, to deal with supply chain challenges. This allowed other employees to remain focused on their primary job assignments. The task force was acting proactively, tracking information in real-time and reacting as quickly as possible to bring medicine to patients. A key activity of the task force team was to examine the supply of various products, dependencies internally and externally, and risk management. Moreover, they have immediately built visibility in their supply chain and operational activities, which allowed Novartis to have nearly 100% supply reliability in the last three years. Additionally, in critical moments they were decisive, meaning that if the company needed certain products, they placed the order as soon as possible, no matter what (Grom, 2022; Lang, 2020).

Novartis has also put its employees first since they were working in hard conditions. The workforce, which was not essential to be present on site was instructed to work remotely from home. For those who were present at locations, safety measures were undertaken, such as avoiding interaction between shifts and, use of surgical masks and other personal protective equipment. The safety and well-being of employees were Novartis's top priority and thanks to their safety measures and highly committed employees, not one of Novartis's sites was closed during these difficult times (Grom, 2022; Lang, 2020).

Based on the comments from Steffen Lang from Novartis, two crucial strategies were needed for success. First, was having multiple sources of supply, second, higher inventory levels across different countries. This allowed for the company to be more agile and flexible with decision-making (Blankenship, 2020).

Furthermore, Novartis built an integrated system to control the five steps of the value chain, which are planning, sourcing of the materials, making the medicine, using quality control, and delivering the products to patients. Their integrated system with the help of artificial intelligence (AI) allowed them to make fast and accurate decisions. Still, there are some areas from which company can learn from the pandemic. For instance, the workforce cannot be taken for granted, hence the need for additional automation of production. Also, suppliers need to have integrated systems to have better transparency and visibility of the status of orders and products in the firm's system (Grom, 2022).

Similar to others, also Bayer, a pharmaceutical giant from Germany put great effort into protecting the health of its employees. As soon as the pandemic hit, they immediately implemented safety measures such as working from home, flexible schedules, plastic barriers, and increased sanitizing and cleaning. Along that, they also put in place daily

communications to all employees, so that everyone was aware of any changes. Production and supply chain departments created a priority list of the products, which needed to be available at all times. Furthermore, workloads tremendously increased for everyone, hence health of employees was crucial for the company since they were the ones who pushed through this hard period (Bayer, n.d.).

When the pandemic hit, executives at pharmaceutical company Roche instantly knew that supply chains would be disrupted. As a response, they created a small team of talented experts from various parts of the organization, who were responsible for making important decisions with regard to strategy. To shorten the deliveries of raw materials, Roche expanded its network of global suppliers, which allowed for shorter lead times. Additionally, they made the whole supply chain work more closely, in a more collaborative way to create transparency among the members of the chain (Buss, n.d.).

Based on the above research we can find some common approaches by the companies. For instance, employee safety was one of the top priorities. With measures such as working from home, frequent sanitizing, and use of protective equipment, companies prevented any major disruption within the work process. Furthermore, companies largely increased production capacities to cope with the spike in demand. By appointing experts to special teams, they allowed them to be fully focused when it came to making strategic decisions, especially related to supply chains. And lastly, integration and collaboration of the supply chain was crucial for the companies to deliver the products.

5.5 Case of Slovenia

Looking at the impact of supply chain disruptions in pharmaceutical industry in Slovenia, we see that the major pharmaceutical businesses were able to provide medicines during the pandemic. This was confirmed by the CEO of Lek d.d. and president of Novartis in Slovenia, Robert Ljoljo, who stated that initially company experienced very high demand, which has eventually stabilized. He furthermore commented that thanks to their robust supply chain, their production of medicines was not stopped for even one day (Fazarinc, 2021).

Another pharmaceutical giant from Slovenia, Krka d.d., which is one of the leading manufacturers of generic pharmaceuticals, also shared that they didn’t face any major disruptions. Their production sites were functioning successfully thanks to the large size of their own supply of raw materials (Krka, n.d.).

Additionally, the director of Zavod za zdravstveno zavarovanje Slovenije, Marjan Sušelj, confirmed that patients in Slovenia during the peaks of the pandemic had uninterrupted access to medicines (Farma Forum, n.d.).

However, there have been some complaints of pharmaceutical shortages in Slovenian pharmacies. According to the Agency for Medicinal Products and Medical Devices of the

Republic of Slovenia (JAZMP), around 300 different medicines are now unavailable due to shortages of supply in Slovenia. Low availability is having an impact on drugs including Claritine, Ospen, Retafer, and Brufen. Furthermore, they noted that other European countries are dealing with comparable difficulties as Slovenia. Additionally, JAZMP raised the issue of Slovenia's small market, which is unappealing to large pharmaceutical companies. This means that Slovenia must collaborate with other countries to obtain the necessary quantities of certain medicines (Cerar, 2023; Delo, 2023).

6 METHODOLOGY

6.1 Purpose and objectives of qualitative research

The purpose of my master's thesis is to understand the relationship between the COVID-19 pandemic and supply chains in the pharmaceutical industry in the region of Central Europe in general, and in particular, in the case of Slovenia. I want to examine whether pharmaceutical companies experienced any disruptions caused by the pandemic and how the industry reacted to the world health crisis. Additionally, I would like to research the state of medicine supply during and after the pandemic of COVID-19. Therefore, my research aims to provide pharmaceutical companies with the knowledge and information on navigating through uncertain events, such as the pandemic, to fulfill the goal of supplying medicine to patients.

6.2 Research method

The thesis is written using both, primary and secondary data sources. Secondary data is data that has already been collected for some other purpose. It consists of raw data, compiled data, and big data, which can be further analyzed to provide answers to research questions (Saunders et al., 2016). The main advantage of using secondary data is timesaving when doing the research. Furthermore, data can be used for longitudinal studies and can help to better understand primary data. On the other hand, secondary data can be misinterpreted when analyzed or outdated, hence not useful for the research (Bregar et al., 2005).

For the collection of secondary data, I used different sources, including a) scientific sources, such as scientific journals and books; b) popular sources, such as news reports from professional agencies; and c) official sources, like government reports and official statistics from statistical institutes. With the review of secondary sources, I managed to build a theoretical foundation and get an overview of the research problem my thesis is addressing.

The empirical part of the thesis is based on qualitative research, where the researcher needs to make a connection between respondents' subjective meanings to the phenomenon studied by the researcher. With various qualitative methods, such as interviews, researchers can develop conceptual and theoretical frameworks. Usually, a non-probability sampling

technique is used, followed by non-standardized data collection, meaning that questions can differ during the research process. Social interaction plays a big role in qualitative research, hence data collected is often more varied and complex, than quantitative data. Gathered data is non-numeric, mostly in the form of words or images, which need to be analyzed through conceptualization (Saunders et al., 2016).

For the collection of primary data, a non-standardized, semi-structured interview will be used. Such method allows for a more flexible approach to the research. The researcher usually follows certain themes or a list of questions, which can be changed during the conversation. Furthermore, with the semi-structured interview, you can have a larger number of questions, which are usually open-ended. Such questions provide deeper and more meaningful answers from the respondents. Since there is no standardization in semi-structured interviews, there is a question of the reliability of the data collected, which can be related to interviewer, response, or participation biases. Using a semi-structured interview research method also triggers the issue of generalizability, mainly because such studies use smaller samples (Saunders et al., 2016).

In my thesis, I use secondary data to gain a better understanding of the pandemic's impact on the operation of pharmaceutical industry in Central Europe. Furthermore, this provided me with an insight of how organizations responded to supply chain disruptions. In addition, I acquired information about supply shortages of medicine in Central Europe. Following the secondary data search, I focused on a case study with Slovenian pharmacies, by conducting interviews to gather information about the current state of pharmaceutical market in Slovenia.

6.3 Collecting data

For the interviews, I have made a list of pre-prepared questions, which were divided into four themes. The first group of questions focused on the state of medicine supply on the market. Here, my goal was to find out whether respondents face any shortages of medicine. Additionally, I was also interested in the comparison of supply before and during the pandemic of COVID-19. In the second group of questions, I wanted to learn about the response and mitigation strategies, in case there is a supply shortage of medicine. The third group of questions was asking about the impacts of medicine shortages on patients and their treatments. Finally, the last group of questions addressed the possible reasons for shortages and solutions for the future. In total, there were 14 main questions with few sub-questions, which were designed to provide insightful answers for my research. The goal of the interview was to gather as much detailed and meaningful information, hence I used mostly open-ended and probing questions.

Before I proceeded with interviewing, I passed the interview questions among two interviewees. The purpose of this was to make sure that questions were clear and understandable. Upon their confirmation, I proceeded with conducting the research.

Respondents were selected using the purposive sampling method, with which I was able to find the most suitable interviewees from the pharmaceutical sector, who were able to provide me with first-hand experience. In total, I conducted four interviews, with four different pharmacies in Slovenia, who wanted to remain anonymous.

All interviews were conducted in person in March 2024 at the pre-arranged time and location. I have tried to make a comfortable and pleasant environment for the respondents, where they could share their experiences. Before the interview, I presented myself, along with the goals and purpose of the research I am doing. Respondents were provided with a consent form, where they were informed that the interview would be recorded for transcriptive purpose. Furthermore, I informed them that I will adhere to GDPR policies and all ethical and other standards for doing field research and ensure that all collected data will be used in my research anonymously.

After I finished with the interviews, I proceeded with transcription. Then, the next step was an analysis of the data, for which I used the thematic analysis. A method, which is often used to analyze qualitative data.

6.4 Sample description

As mentioned above, respondents were selected using a purposive sampling method, which allowed me to be more flexible when searching for interviewees. First, I tried to approach 9 pharmacies via e-mail communication, where I tried to establish contact. Unfortunately, none of the pharmacies responded, hence I had to go to each pharmacy in person and ask them whether they would be willing to participate in my research. I visited 7 different pharmacies, out of which 4 agreed to be interviewed and are shown in the Table 4, which also presents the list of respondents and the duration of interviews.

Table 4: List of respondents

Respondent	**Pharmacy**	**Position**	**Duration**
Pharmacist A	Pharmacy A	Pharmacist	00:18:20
Pharmacist B	Pharmacy B	Pharmacist	00:21:10
Pharmacist C	Pharmacy C	Pharmacist	00:23:40
Pharmacist D	Pharmacy D	Pharmacist	00:14:50

Source: Own work

When searching for potential pharmacies, I was looking for pharmacies with different characteristics and environments. For instance, Pharmacy A is a privately owned pharmacy with a concession, located in the suburb of a larger city in Slovenia. Pharmacy B is the largest pharmacy within the group of pharmacies, which was established by multiple municipalities. Pharmacy C is a pharmacy located inside the shopping center, with a high frequency of people. And lastly, pharmacy D is a small, privately owned pharmacy in a smaller city in

Slovenia. All of the above pharmacies are separated in terms of ownership, so they all operate on their own. Such an approach allowed me to have a wider view and understanding of how different pharmacies are experiencing the current pharmaceutical market and how they operate.

Questions for all of the respondents were mostly the same, with some differences in the sub-questions. The duration of the interviews varied, with the shortest interview being 14 minutes and 50 seconds, while the longest interview being 23 minutes and 40 seconds.

7 ANALYSIS OF THE RESULTS

The analysis of the interviews is divided into four parts, where each part discusses a separate theme of the interview.

7.1 Supply shortages of medicine

Based on the conducted interviews, I can assume that pharmacies and patients are experiencing the issue of supply shortages of medicine. All interviewed pharmacies confirmed that they were and still are dealing with shortages of certain medicines. I received similar responses from all four pharmacies. Pharmacy A stated that this is not a novel issue for the pharmaceutical industry. It is an ongoing challenge for the last 10 or more years. A similar thought was shared by pharmacy B, who added that the issue is getting more and more problematic in recent years, especially now after the pandemic. Pharmacy C said: "Recently, we can witness more and more medicine, which is not available. Including medicine, which a few years back, was always available". Smaller pharmacy D is experiencing shortages in waves, sometimes a bit more, sometimes a bit less.

Not only that some medicines are completely not available, but pharmacies are also facing issues with delayed deliveries of medicine. For instance, Pharmacy B said that even for medicines, that are in stock, the delivery times are longer than usual. This shows us that transportation could also be a factor for shortages.

As for the number of unavailable medicines, pharmacies shared different views, mainly because they do not keep the exact record list. Therefore, they answered this question based on their experience. Pharmacy D stated: "We are a small pharmacy, and we might have a specific type or group of customers, so in our experience, I would say that around 2-3% of the medicine we have on offer is being affected by the shortages". Pharmacies A and C were more specific. Pharmacy A claims that daily, they face roughly 2 patients, who require a certain medicine, which is not in stock. Similarly, Pharmacy C described that every week, there are around 10 to 15 cases when medicine is not available. While pharmacy B didn't know the exact number of cases or medicines they are missing, they mentioned that general information is around 250-300 medicines being affected by the shortages.

When it comes to the question of which group of medicine is facing shortages of supply the most, the answers from the pharmacies were very similar. In Table 5, I present the groups, which were identified by the pharmacies.

Table 5: Groups of medicine affected by the shortages

Pharmacy A	**Pharmacy B**	**Pharmacy C**	**Pharmacy D**
-Antibiotics for adults and children -Drugs for treating cardiovascular diseases -Drugs for treating diabetes -Anti-viral drugs	-Antibiotics for adults and children -Drugs for treating diabetes -Drugs for lowering blood pressure -Drugs for treating anemia	-Antibiotics for adults and children -Drugs for treating diabetes -Enzymes -Anti-viral drugs	-Antibiotics for adults and children -Biological drugs -Drugs for lowering body temperature -Drugs for treating diabetes

Source: Own work

We can clearly see some commonality among the answers. All four pharmacies pointed out that antibiotics for adults and children are facing big issues with supply. Pharmacy B highlighted that antibiotics are more often unavailable compared to other groups, especially during winter time. This finding is similar to reports from pharmacies in Germany, Austria, and Slovakia, where they as well have severe shortages of antibiotics (Ahmed, 2022; Martuscelli, 2023; Hungary Today, 2022). Pharmacy D expressed that in their view, the more expensive drugs, such as biological drugs are being affected as well. Furthermore, Pharmacy D mentioned that by their experience, the situation with antibiotics is getting slowly better.

An interesting topic was brought up by Pharmacies A, C, and D, concerning a specific drug, called Ozempic. This medicine is primarily used for treating diabetes. But recently, it has been used as a medicine, which helps a person to lose weight. As a consequence, demand for Ozempic increased, resulting in shortages, and leaving diabetic patients without the needed medicine. Same issues are present also in other Central European countries, for instance, Germany will not have Ozempic available before Q3 of 2024. Hence, German doctors are urged to prescribe Ozempic only for diabetic patients, and use other alternatives for weight loss (Burger, 2024).

Another recent case was mentioned by Pharmacy C, who said that there is a worldwide shortage of enzymes to help with digestion problems, saying: “Enzymes are completely out of stock, and you simply cannot get them”. This is in line with report from European medicines agency, who reported that several European countries are facing shortages of enzymes called Creon. Reasons for this are supposed to be production limitations, which should be resolved in second half of 2026 (EMA, 2024).

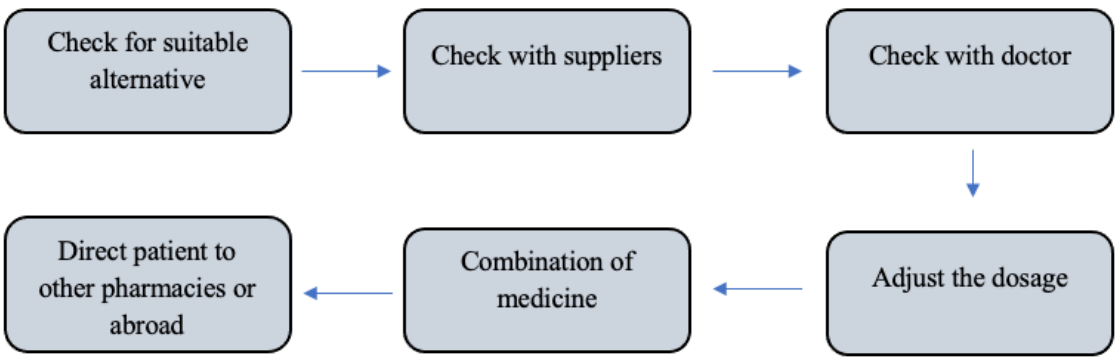
When comparing medicine supplies before, during, and after the COVID-19 pandemic, answers from all four pharmacies were straightforward. All respondents stated that supply shortages after the pandemic increased significantly. During the pandemic, they saw a reasonable increase in demand for all medicines, which is not unusual in a health crisis. Back then, the pressure was primarily on medicines used for treating COVID-19 symptoms. But the real picture is being shown now, after the pandemic. According to the comment from Pharmacy A: "I would reckon that supply shortages are now about 3-5 times larger than before the pandemic, but still manageable".

7.2 Pharmacies and their response to shortages of medicine

The second group of questions was focusing on how pharmacies respond, in case there is a shortage of medicine. In the figures that follow, we can see how each individual pharmacy approaches to supply shortages.

First, we will look at the response of Pharmacy A (see Figure 10), who stated that they don't have any protocol implemented, which would tell them what to do exactly. Instead, they follow certain steps, like "unwritten rules", to help them guarantee the medicine for patients. In the first step, Pharmacy A checks whether they can provide a substitute drug, which is made from the same active pharmaceutical ingredients, usually manufactured by a different manufacturer under a different brand. Pharmacy A said: "In most cases, we can find a solution to the shortage by providing a substitute to the patient, which has the same therapeutic effects as the initially required one".

Figure 10: Response map of Pharmacy A



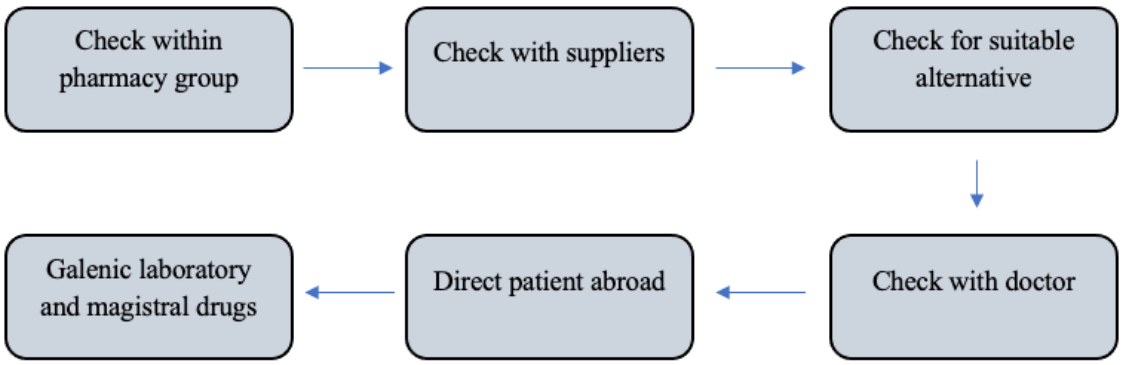
Source: Own work

In the next step, Pharmacy A checks the availability of medicine directly with the suppliers to see when the medicine can be delivered. If the medicine is still not available, then pharmacists contact the doctor to discuss possible alternative treatments, with completely different ingredients. The fourth step is then trying to adjust the dosage. For instance, they split the pills to provide medicine for longer periods. In some cases, Pharmacy A also tries

to combine different medicines. This means they provide patients with two different medicines, whose ingredients can be found in the unavailable medicine. Lastly, if there is still no solution to be found within Pharmacy A, they direct patients to other pharmacies or pharmacies in Italy. In the end, all this requires additional input from the pharmacists, who said: "Unfortunately for us, this means that we need to spend additional time and effort, to find the available medicine for patients".

The next Figure 11 is showing us the response of Pharmacy B, which is part of a larger pharmacy group. Their first action is to check with other pharmacies within the group if any of them have the medicine available. In such cases, they have the medicine delivered with their in-house logistics. In the next step, pharmacists contact suppliers directly and seek information about the availability of the product. Usually, they contact several different suppliers and check all possible alternatives. In the third step, Pharmacy B tries to provide substitute medicine, usually by a different brand. According to Pharmacy B, they can provide substitution only if the substitute is made from the same active pharmaceutical ingredients. In all other cases, they need to consult with a doctor, who can prescribe a different therapy. If the medicine still cannot be found, Pharmacy B directs patients to other pharmacies or pharmacies in Italy: "We often direct patients to Italy, and the same applies for Italian pharmacists. They direct their patients to pharmacies in Slovenia".

Figure 11: Response map of Pharmacy B



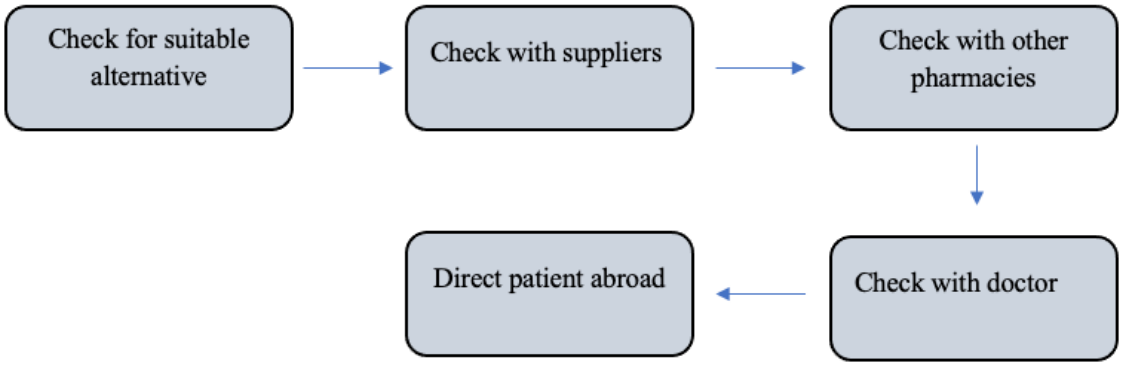
Source: Own work

Since Pharmacy B is a larger pharmacy, they have the option to use magistral medicines, which are made by the pharmacists. Such medicines are made only for specific patients, in most cases for children. Furthermore, Pharmacy B also explained the use of galenic laboratories as a possible solution: "Luckily, we also have a galenic laboratory, where we can produce medicines in smaller quantities because they are not interesting for the big pharmaceutical companies". This allows pharmacy to produce different herbal teas and syrups, mostly made from plants.

The next Figure 12 shows the response from Pharmacy C, who stated: "We are always looking for alternatives, meaning we first try to find an equivalent substitute from a different

supplier, under a different brand". In the next step, they contact various suppliers to get information on when the medicine is going to be available. If there is no data about availability, Pharmacy C contacts neighboring pharmacies, to check whether they have medicine in stock. In case there is still no medicine available for a patient, pharmacists check with a doctor, who can prescribe a different medicine, usually made from different active pharmaceutical ingredients. As a last possible solution, Pharmacy C also directs patients to pharmacies in Italy, where patients need to pay for the medicine.

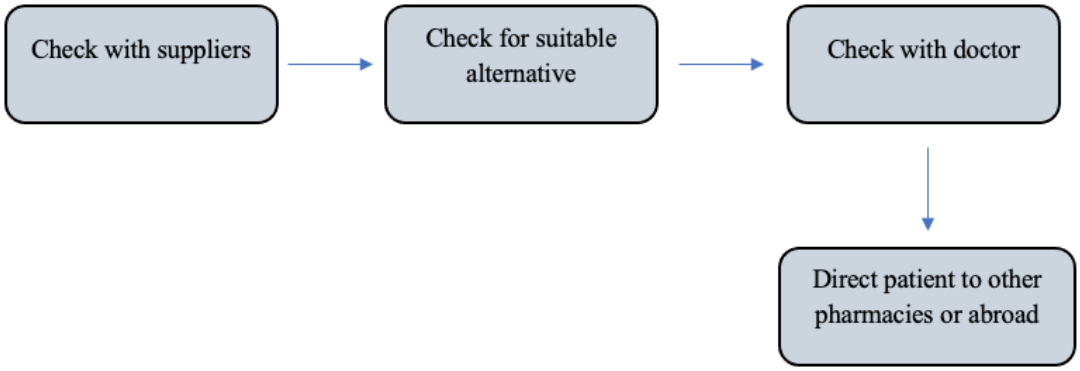
Figure 12: Response map of Pharmacy C



Source: Own work

As it can be seen from the Figure 13, Pharmacy D has a similar approach when it comes to shortages of medicine. First, they get in touch with suppliers, where they check when the medicine can be delivered. In some cases, the medicine may be available with the supplier and will be delivered in the next few days. If the medicine is not available, Pharmacy D tries to find substitute medicine with the same active ingredients. The next step is then to discuss with the doctor for any other possible alternative treatments. In the last step, Pharmacy D redirects patients either to other pharmacies or to pharmacies in Italy.

Figure 13: Response map of Pharmacy D



Source: Own work

None of the four pharmacies have a list of urgent medicines, which need to be always in stock. Hence, they keep inventory based on historical data of demand. Pharmacy D mentioned: “We don’t have a list, but we always keep certain levels of inventory, which should suffice for some time. At least for those drugs, which are usually needed more often”.

When it comes to the question if the pharmacies are notified about the supply shortage, we see very similar answers from all four respondents. All four pharmacies get information about the shortage of medicine only at the time they want to place an order in the system unless they are notified by the supplier in advance. By the experience of pharmacies, suppliers in most cases don’t notify them about future shortages, leaving them with little to no information. Of course, there are some occasions where suppliers notify the pharmacy. In such cases, Pharmacy C highlights: “If we get information about the future shortage, we always try to make larger stock, to have the medicine available for a longer period”. Pharmacy C also emphasizes that they are constantly checking the system because the availability of the medicine is changing daily. Interestingly, pharmacies do get notifications from the suppliers when the medicine will be available again, which helps pharmacies plan future orders.

In terms of IT systems, which connect supplier databases and pharmacies, I received similar responses. Pharmacy A said that each supplier has a different system, which is showing availability of the medicine. Some systems, also provide information about the quantity available. Pharmacy A stressed that information about quantity is very important because in some cases there are only a few packs of medicine available, which then needs to be prioritized among the patients who need it the most. Since Pharmacy B is part of a larger group, besides the supplier system, they also have an internal group database, where they see stock from other in-group pharmacies. Pharmacy C and D stated that they also have systems with suppliers, but not all suppliers have such options, especially smaller suppliers. Overall, pharmacies perceive systems as very useful, but they still need to make many telephone calls to get the most up-to-date information about the stock.

7.3 Effect of medicine shortages on patients

In the third group of questions, respondents were asked about the potential issues for patients, caused by supply shortages of medicine. In general, all four pharmacies stated that there are some issues for patients, but none of the issues is critical. For now, the situation is still manageable, and a solution can always be found for the patient.

Pharmacy A pointed out that there are no major issues for patients, in terms of getting the right medication. However, they noticed that the extra time and effort needed from the patient is definitely not welcomed, especially when the patient needs to drive to other pharmacies to get the medicine. Another aspect brought up by Pharmacy A was concerning the patient’s routine. They are normally used to a certain brand and in case the patient is

offered a substitute, they often express doubts, about whether different brands will have the same effect.

A respondent from Pharmacy B shared a similar opinion, stating that currently, they are able to manage the shortages without any major impacts on patients. According to them, in most cases, the issue is resolved by providing substitution medicine. Furthermore, they explained, that in some non-critical cases, patients need to wait for the medicine for a few days, meaning there is a slight delay with the treatment, but nothing serious. Pharmacy B highlighted the importance of cooperation between pharmacists and patients: "As long as all involved parties cooperate calmly and patiently, the patient will understand the shortage, because, at the end of the day, we always provide the solution".

Looking at Pharmacy C, they said: "For now, luckily, we can always find a solution. Of course, there are some issues or inconveniences for patients, but the worst-case scenario is that they need to wait for a day or a week, to get the medicine". They also stressed that a lot of patients come to the pharmacy to get new medicine before they run out of stock at home. This usually means that even if they have to wait for a few days, they still have enough medicine at home. Pharmacy C emphasized, that there is more time and effort needed from the patients because sometimes they need to visit different pharmacies to get the needed medicine. Furthermore, Pharmacy C perceives that some patients don't understand that there are shortages, and they might not accept a different brand, that was offered as a substitute. This shows that patients are used to a routine, and if they don't get the same brand, they might get doubts. However, it is true that some substitutes have the same active pharmaceutical ingredients, but could also have some additional ingredients, whose effect on the patient might be different and unknown.

According to experiences from Pharmacy D, they said that all issues are manageable for now, mainly by providing substitute medicine to patients or directing patients to other pharmacies. In the end, all this means that there is extra time and effort needed from both, the pharmacist and patient, but what matters the most is, that the patient gets the medicine.

In conclusion, all four pharmacies agreed that there are no risks to health or even the life of patients because solutions can be provided. Pharmacies also stated that in most cases, they are able to provide the solution with substitute medicines.

7.4 Reasons for shortages of supply

In Table 6, I summarize the identified reasons for shortages, according to the opinion of pharmacies. All four pharmacies pointed out that the two main reasons are connected with active pharmaceutical ingredients, which are located at the beginning of the whole pharmaceutical supply chain. Pharmacies mentioned that there are huge shortages of API, hence pharmaceutical companies cannot produce the medicine in needed quantity. On top of that, API are mostly being manufactured in China and India, leaving companies highly

dependent on the two countries. Pharmacies A and D highlighted also the small market size of Slovenia as the reason for shortages. It could be that the market is too small and not interesting for the big pharmaceutical companies because at the end companies are still looking from a financial perspective. Lastly, Pharmacy D identified the reason of the unexpected high demand, that causes supply shortages.

Table 6: Reasons for shortages of supply

Reasons	**Identified by**
Shortages of active pharmaceutical ingredients	Pharmacy A, B, C, D
Production of active pharmaceutical ingredients is located in China and India	Pharmacy A, B, C, D
Slovenia is a small market	Pharmacy A, D
Unexpected high demand	Pharmacy D

Source: Own work

When it comes to the solutions for the future, pharmacies share the same view, that moving production of active pharmaceutical ingredients from China and India back to Europe or closer to pharmaceutical companies, could help resolve the shortages to a certain degree. However, as Pharmacy B perceives the situation: "This is a problem on a larger scale, which cannot be solved immediately", meaning that many things must be done to fix the supply chains. In terms of the small market size of Slovenia, Pharmacy A suggested that Slovenia should try to be more competitive and make the market more interesting for the pharmaceutical companies, to supply us with the required quantities.

8 DISCUSSION

8.1 Discussion of the results

Before proceeding with the discussion of the results, it is very important to note the location of pharmacies in the pharmaceutical supply chains. They are located at the end of the downstream part of the chain, where they distribute medicine to patients. In other words, pharmacies are the connecting link between wholesalers of medicines and patients, who are the end customers of the chain. It can be said that pharmacies are the final link in the whole pharmaceutical supply chain, where the effectiveness and efficiency of the whole supply chain can be seen. Hence, any issues in the previous steps of the supply chain are most likely to show negative results at the very end of the chain.

Upon analysis of the conducted interviews, we see that all four pharmacies face similar challenges with the supply of medicine. It is an ongoing issue, that has been affecting the pharmaceutical sector for the last 10 or more years. However, pharmacies reported that in recent years, the number of shortages of medicine is increasing, especially now after the

COVID-19 pandemic. Pharmacies are dealing with patients daily, who need a certain medicine, but it is not available, pushing pharmacists to find different solutions. There is a general estimation that there are around 250-300 medicines in Slovenia affected by the shortages. According to observations from the pharmacies, supply shortages are larger for 3-5 times after the pandemic, than before.

In terms of groups of medicine facing shortages of supply, respondents clearly identified some of the most common groups, such as: antibiotics for adults and children, drugs for treating cardiovascular diseases, drugs for treating diabetes, biological drugs, anti-viral drugs, drugs for lowering blood pressure and drugs for lowering body temperature. This is in line with the findings in one of the previous chapters, where different authors reported same groups as the most critical for shortages. This shows that the issue is most likely present globally. Furthermore, pharmacies highlighted specific case, which started to occur only recently. It is in relation to one of the drugs, which is used for treating diabetes, called Ozempic. There is a big shortage of Ozempic, mainly because it is now also being promoted and used as a drug, which helps with losing weight.

According to responses from pharmacies, none of them have exactly a defined strategy or plan on how to respond, in case of a shortage. However, all the pharmacies follow certain steps, which help them provide the medicine to patients. By interviewing pharmacies, I was able to define below action steps:

- **Check for suitable alternative:** based on comments from pharmacies, this is the most common solution for the shortages. This means that pharmacist provides a medicine manufactured by different pharmaceutical company, using the same active pharmaceutical ingredients as the initially prescribed one. This solution is allowed only if the ingredients are the same, providing the same therapeutic effect and it can be done within the pharmacy. For any other changes of medicine, pharmacist needs to seek advice from the doctor.

- **Check with suppliers:** Pharmacies are constantly communicating with the suppliers to get the information about availability of the medicine. In some cases, supplier might have some stock left and can dispatch the order, but in other cases, pharmacy needs to look for other solutions.

- **Check with doctor:** In case pharmacy cannot provide substitute drug for patient, pharmacist needs to contact the doctor, who can suggest alternative treatment, usually with a different medicine, using different active pharmaceutical ingredients.

- **Adjust the dosage:** One of the short-term solutions is also adjusting the dosage of medicine, meaning that pharmacist splits the pill or syrup into smaller dosages. Such action allows patients to “bridge” the gap of supply shortage, until they get the medicine.

- **Combination of medicine:** One of the possible solutions is to combine different medicines. For instance, instead of taking one specific medicine, pharmacists combine two or more medicines, which together combine all active pharmaceutical ingredients, as the initially required medicine.

- **Direct patient to other pharmacies or abroad:** One of the last options for pharmacies is to redirect patients to other pharmacies or even to other countries, to check whether they have medicine available. In case the pharmacy is part of a larger group of pharmacies, patients are usually redirected to the pharmacy within the group. In some cases, when pharmacy is located near country border, patients are redirected abroad, where they have to pay for the medicine and get refund from the insurance company back in Slovenia.

- **Use of galenic laboratory and magistral drugs:** Larger pharmacies have the option to use galenic laboratory, where pharmacists can produce smaller amount of medicine, using various natural ingredients from plants. For instance, they can produce different herbal teas and syrups. Furthermore, there is also option to use magistral drugs, which are drugs made by the pharmacists for specific patients, mostly for children, where they adjust the dosage for them.

The steps described above are presented in a response map for every pharmacy I interviewed, which is shown in the previous chapter. The order of the steps was made based on comments from each pharmacy to provide an overview of pharmacy's response to supply shortages of medicine. I would say that response from pharmacy is much more complex and usually doesn't follow the exact order of steps. Instead, steps are often interchanged and modified according to patient's needs.

Through the interviews I learned that pharmacies rarely get any notification from the suppliers for the upcoming shortages of medicine. This means that pharmacies learn about a shortage only at the time they want to place an order in the system, leaving them unprepared. In case suppliers notify pharmacy about the shortage, pharmacy usually orders larger stock of such medicine. Hence, pharmacies are often checking with suppliers and seeking information about availability of the medicine. Most suppliers offer different IT systems, which enable pharmacies an overview of available medicine, but not all systems show the exact quantities available, which makes future planning harder for the pharmacies. In that regard, I see a big room for improvement, especially in terms of visibility and information sharing between suppliers and the pharmacies.

The main goal of pharmaceutical supply chain is to provide patients with the needed medicine and for now, this goal is being fulfilled successfully. Even though there is an increasing number of shortages, pharmacists are still able to manage all the issues and can provide the required medicine to patients, using one of the solutions described previously. But this doesn't mean that solutions are easily provided. Due to issues in the supply chain,

pharmacists are required to invest extra effort and time, to find the needed medicine. Same applies for patients, which often need to visit multiple pharmacies to get the treatment. Not only that, there is also a change in routine for patients, which can raise doubts about effectiveness of the different medicine. What matter the most is, that patient's live is not in danger, since pharmacists are working hard to provide the solution.

When it comes to the reasons for shortages of medicine, pharmacies identified four main reasons. Shortages of active pharmaceutical ingredients is one of the main issues in the supply chain, which limits the manufacturing process for the companies. On top of that, production of API is concentrated mainly in China and India, leaving most of the manufacturers highly depended on them. These reasons are very much in line with the theoretical part of the thesis, where different authors identified dependency on China and India as a big issue for the supply chains. Furthermore, pharmacies also mentioned that big pharmaceutical companies see Slovenia as too small, hence they do not provide enough quantities. And lastly, there is a reason of unexpected rise in demand, which puts pressure on whole supply chain, as it was seen in the post pandemic times. Naturally, all four pharmacies suggested that shifting production of API back to Europe or closer to pharmaceutical companies, could help resolving the issue with shortages. But they all agreed that the issues are larger and cannot be resolved immediately.

8.2 Illustrative map of disruptions in pharmaceutical supply chains during the pandemic of COVID-19 in Central Europe

In the following section, I provide a series of events, which disrupted the pharmaceutical supply chains, leading to supply shortages of medicine. Findings from theoretical and empirical part of the thesis were used to design illustrative map, through which I visually present the main reasons for supply shortages.

The Figure 14 shows a simplified pharmaceutical supply chain flow, adapted from Kaufman and others (2005). It is built out of four main links:

- **Supply of raw materials:** This includes all suppliers around the world, who produce aluminum, plastic, paper, packaging material, chemicals, and active pharmaceutical ingredients. This first link of the supply chain is responsible for ensuring the raw materials needed by pharmaceutical companies for manufacturing processes.

- **Pharmaceutical manufacturing:** This step is responsible for all pharma production and includes all pharmaceutical manufacturers.

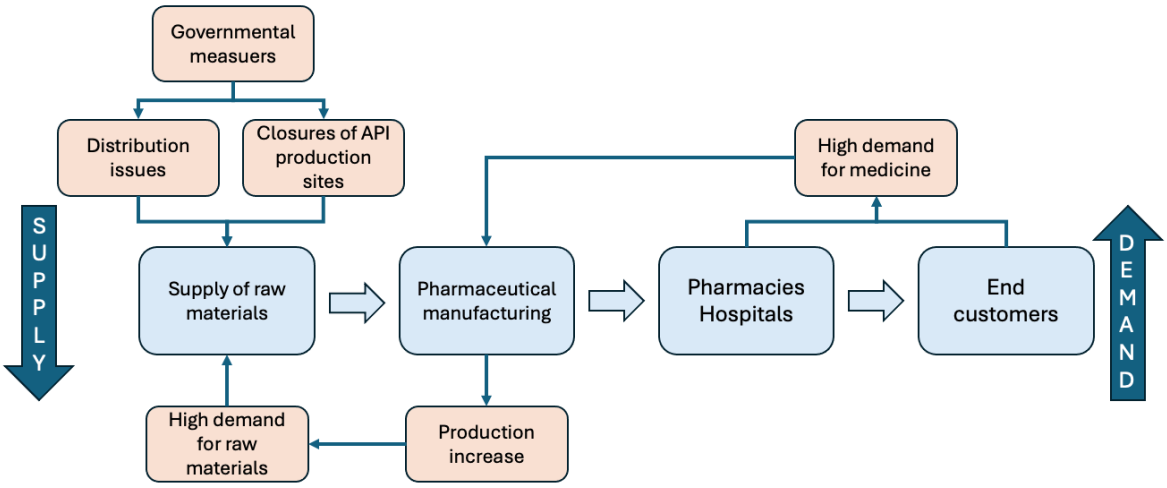
- **Pharmacies & Hospitals:** On the distribution side we have pharmacies, hospitals, and wholesalers, who are responsible for providing medicines to the last link of the chain.

- **End customers:** Finally, there are the end customers, who are usually patients, that require certain treatment.

From the illustrative map it is seen that during COVID-19 pandemic, pharmaceutical supply chains were impacted by two events happening simultaneously. On one side there was huge increase in demand for all types of medicines, where the number of people infected with COVID-19 significantly increased the demand. Additionally, governments and people at home started to stockpile various pharmaceuticals, putting even more pressure on pharmaceutical supply chain. As a response, pharmaceutical companies increased the production and by doing that, they created huge demand for raw materials.

Concurrently, the other side of the supply chain was facing the issues with low supplies of raw materials needed for manufacturing. The issues mainly originated from restrictive governmental measures, which had to be implemented to limit the spread of the virus. Measures such as lockdowns, border closures and social distancing lead to closures of API production sites in China and India. Additionally, this further caused issues in distribution network. The above reasons together with high demand for raw materials, seriously shocked the supply chains.

Figure 14: Illustrative map of disruptions in PSC in Central Europe



Source: Own work

8.3 Relevance of the findings

Upon my research, I encountered interesting discrepancy in the claims between the pharmacies I interviewed on one hand, and statements by large pharmaceutical companies on the other hand, with regards to supply shortages of medicine. When I was searching for information about the impact of supply chain disruptions on pharmaceutical companies, I noticed that most companies stated, that they were always able to provide sufficient quantities of medicine to patients. Pharmaceutical companies highlighted the issues of

supply chains in different public interviews and official statements. However, they concluded that even though there were issues, supply of medicine to patients was never at risk (Grom, 2022; Zalar, 2021). This was in complete contrast with the findings I discovered by conducting interviews, where all pharmacies confirmed, that there are many supply shortages of medicine.

In my view, pharmaceutical companies tend to depict themselves as perfect, particularly in public relations. I believe that every pharmaceutical company encountered significant challenges during the pandemic, thus it is unsurprising that there are medicine shortages. While some businesses may be better at responding to interruptions than others, any disruption throughout the chain can have a negative impact at the end. For me, the most important finding of my research is that patients' lives are not in risk, and I am really grateful for all of the hard work done by pharmacists who are doing all necessary to ensure that patients receive the medicine they require.

8.4 Recommendations

In this chapter, I provide an overview of possible actions, that could improve pharmaceutical supply chains and resolve the issues with shortages of medicine on the market.

The first step in improving pharmaceutical supply chain should be a shift from reactive to proactive approach, where companies adapt supply chain resilience, being enabled by end-to-end visibility and agility. Visibility would enable companies to have an overview of the whole supply chain, including suppliers, wholesalers, distributors, and customers. Agility on the other hand provides companies the ability to respond to different events in the most effective way (Ellis, 2020).

Companies should focus on improving visibility, moving from being localized to enabling full visibility for all upstream and downstream supply chain members. This could be achieved with the use of latest technology, best IT systems and applications, suppliers and customers portals, analytic tools, Internet of things (IoT) and collaboration tools (Ellis, 2020).

Mapping suppliers by tier can also help companies achieve better end-to-end visibility, making it easier to detect any possible vulnerabilities. To get a clear picture of every step in the supply chain, companies need to gather data from both internal and external sources (Foster et al., 2021).

Moving to agility of the supply chain, pharmaceutical companies need to improve responsiveness. This could be done by diversifying the supplier base, increasing the use of automation in the manufacturing processes, increasing safety inventories, and moving production to in-house. This would allow companies to be more in control in terms of supply processes and more flexible in production processes. Furthermore, there is a question about

localization of the supply chain, since supply chains became very complex and global. One of the suggestions is to bring manufacturing of raw materials closer to pharmaceutical companies, in the process of nearshoring. To achieve this, governments might need to introduce some incentives for the companies, since sourcing raw material in 3rd world countries is still much cheaper compared to Europe (Ellis, 2020).

One way for avoiding disruptions and becoming more agile in the supply chain is also expanding the supplier network. This suggests that companies need to move away from single source of supply to multiple sources of supply. However, multiple sources need to be dispersed across the world, since concentration in one place could be vulnerable for the company. In terms of inventory levels, it is recommended to have a good balance between just-in-time deliveries and just-in-case inventories. Having some safety stock of raw materials allows companies to be more agile and can respond quicker to shocks (Foster et al., 2021).

Another recommendation for dealing with market instabilities and risks is to increase collaboration among supply chain members. Such approach enhances capabilities, knowledge, and communication in the firms, leading to better responsiveness of the supply chain. Furthermore, investing in new technologies is a must for the companies to stay competitive. Not only that, but new technologies can also optimize production and increase flexibility. Moreover, with the lead times being shortened, the responsiveness is also improved. Information is one of the most valuable assets in supply chain, hence technology for seamless information sharing among all parties in supply chain must be implemented. This will help firms to calculate possible future market demands more easily, since they will have the access to information from other firms involved in both upstream and downstream supply chain. This will then lead to higher efficiencies in the chain, resulting in lower costs (Moosivand et al., 2019).

There are many measures, which should be considered by pharmaceutical companies. For instance, firms should build strong relationships among supply chain members, as this is the key for having better coordination, communication and information sharing during the disruption. Moving on, there is always a question about inventory levels, which are costly. A very strategic planning for the inventory levels must be implemented by the companies, especially for the most urgent supplies and medicines. Sufficient inventory levels can provide buffer in case of sudden surges in demand. Since pharmaceutical industry is highly regulated, companies need to act proactively with the new regulations and always keep track of changes, as this will help companies lower the chances of disruptions caused by regulatory demands. Risk assessment is another critical action, that needs to be considered by the supply chain members. Through the use of scenario simulations and risk assessments, companies can develop mitigation plans, which are needed in case of disruptions (Peachey, 2023).

8.5 Research limitations and future research

Throughout the process of writing this thesis I encountered several constraints, which limited my research. First issue I encountered was the lack of prior research of the topic, which limited my literature review. Since the pandemic of COVID-19 was rather new, there has not been much research done about pharmaceutical supply chains in the times of pandemic. Second limitation is the small sample of interview respondents, meaning that study cannot be generalized across wider population of pharmacies in Central Europe.

Furthermore, I had issues with respondents, which were unwilling to take more time for conversation. Hence, some of the answers I got were rather short and not profound. The conducted research also lacks primary data from experts who work in pharmaceutical companies, who could provide firsthand experience, on how pharmaceutical companies dealt with crisis. Here I had difficulties finding respondents, who would be willing to participate in the interview, even if I said that data gathered will be used anonymously.

The future research should include more links of the supply chain, including the suppliers of raw material, pharmaceutical manufacturers, and wholesalers. This would provide a more comprehensive understanding of functioning of the whole pharmaceutical supply chain and much more reliable results. Furthermore, as my research was developed and implemented for the case of Slovenia, other researchers should focus also on other countries from Central Europe in order to develop more granular comparative and regional perspectives.

9 CONCLUSION

The pharmaceutical industry is one of the most significant sectors because it supplies medicines to people. The key to industry’s success is establishing reliable supply chains that can achieve the goal of delivering medicine to end users in the most effective and efficient way. Any disruption in the supply chain can cause significant complications along the way, resulting in drug shortages and endangering patients' lives. The pharmaceutical sector was shocked in 2020 by the COVID-19 pandemic, which caused serious supply chain disruptions. Because relationship between pandemic and pharmaceutical industry in Central Europe is rather new and unexplored, this thesis gives a clearer understanding of the impact of the COVID-19 pandemic on the pharmaceutical industry in Central Europe and the industry’s response.

The second chapter of the thesis covers the fundamental ideas of supply chain, supply chain management, supply chain risks, and supply chain risk management. This is critical for the reader to understand because it lays the foundation for the thesis' continuance. The third chapter focuses on the previously described principles, but with a special reference to the pharmaceutical sector. The basic PSC is presented in detail here, as well as potential risks and disruptions. The fourth chapter analyses data on the pharmaceutical industry in Central Europe and Slovenia, providing insight into the industry's importance in the region.

The fifth chapter presents a comprehensive analysis of PSC in Central Europe during the COVID-19 pandemic. The study found that the pandemic had a significant impact on the region's socioeconomic characteristics, mostly because of the rigorous restrictions put in place to limit the virus' spread. For example, the pharmaceutical business had experienced unusually high demand for medicine on the one hand, while on the other they encountered insufficient supplies of raw materials, resulting in disruptions in production operations. According to secondary data, pharmaceutical companies in Central Europe were able to deliver sufficient medicine during the pandemic. However, according to multiple reports from other countries, people are experiencing pharmaceutical shortages. Hence, the empirical work presented in this thesis provides a more complete picture of the pharmaceutical industry, with a special emphasis on Slovenian pharmacies.

The first five chapters of the thesis provided me with unquestionably valuable theoretical information about how the pharmaceutical sector in Central Europe operates. This aided me in the design of my own empirical research, which involved conducting interviews with four pharmacies in Slovenia. The primary goal of my field research was to determine whether there are any pharmaceutical shortages in Slovenian pharmacies and how pharmacies handle such issues. Chapter six describes the methodology process in depth.

All four pharmacies were questioned using the identical set of questions, with certain sub-questions adjusted based on the conversation. The results are analyzed in Chapter seven, and then discussed in Chapter eight. Based on the results, I conclude that pharmacies in Slovenia confront numerous challenges in terms of pharmaceutical supply shortages. This is not totally due to the pandemic, as pharmacists have been experiencing increasing shortages over the past ten years. However, following the outbreak, pharmacists reported substantial increase in shortages of supply. Antibiotics for adults and children, drugs for treating cardiovascular illnesses, drugs for treating diabetes, biological treatments, and drugs for regulating blood pressure and body temperature are among the most heavily impacted groups of medicines recognized by Slovenian pharmacies. This is consistent with the findings of my secondary data research, in which numerous countries reported the same concerns.

In the event of a drug shortage, Slovenian pharmacies take specific actions to ensure that patients receive the medication they require. Based on conversations with all four pharmacies, the following actions were identified: look for a suitable alternative, check with suppliers, check with doctors, change the dosage, combine medications, direct the patient to other pharmacies or abroad, and employ galenic laboratory and magistral pharmaceuticals. Because each case is unique, the exact order of actions taken by pharmacists is not defined, and stages are typically employed interchangeably, tailored to the situation.

One of the most crucial conclusions from my research is that pharmacies can still supply patients with the drugs they require for the time being. Even as the issue of shortages grows, pharmacists are able to provide the supply, thanks in large part to the actions listed above.

Of course, this comes at a cost, primarily in the form of extra time and effort required by both pharmacists and patients.

Pharmacies identified four key reasons for supply limitations: shortages of API, API production locations, Slovenia's small market size, and unexpectedly strong demand for pharmaceuticals. Again, this is consistent with the theoretical findings of the thesis, which are based on Central European countries.

Using both primary and secondary data, I designed an illustrative map that depicts the reasons of disruptions in the Central European PSC. Furthermore, I was able to make some crucial advice for the companies to help them deal with such challenges. The key to success is the implementation of supply chain visibility, which allows pharmaceutical companies to monitor the entire chain. Along with agility, which allows organizations to respond as quickly as possible, the combination of the two would considerably improve the overall operation of the PSC. Pharmaceutical supply chains, when combined with strong relationships and collaborations among supply chain members, would improve much-needed crisis response. Another factor to consider is the localization of raw material sourcing, which would result in a shift away from China and India and towards regions closer to pharmaceutical companies.

With the completed research, I was able to provide some significant insights into the relationship between the COVID-19 pandemic and the Central European pharmaceutical industry. While I mostly concentrated on Central Europe, I also gave useful information about Slovenian pharmacies, which were taken as a specific case study. However, there are several limits to the research, namely the fact that it cannot be generalized. As a result, I advise other researchers to include more pharmacies from other Central European nations, which would provide more reliable results.

To conclude, my master’s thesis findings can be very beneficial to all members of pharmaceutical supply chain, who are responsible for following the goal of providing medicines to patients. I believe that this valuable information can be crucial in resolving the issues with supply shortages of medicine.

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APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

Izbruh pandemije COVID-19 je farmacevtsko panogo v Srednji Evropi postavil pred izjemno velik izziv. Ne le da je farmacija morala poskrbeti za cepivo proti virusu, morala je tudi zagotoviti nemoteno dobavo zdravil za druge bolezni. Žal pa je bil vpliv pandemije na oskrbovalne verige v farmacevtski industriji neizbežen, zato je ena izmed ključnih tematik tega magistrskega dela raziskovanje vpliva pandemije na farmacevtsko panogo. Poleg tega, naloga raziskuje tudi kakšen je bil odziv farmacevtskih podjetji ter kakšno je stanje z zdravili na trgu v Srednji Evropi, zlasti v Sloveniji.

Prva štiri poglavja so osredotočena na razlago ključnih pojmov in konceptov, ki predstavljajo osnovo za razumevanje nadaljnega dela. Tukaj so podrobno definirani pojmi tako iz teoretičnega vidika, kot tudi iz praktičnega primera farmacevtske industrije, kjer je tudi predstavljen primer dobavne verige. Poleg tega so opisana tudi vsa morebitna tveganja, ki lahko negativno vplivajo na delovanje oskrbovalnih verig. Prav tako je predstavljena farmacevtska industrija v Srednji Evropi, ter Sloveniji, katero sem vzel kot posebni primer znotraj regije.

Sledi analiza vpliva pandemije COVID-19 na oskrbovalne verige v farmacevtski industriji v Srednji Evropi. V tem delu je izpostavljena velika zanimivost, namreč na eni strani so farmacevtska podjetja trdila, da med in po pandemiji niso imela nobenih težav z dobavami zdravil. Na drugi strani pa se najdejo številna poročila iz raznih medijev iz Srednje Evrope, vključno s Slovenijo, da na trgu primanjkuje večje število zdravil. V namen da se ugotovi dejansko stanje na trgu z zdravili, se je izvedla raziskava s štirimi lekarnami iz Slovenije, kjer se je ugotovilo da se lekarne soočajo s številnim pomanjkanjem zdravil na trgu.

Ključne ugotovitve raziskave so predstavljene v zadnjih poglavjih magistrskega dela. Bistvena ugotovitev je ta, da kljub težavam z dobavami zdravil, zdravje in življenje pacientov v Sloveniji ni ogroženo. To gre predvsem na račun trdega dela farmacevtov v lekarnah, ki s številnimi ukrepi zagotavljajo potrebna zdravila. Ugotovitve raziskave so v zaključku dela predstavljene v shemi, kjer so razvidni vplivi pandemije na posamezne člene dobavne verige v farmacevtski industriji. V samem zaključku naloge so našteti razni predlogi, ki lahko pripomorejo k izboljšanju delovanja farmacevtskih oskrbovalnih verig, ki so ključne pri zagotavljanju zdravil za bolnike.

Appendix 2: Interview questions

A. STANJE NA TRGU ZDRAVIL – POMANJKANJE

1. Ali se srečujete s pomanjkanjem zdravil na trgu? Kakšno je stanje na trgu zdravil trenutno? Ali se srečujete z zamudami pri dobavah?

2. Koliko zdravil primanjkuje po vaši oceni?

3. Katera skupina ali skupine zdravil so najbolj na udaru pomanjkanja?

4. Ali je kakšna skupina zdravil, katera večkrat niso na voljo?

5. Kakšna je bila dobavljivost zdravil pred, med in po pandemiji COVID-19?

B. ODZIV NA POMANJKANJE ZDRAVIL

1. Kakšen je vaš odziv v primeru da pride do pomanjkanja zdravil? Imate kakšen načrt za "ublažitev" v takih primerih? Kakšna je vaša strategija? Ali imate seznam zdravil, ki morajo biti vedno na zalogi?

2. Ali vam zamude pri dobavah zdravil povzročajo kakšne težave?

3. Ali ste obveščeni o pomanjkanju zdravil? Kdo vas obvešča o pomanjkanju? Kako pogosto vas obveščajo? Ali vas obvestijo v naprej da bo prišlo do pomanjkanja?

4. Ali imate kakšen IT sistem, kjer je razvidna zaloga zdravil ter njihova dobavljivost?

5. Ali morate komu poročati o pomanjkanju zdravil?

C. VPLIV NA PACIENTE

1. Ali pomanjkanje zdravil povzroča kakšne težave za paciente? Kakšen je vpliv pomanjkanja zdravil na paciente?

2. Ali menite da je zdravje/življenje pacientov ogroženo zaradi pomanjkanja zdravil?

D. VZROKI ZA POMANJKANJE ZDRAVIL

1. Kaj je glavni vzrok za pomanjkanje zdravil?

2. Kaj je potrebno narediti za odpravo težav v prihodnosti?

Appendix 3: Participant consent form

Soglasje o sodelovanju v intervjuju in izjava o strinjanju z javno objavo anonimnih podatkov sodelujočih intervjuvancev

Naslov magistrske naloge: Motnje oskrbovalne verige v času pandemije COVID-19 v farmacevtski dejavnosti v Srednji Evropi

Avtor**:** Mitja Ergaver (raziskovalec) in doc. dr. Anastas Vangeli (mentor)

Prosim Vas, da preberete spodnje izjave.

1. Potrjujem, da sem seznanjen(a) z informacijami, ki so relevantne za raziskavo v kateri sodelujem. Imel(a) sem možnost pridobiti informacije in dodatno vprašati o temah.
2. Razumem, da je moje sodelovanje prostovoljno in neobvezno, ter da lahko zapustim intervju brez razloga.
3. Stinjam se, da bo intervju sneman za namene transkripcije, v kateri bodo osebni podatki anonimni.
4. Strinjam se, da bodo podatki zbrani v intervjuju javno objavljeni, vendar bo pri tem moja identiteta skrita.
5. V primeru dodatnih vprašanj ali skrbi lahko kontaktiram raziskovalca Mitja Ergaver na elektronski naslov mitja.ergaver@hotmail.com

S podpisom se strinjam z zgornjimi izjavami in pristopam k sodelovanju v raziskavi.

_____	_____	_____
Ime udeleženca	Datum	Podpis
_____	_____	_____
Ime raziskovalca	Datum	Podpis