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Evaluating the Impact, reaction, and building of resiliency among public and professionals caused by the disturbed Pharmaceutical Supply Chain due to the Russia-Ukraine War

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Abstract

Evaluating the Impact, reaction, and building of resiliency among public and professionals caused by the disturbed Pharmaceutical Supply Chain due to the Russia-Ukraine War

By

Vishakha Mukunda Wankhade

The focus of this research is to look into the influence of the Russia-Ukraine conflict on the Pharmaceutical Supply Chain as seen by the general public and supply chain specialists. The study also investigates the public's reaction and the development of resiliency among professionals, industry, and institutions. The major factors that affected the supply chain, particularly in the pharmaceutical business, such as Covid-19 and Brexit, are explained first. Following that, the primary crisis caused by the Russia-Ukraine war and its consequences are examined. The literature review indicates the impact of the conflict on policies, product manufacturing (particularly pharmaceuticals and medical devices), and clinical trials. Furthermore, the study looks at how different governments and businesses manage their supply networks and other departments during catastrophes. It highlights the individual nature of each crisis and the varying responses by different countries by highlighting examples from Covid-19 and the Russia-Ukraine war. Surveys and questionnaires were used to collect information from the general public and specialists on product shortages during the war, with a focus on their business continuity plans in different crises scenarios. The study concludes by outlining the categories of items that experienced shortages and highlighting the efforts taken by professionals at both the personal and corporate levels to mitigate supply chain interruptions. Using a realistic perspective, this study presents an examination of reality as experienced by all survey and interview participants.

Keywords: Pharmaceutical Supply Chain, Russia-Ukraine war, business continuity plans, Brexit, Covid-19, Resiliency

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List of Abbreviations

PSC: Pharmaceutical Supply Chain

ELSD: Emergency life-saving drugs

BCP: Business continuity plans

WHO: World health organization

HDS: Healthcare delivery system

CSO: Central Statistics Office

EU: European Union

EMA: European Medicines Agency

VAT: Value-Added tax

PPE: Personal Protective Equipment

NATO: The north Atlantic Treaty Organization

IFPRI: International Food Policy Research Institute

GDP: Gross Domestic Product

HSE: Health service executive

R&D: Research and Development

GVC: Global Value Chain

JIT: just-in-time

AI: Artificial Intelligence

ALX: Any logistics

QMS: Quality Management System

ERP: Enterprise Resource Planning

CAPA: Corrective and Preventive Actions

DCT: Decentralised Clinical Trials

SAP: Systems, Applications and Products in Data Processing

MRO: Materials needed for routine maintenance, repair and operations

API: Active Pharmaceutical Ingredient

QA: Quality Assurance

OTC: Over-the-counter

Chapter 1: Introduction

Overview

The supply chain consists of series of activities and organisations that materials move through on their journey from Initial supplier to final customers. People use different names for these chains of activities. When they emphasise the operations, they call it “process”; when they emphasise marketing they call it “logistic channel”; when they look at added value, they call it “value chain”; when they see how customer demands are satisfied, they call it “demand chain”; and finally, when emphasis is on movement of materials it is called “supply chain” (Waters, 2003). In simple words, the cycle of demand and supply can be illustrated as follows:

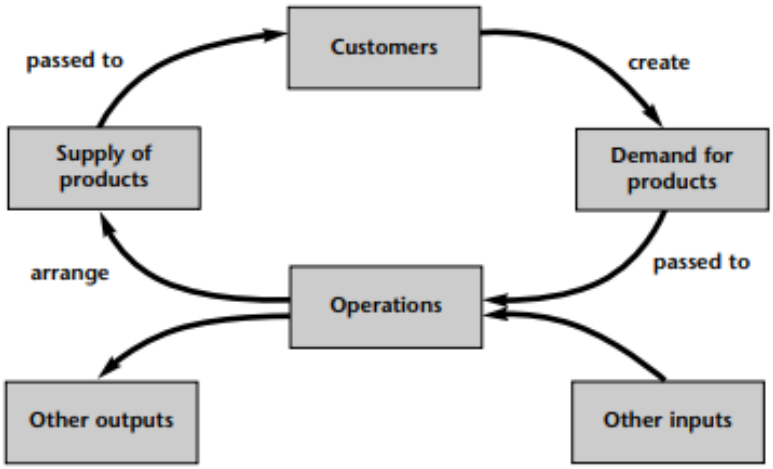

Figure 1.1: Basic components of Supply Chain
(Waters, 2003)

If we are talking about the healthcare system, it’s the onus of Pharmaceutical Supply Chain (PSC) to provide medicines to all patients with good quality, in adequate condition. Typically the configuration of the Pharmaceutical Supply Chain is constituted by manufacturers which can be multinational companies, local companies, generic manufacturers, contract manufacturers and biotechnological companies. The group that purchases medicines or related products includes wholesalers and distributors. The group of providers includes hospitals, clinics and pharmacies. The management of Pharmaceutical products is directly related to the ability of a country to address public health concerns. (Franco and Alfonso-Lizarazo, 2017).

On 24th February 2022, when Covid-19 was not fully vanished and countries were on the verge of balancing everything again, Russia started an invasion of Ukraine and it was proved as an additional crisis for many countries including Ireland. Pharmaceutical industries from all over the globe were already improving their manufacturing and supply and the war interfered with it again (Dhawan *et al.*, 2022). Supply chains for many products including Pharmaceuticals were affected. This research will thoroughly analyse the impact of war, the reaction of people after the disturbed supply chain, and other aspects including the readiness of Pharmaceutical and supply chain firms to face such emergencies in the future.

The work has been structured around 4 main objectives each of then addressing key questions in the research as follows:

1. What was the effect on the general public and what were their struggles and how they reacted?
2. Which category of products were in shortage and its impact on various processes such as trials?
3. What amendments the Pharmaceutical companies did to neutralize the effect if any?
4. What alternatives exist for managing a disrupted Pharmaceutical Supply Chain during crises like war and other similar circumstances?

Research objectives

1) To appraise the experience and perspective of the general public in Ireland regarding the Pharmaceutical Supply Chain since the Russia-Ukraine war started.
2) To determine which products, pharmaceutical companies and therapeutic areas suffered stock shortage (between February 2022 and February 2023) and evaluate involved supply chains accordingly, to establish correlation effects.
3) To investigate which amendments have been introduced in supply chain management and business continuity plans at multiple levels (i.e. retail/vendors/healthcare professionals/ pharmaceutical companies) to mitigate such effects
4) To identify potential additional measures which can be implemented for such major crisis situations in future

When the world was already in the third year of the Covid-19 pandemic and there was no definitive treatment other than supportive care, though a vaccine course has been developed but remains elusive. Non-pharmaceutical interventions such as isolation, hygiene, and the use of masks; Russia-Ukraine war came as a new challenge for the world. Ukraine was already lacking facilities such as diagnostic kits, and vaccination coverage for the population, and the start of the invasion worsened the situation further (Dhawan *et al.*, 2022). This has been proved as a so-called 'crisis after crisis' situation in Europe as well. Firstly the Global financial crisis in 2008. It was started in United States in 2007 with the collapse of the mortgage market. Europe had not escaped the effects of it. As per the experts of the European central bank, there was 649 billion dollars on securities and loans by euro area banks alone over the period of 2007-2010 (Hodson and Quaglia, 2009). Then the Covid-19 pandemic in 2019, and then the Russia-Ukraine war. There was a profound decline in multiple economic key indicators, including investment and employment during all the crises. Rising energy cost leads to a decrease in production, reduce employment and postpone investment.

The world is dependent on one another for a variety of goods. Many EU countries are dependent on Russia for natural gas, oil and petroleum, as well as solid fuels (Celi *et al.*, 2022). Also, Ukraine is a major supplier of crops, and when the navy sealed the borders due to the war, millions of tons of food got stuck in the sea (BBC, 2022). In such a scenario, supply chains for all kinds of products got affected globally, hence pharmaceuticals were not the exception as per researcher's opinion.

As the Pharmaceutical industries are always a connector in many countries with respect to the supply chain, there was a huge and negative impact on the drug development process and clinical research. In general, regulatory approvals for new medicaments are complex processes that take significant time. Deadlines were already delayed in Covid-19 for many medicines as the focus was on developing the Covid-19 vaccine, and the war deteriorated the situation further. Covid-19 medicine is still an unmet clinical need for which all the big Pharmaceutical companies are working. Additionally, the supply of many emergency life-saving drugs (ELSD) which are routinely delivered to other countries, was perilously affected due to both the crises (Mishra *et al.*, 2022). The main purpose of this study is trying to understand the impact on the Pharmaceutical Supply Chain, focusing on the many European countries which are helping Ukraine and Ukrainian in terms of weapons, food, and for related

items as per Euronews (Duthois, 2022). The most crucial concern for these nations was ensuring safety and providing shelter for Ukrainian in various countries (Isański *et al.*, 2022). From my perspective, the migration of so many war refugees may also have contributed to the disturbed supply chain. There was a scarcity of many types of medicines in European countries which was the focus of the research. It was found during the literature review that Ireland has been struggling with the supply of essential medicines during the war as per (Coyle, 2022) which shows that from food and fuels to Pharmaceuticals, supply chains have been globally disrupted due to the war.

Ireland is a hub of many small and big pharmaceutical companies which also have branches all over the world. Many pharmaceutical companies prefer the ocean way to import and export various pharmaceutical ingredients or finished products, to road or air in recent years. The ocean way is comparatively cheap and except for a few medicines which have a short half-life (e. g. radioactive drugs), this route is quite common for transportation. Many companies, have shifted their transport from air to ocean in recent years, for example, AstraZeneca. The company transported only a 5% of its products by sea in 2012, but increased significantly to 7% in 2017 (Klinge, 2019). Ireland, surrounded by the Atlantic Ocean, is from my point of view, an ideal country to assess the disruption of the supply chain, its impacts, and to identify possible protocols and measures which could be implemented in the future to overcome such emergencies.

As Ireland is a good spot for many Pharmaceutical industries, this research was focused mainly on the companies in Ireland for supply chain-related professionals and general public to study the impact, reaction, and resilience after the Russia-Ukraine war on the Pharmaceutical Supply Chain.

As the literature was studied with respect to impact of various crises including recent crisis of Covid-19, the manufacturing, supply, and other essential operations were ongoing during the Covid-19 pandemic and the companies were preparing themselves with risk management plans and business continuity plans (BCP) in Covid-19 and similar situations. But there is comparatively less data available regarding the supply chain disruption of Pharmaceuticals and theories to manage it in the situation of war. Hence, this topic was selected for the research. Various problems in detail and how companies resolved them or their learnings are noted further.

Chapter 2: Literature review

This literature review will focus on the impact of the Russia-Ukraine war on the Pharmaceutical Supply Chain, reaction of people and resiliency plans. Additionally it will also cover different aspects of other crises such as Brexit and Covid-19 as all the above crises has a temporal relationship. The review was carried out mainly through Google Scholar as well as some other sites (e. g. Science direct, PubMed) by using keywords such as "Russia-Ukraine war and Pharmaceutical Supply Chain", "Brexit and its impact", "Covid-19 and Pharmaceutical Supply Chain", "Covid-19 and impact", "Russia-Ukraine war and impact", 'Russia-Ukraine war and Covid-19", Covid-19 and changes in healthcare policies", "migration of people from Ukraine", "resilience strategies of Pharmaceutical companies during Russia-Ukraine war", "business continuity plans of pharmaceutical companies during Covid", "crises in the past like Covid-19, Russia-Ukraine war", The search was not limited to journal articles, but also news platforms such as BBC, newspapers from Ireland, webpages, and videos from You tube were also consulted to collect the information.

Healthcare systems are the backbone of the wealth of any country which is totally dependent on Pharmaceutical Supply Chain. Hence, PSC is a phenomenon that should be revised by the firms as per need and should be kept on the priority always. The Pharmaceutical Supply Chain is a complex phenomenon that needs a lot of planning so that the products should be delivered at the desired time, with all the import or export and related approvals and especially the storage conditions required to maintain the efficacy of the product. Good communication at various levels and throughout departments in the supply chain is also crucial. Manufacturing or clinical trials should not be hampered due to late delivery of pharmaceutical products in any situation, even a world crisis. In my opinion, to face an emergency crisis, to minimising the hustle, it is imperative to identify risks well in advance. Risk factors are responsible to disrupt the supply of medicines in many ways such as quality, quantity and mainly the delivery to the right place, at the right time which makes risk identification in the supply process as highly recommended (Jaberidoost *et al.*, 2013). Continuous surveillance is important right after the shipment of the products starts. Indian news reported in 2014 how a train with goods was missing and tracked after 17 days (Hindustan times, 2014). If such failures happened with the shipment of Pharmaceutical

products, consequences could lead to theft or fraudulent introduction of counterfeit products in the supply chain. For this reason, in researcher's opinion, the methods used to communicate with supply chain staff should be validated for any technical issues or if needed there must be innovation to improve supply chain integration.

The World health organization (WHO), and the Healthcare delivery system (HDS), are integrated by institutes, organizations, resources, and people who are engaged in the delivery of medicines to everyone in order to achieve better health status globally (Settanni *et al.*, 2017). Pharmaceutical supply is a significant part of healthcare costs. For example, In Ireland healthcare cost in 2020 was 26.5 billion euro according to the Central Statistics Office (CSO). This was an 11.3% increase from 2019 which can be explained by the additional cost due to Covid-19 (CSO Ireland, 2020).

Brexit

In researcher's opinion, it is hard to neglect the fact that Brexit not only had an impact when COVID-19 began, but its effects continued throughout the pandemic and persisted during the war in Ukraine. If we are focusing on health and healthcare, the UK was enormously impacted. UK-based companies, which supply products across the EU, need to shift regulatory interactions to other member states, so as to secure continued access to the EU's internal market. The UK is a very reputable location for regulatory monitoring, ensuring both patient safety and certainty for business owners. As per (Hervey *et al.*, 2021), Ninety-nine per cent of centrally authorized medicines had been brought into regulatory conformity by the 12th April 2019 and relocated European Medicines Agency (EMA) completed this work, alongside ongoing work on the UK nationally authorized medicines. The impact of EMA relocation included the physical costs of the moving as well as the delays caused to the EMA's work. Because of Brexit, national administrative capacity had to be expanded, for example in the Dutch or French ports and airports.

In such a scenario, pharmaceutical batch-testing facilities needed to be transferred from the UK to the EU. Companies such as AstraZeneca, and the European Federation of Pharmaceutical Industries and Associations, warned on the complexities of securing the supply of medicines, especially to countries such as the Netherlands and Belgium. Even though the supply was secured, there were unavoidable cost implications and required legal

changes. In the region where the health services and products provisions are particularly close ties to the UK, health brexternalities (external cost due to Brexit) were most severe. The prime example is the Republic of Ireland. As it is the closest historical, political, and economic ties with the UK. Also, other countries were impacted like Spain, with a high concentration of UK nationals receiving healthcare, due to climate; Malta, which is closely integrated with the UK in terms of supply of medicines and regulatory capacity building and other Central and Eastern Europe, where the UK was seen as the ideal place to train as a medical professional. Around 60-70 % of medicines used in Malta come through the UK, supplied by UK-based agents (Hervey *et al.*, 2021).

Around 190, 000 UK pensioners chose to settle in Spain post-retirement. If these people had to rely on a medical device for any condition they suffered, they relied on EU (European Union) law rights to access healthcare, otherwise, they should have opted for private healthcare insurance, increasing costs significantly. Ireland is closely related to UK through integrated supply chains, with Britain accounting for 30% of Irish imports. Most analyses showed economic losses in Ireland due to Brexit. Pharmaceuticals, devices, and consumables supply chains are deeply integrated on the islands of Ireland, and this is supported by EU law on the free movement of products (Hervey *et al.*, 2021). Northern Ireland was also struggling post-Brexit. UK government issued on August 7, 2020, the guidance on the movement of goods to or from Northern Ireland as of 1st January 2021. Under the Northern Ireland protocol, goods between EU member states and Northern Ireland would continue being treated the same way as they were at that moment, but did not go into details on the need to issue or administer any new VAT numbers. On the same day, the EU proposed changes to introduce a special VAT registration number for businesses in Northern Ireland. It was decided that businesses in Northern Ireland were being required to have two separate VAT accounting systems: an EU VAT (Value-Added tax) accounting and UK VAT accounting requirements. Depending on the flexibility of companies some will be able to create an additional country code within their Northern Ireland accounting system, while others would require a separate country code. This was predicted to have a knock-on effect on the wider businesses as an added administrative burden (Cano, 2020).

Covid-19

As per (Faggioni *et al.*, 2023), Covid-19 is considered a Super-disruption or the worst disruption which has changed significantly the lives of everyone in the world. The supply chain sector of companies was also negatively affected, being the 'breaking point' for the corporates and their processes which were well established (including activities, way of work, managerial styles, organizational strategies, etc). There are sectors that have been called to do their part not only to mitigate the effects of disruption but also to find solutions to establish an escape route from economic and social perspectives. Examples are Pharmaceutical companies trying to find vaccines and goods more in general, strictly depending on the continuity of supply chain forward and backward flows of operation. Author also added that, for these companies, understanding how supply chains can be more resilient to super disruptions is of crucial importance. The scope of the Pharmaceutical Supply Chain is not focused on providing superfluous products, but mostly aimed to produce and deliver medicines, vaccines, and personal protective equipment (PPE) to protect people from diseases. Hence understanding the resilience ability of the supply chains of such companies is a crucial issue.

The role of policies cannot be ignored when considering all Brexit, Covid-19, and the Russia-Ukraine war. The pandemic situation, raised three main questions for policymakers. First, who is best placed to respond to health emergencies? Second, how can people be convinced to work together towards a common goal? And third, what is the longer-term objective of policy coordination across countries? It was also concluded that the pandemic was never the only or the most important challenge in front of the world. There are other challenges, associated for instance with climate change, migration, and social unrest are also factors to take care of. Policymakers had to deal with a sudden, massive drop in output and a rise in unemployment, and they also had to find out ways to unwind such distortions (Anghel and Jones, 2023). Authors amazingly discriminate the difference between Covid-19 and Russia-Ukraine war based on actorness, solidarity and resilience in the Europe. The pandemic and the war were both exogenous shocks that activated the EU's function as an international actor. The pandemic made EU find a unified policy and war pushed EU to realize new roles for itself in the international arena. The war required sanction coordination with international partners,

providing economic and military support to Ukraine. Pandemic pushed EU for high level of centralised coordination, policymakers at national level refused it at the start and focussed on proximity without regard to the quality of the policy output.

In preparing for the impending Russian attack on Ukraine, the EU coordinated with US and NATO (The north Atlantic Treaty Organization), thus reaffirming its great power potential. This shows how the reactions to these 2 different emergencies by EU were opposite. Solidarity was the biggest challenge which showed how these actors worked towards a common purpose. Regarding Solidarity, the EU member states agreed to borrow the common instruments during Covid-19 but failed to agree on many financial issues with European Council. In contrast, solidarity becomes obvious due to the War as millions of Ukrainian refugees were seeking help from European counties. EU's response to the pandemic revealed the length to which the union is willing to go in adapting to the challenges presented by a global health crisis while at the same time fostering a just transition to environmental sustainability and digital economy. EU health authority, enhances supply chain management, and strategic autonomy over critical industries were important innovations that could lead to a stronger EU project. In contrast, in responding to the war, the EU was resistant to strategic adaptability. Member states decided to hold onto their hydrocarbon-based energy economies, and they sought new ways to reduce their dependence on coal oil, and gas. According to (Celi *et al.*, 2022), adapting to the new situation was very difficult because EU was utterly dependent on Russia for importing energy goods. Except during lockdowns in 2020, during Covid-19 dependence of 27 countries in Europe or fossil fuels only grew. In 2019, out of 96 per cent of oil, 90 per cent of natural gas, over 43 per cent of solid fuels demands largest amount was coming from Russia which included 35 per cent of oil, 40 per cent of natural gas and 20 per cent of solid fuels. Hungary, Slovakia and Czechia obtained all of their natural gas from Russia. These figures can make everyone think about and gain awareness of the extent of Europe's dependency on Russia (Celi *et al.*, 2022).

Other emergencies

In the last 20 years, there were instances such as a volcano in 2010 in Iceland, the tsunami in Japan in 2011, and the Covid-19 crisis in 2020 which has shattered the world. Though the Russia-Ukraine war looked initially like a matter of these two countries that is not the case.

Countries all over the globe are always connected for many reasons and transportation or business is one of the main reasons. The supply chains were affected far beyond Ukraine. Germany is the country which is affected the most especially in machines, chemicals, Pharmaceuticals and many others. There are many drivers from Ukraine who were working in Germany and had to return to their country for their families or to help the defence sector of the country. Also, Poland and Lithuania also grant thousands of permits to drivers to work but they had to return to their families during the crisis (Pache, 2022). Additionally, as per international food policy research institute (IFPRI), because of the export restrictions in Ukraine due to the war affected Middle East and Africa the most. Tajikistan is the country which was affected the most comparatively (IFPRI, 2022).

War as a shock

The shock due to war was not limited to just grains or food products manufacturing industries had to search for alternatives for the supply of metals such as Iridium, and rhodium which are in South Africa are used in fuel cells. There were many reasons in history that were responsible for the increase in the price of oil and the war added an extra burden on transportation prices. An increase in the price of oil lead to an increase in manufacturing and finished product cost significantly and consumers have to spend more on the finished product. No doubt, the demand is always high especially for Pharmaceuticals but the disturbed supply chain and increases in cost are always a challenge in such crisis (Pache, 2022). There was a major transportation restriction due to Covid-19 in many countries and activities such as manufacturing was reduced, there was a scarcity of products across the globe. After the introduction of vaccines supply chain started again but was not fully recovered as the Russia-Ukraine conflict weakened it again. With many restrictions, Russia also started oil pipeline maintenance which affect the supply to many European countries. The Figure 2.1 explains that the Covid-19 pandemic and the Russia-Ukraine war both contributed to Supply chain disturbance, the decline in GDP (Gross Domestic Product), unsustainable energy production, and food insecurity (Allam, 2022).

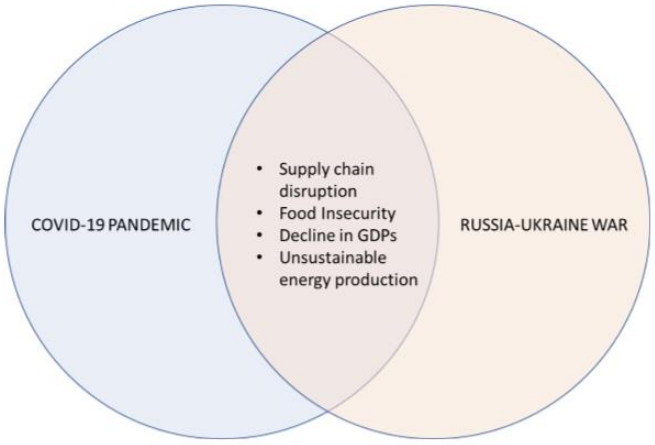

Figure 2.1: Venn diagram
(Allam, 2022)

As Clinical trials are the heart of the drug development process and there are unmet clinical needs for which many studies are ongoing. There are various rare diseases for which the patients get enrolled in clinical trials because they consider this to be the only and last chance to survive, hoping for new “miracle’’ drugs. As shown in Figure II below, there were many clinical trials in Russia and Ukraine that were going on which were affected by the war especially because drugs that were being tested could not reach hospitals and respective institutes. Also, millions of people flee outside the country with severe diseases. Mainly there were many cancer treatment centres in east Ukraine which was bombed by Russia and it had a great ripple effect on clinical trial industry (Mishra *et al.*, 2022).

(Talbot *et al.*, 2022) studied the details of clinical trials for cancer from clinicaltrials.gov and stated the numbers of clinical trials between February 2022 to May 2023. It is explained below in Figure 2.2

Characteristics	Total study cohort	Trial sites	
		Russia	Ukraine
Study site	508	474 (93)	192 (38)
Phase of study			
Phase 1	22 (4)	17 (4)	10 (5)
Phase 2	106 (21)	93 (20)	34 (18)
Phase 3	344 (68)	330 (70)	143 (75)
Phase 4	12 (2)	12 (3)	3 (2)
Recruiting status			
Not yet recruiting	4 (1)	2 (<1)	2 (1)
Recruiting	246 (48)	229 (48)	99 (52)
Enrolling by invitation	7 (1)	7 (1)	0 (0)
Active, not recruiting	251 (49)	236 (50)	91 (47)
Sample size			
Phase 1	104 (30–500)	104 (30–500)	138 (30–500)
Phase 2	200 (4–1595)	200 (8–1595)	168 (4–1000)
Phase 3	624 (12–5637)	644 (12–5637)	682 (60–5637)
Phase 4	280 (81–1036)	334 (81–1036)	387 (160–1000)
Sponsorship type			
Commercial only	454 (89)	426 (90)	178 (93)
Non-commercial only	36 (7)	32 (7)	5 (3)
Both	18 (4)	16 (3)	9 (5)
Treatment intention			
Advanced/palliative	379 (75)	353 (74)	145 (76)
Curative	129 (25)	121 (26)	47 (24)

Data presented as *n* of studies (%) or median (range).

Figure 2.2: Clinical Trials affected due to the war
(Talbot *et al.*, 2022)

The paper also stated that in 2020, Germany (370 million), India (222 million) and France (163 millions) were the strongest contributors in terms of import for Ukraininian pharmaceuticals. After the inception of the war the aerial flights were cancelled and road was the only way to transport the medications. Pharmaceuticals needs particular storage conditions and especially to protect efficacy of medications hence there is always a risk of loss of medications by armed conflict. For example, shelling of oncology dispensaries in Melitopol and Chernihiv by the Russian army. Due to displaced clinical trials continuity of care was more challenging.

The big Pharma companies like Pfizer, Bayer, Roche, Merck, Novartis and Eli Lilly decided to supply the medications to Russia and Ukraine both but they paused the recruitment in the clinical studies. Also some companies decided not to open new clinical trial site in Russia. As healthcare professional are so much concerned they demanded end of the war, by more than 1000 signatures, which is published in British medical Journal. As the trials included multinational patients it affected the global clinical trial network (Talbot *et al.*, 2022).

As per the data published on 11th March 2022, seven companies including Pfizer said that there is a big disruption due to the invasion and as per the research by Globaldata, there are 502 trials were ongoing at the time of the beginning of the war. Roche, a Swiss drugmaker also had 33 ongoing trials in Ukraine accounting for 1.5 per cent of the active trial population across its global studies. In response to the war, companies migrated their patients so that they don't have to stop the clinical trials and ultimately the medicines should reach the patients because in many instances the patients can only access those by participating in clinical trials (Mishra *et al.*, 2022).

Pharmaceutical companies were proactive for the commencement of hostilities 4th of April 2022, the European Clinical Trial Coordination Group (CTCG) issued guidelines for the transfer of displaced Ukrainian trial patients to sites participating in the same multinational trial in other counties within the EU. As per the guidelines, it was ordered that the patients should be transferred to the alternative clinical trial site in their destination country, if such trials are not available in the country then 'compassionate use' is allowed for the patient for a specific medication. In the end, administration hurdles were constant as per the report. Though companies are trying to reach or maintain the number of patients required in clinical trials, it cannot be denied that there is a significant risk that trials will need to be prolonged, ultimately delaying regulatory approvals (Easton, 2022).

Moreover, the impact of war and armed conflict on the vaccine cold chain was a timely point of consideration. Also, many Pharmaceutical companies put their collaboration on hold with Russia and these factors immensely affected the efforts to maintain thermostable vaccines against Covid-19 and other diseases. Evidently, war lead to increased vaccine wastage at the epicentre of the conflict. Therefore related experts and health bodies advocating in favour of thermostable vaccines should emphasize the impact of war on vaccination to persuade competent authorities to take relevant actions (Tsagkaris *et al.*, 2022).

The review report by (WHO-EURO, 2022), stated that access to medicines and medical devices was compromised from the inception of the war in Ukraine, despite the considerable acts of solidarity and resilience of Ukraine's Pharmaceutical Supply Chain. Access disruption manifested mainly dwindling stocks, increased use costs and longer waiting time, with subsequent market disruptions resulting from shifting consumption patterns, loss of income, and supply chain issues. With Clinical trials, manufacturing, and research and development it

is obvious that there was a huge impact on other aspects of drug development derived from disturbed supply chain or distribution but the primary research related to this research will focus on the delivery part of the supply chain which is related to finished product delivery.

Migration

Many countries helped Ukraine after war, for example by tenth week of the war 2,37,700 refugees migrated to Poland from Ukraine. It mainly included women, children and elderly. The polish government released an act for assistance to Ukrainian citizens in connection with armed conflict in Ukrainian territory on 12th March 2020. The special act was in force from 24th February 2020 grants the right to medical benefits, reimbursement for drugs and supply of medical devices to citizens who came to Poland due to the war. For children various vaccination programmes were conducted and for disabled elderly were granted with funds from the state fund for the rehabilitation of disabled people. All type of support including Psychological support was provided by the polish government (Fatyga *et al.*, 2022). Germany was struggling to provide shelter to refugees (BBC, 2022). Refugees also migrated to Romania, and many other countries including Ireland explained in Figure 2.3. It is obvious that there were many people with various ailments came to Ireland for example, diabetes or Kidney ailments. Hence it is the responsibility of the country to fulfil the need of refugees in the situation of war additionally to that of the residents who are already in the country (Isański *et al.*, 2022). Migration of people in Ireland is as follows:

	Number of persons	Mean group size	Mean number of children under 16	Number of distinct groups
2022 May 23	10,158	1	0	10,158
2022 June 07	11,006	1	0	11,006
2022 June 20	11,980	1	0	11,980
2022 July 11	13,441	1	0	13,441
2022 August 07	15,034	1	0	15,034
2022 September 25	17,149	2	0	17,149

Source: Central Statistics Office, Ireland.

Figure 2.3: Migration of Refugees to Ireland
(Government of Ireland, 2022)

Health service executive (HSE) is the large organisation in Ireland containing more than 100,000 people and whose onus is to run all the public health services in Ireland they played important role in Covid-19 and during war.

As per a research report by UKREF, (Isański *et al.*, 2022) regarding various needs, concerns, and plans of Ukrainian refugees following figure 2.4, shows the most important needs and most important concerns of refugees in various countries where they migrated.

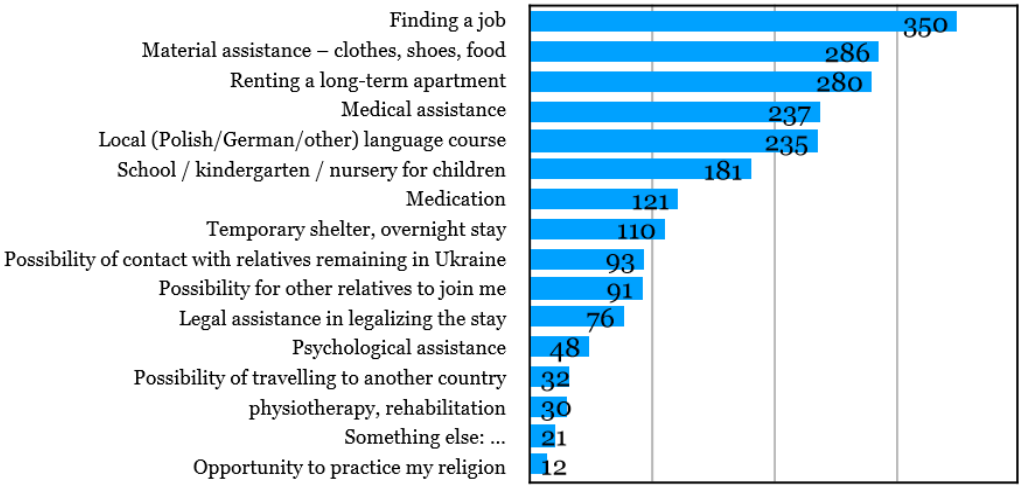

Figure 2.4: Needs of Immigrants
(Isański *et al.*, 2022)

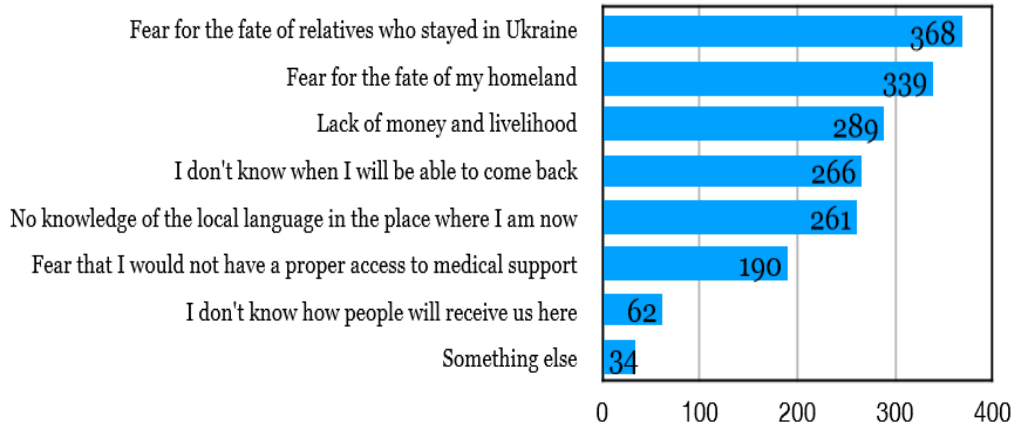

Figure 2.5: Fear of Immigrants
(Isański *et al.*, 2022)

From above results in figure 2.5, it was inferred that the relatively distant temporary shelter and accommodation position suggests that there were also people at an utterly preliminary stage of refugeehood within the study group.

Total impact of Brexit, Covid-19 and the Russia-Ukraine war

Overall, Brexit, Covid-19 and war obviously had an enormous impact for everything and everyone. Regarding Brexit, it impacted the UK with respect to all types of industries. Pharmaceutical businesses demonstrated a range of reactions to Brexit. Some companies invested in the UK market to underline their commitment to the country, while others remained wary of starting new initiatives before the withdrawal process was fully completed. Pharmaceutical companies continued to engage in Research and Development (R&D) and increase their investments in the UK since 2018. The government intends to boost funding for life sciences research and promote collaborations between businesses and academic institutions. One of the largest pharmaceutical businesses in the UK, GlaxoSmithKline, expressed concern about potential changes to the regulatory structure following Brexit. The European Medicines Agency recently moved its headquarters from London to Amsterdam. Additionally, the industry's ability to recruit the top talent suffered. To guard against any business disruptions and gain access to the European market, the company constructed a drug testing laboratory in continental Europe (Correia, 2019). Due to a major increase in demand as the illness swept the globe in the first half of 2020, Covid-19 has resulted in a dramatic shortage of the medical supplies required to treat the virus. Face masks are the most important product in the war against the COVID-19 virus. While studying and explaining the GVC (Global Value Chain) analysis of face masks (Gereffi, 2020) also mentioned the JIT (just-in-time) business model for it. The healthcare industry prefers JIT's business model, which promotes lean production and minimal stocks throughout the supply chain. The market also needs liability waivers when it switches from industrial to medical N95 masks to combat the pandemic.

Organizations were already compelled to change their manufacturing and supply chain systems to be more sustainable during the post-Covid-19 era. In order to overcome production losses and improve consumption patterns, which would further stimulate the economy, it is necessary to develop sufficient institutional and operational strategies. To address crises like pandemics and Brexit, many organizations created preparedness strategies. To satisfy client demand, it is crucial to maintain enough supplies of necessary goods and raw materials, with an emphasis on necessities. The WHO also created a strategy for preparedness during the pandemic that placed an emphasis on livelihood potential and

lowered the Covid-19 morbidity and mortality rate. Stocking of PPE kits is required as most countries faced shortages during the pandemic. Impact on the ship and receiving products on time due to shortages and logistics bottlenecks was considered as the main factor of shortages. To deal with these issues, a smooth production plan and Artificial Intelligence (AI) based production techniques are always beneficial. Also, partnering with government agencies was imperative to reduce the severity of Covid-19 illness and treat infections, possibly leading to a vaccine. Application of advanced technologies such as AI, 3D printing, Data analytics, robots, and Cyber-physical systems can help in developing decentralizing production systems (Kumar *et al.*, 2020). Additionally, as per (Lozano-Diez *et al.*, 2020), the solution methodology based on the simulation-optimization approach allows for analyzing the impacts of different recovery strategies for a subsequent epidemiological outbreak. The need for a supply chain for medicines and supplies that allows dealing with external events such as pandemics, war, and Brexit was evident. Hence it is necessary to take into account innovative concepts of supply chain management, simulation, risk analysis, and optimization.

Resiliency plans

Shortly before the initiation of war, the Covid-19 crisis created a lot of challenges in the Pharmaceutical Supply Chain. There were many theories that came up to balance the supply chain during such a crisis. In Covid-19, there were additional things was in the demand list such as masks, gloves, and mainly PPE (Personal protective kit) which were essential to stop the spreading of the virus and these were inevitable because the health of frontline workers or medical care workers was utmost important. With the various medicines supply of such products was an additional task for the supply chain constituents. As there are many technologies coming up to increase business in many industries, Blockchain is one of those which was released in 2008 in the form of Bitcoin. Additionally, Ethereum represents second-generation Blockchain technology that facilitates secure information exchange, improves logistical operations and tracking mainly which helps in the supply chain as well (Omar *et al.*, 2022). Also, there are many Artificial Intelligence (AI) enabled supply chain applications which helps to build more resilient supply chains (Khatua *et al.*, 2021), showed that AI can be used to track social media to know the approach of the public regarding various products; to predict future demand, evaluate product performance, monitor brand reputation, evaluating

promotional campaigns and customer segmentation. The concept of digital twin design also came to improve the supply chain in Covid-19 by using ALX (Any logistics) software. Such many studies were conducted to study the qualitative and quantitative impact of Covid-19 on the supply chain and provided various solutions with many new technologies to deal with it.

Gap in the Research area

To the best of my knowledge, as stated above there were many resolutions in terms of new technologies were provided against Covid-19 crisis but the impact on supply chain due to war and new theories to give solution for it was rarely studied. Furthermore, to best of our knowledge the study was rarely conducted regarding the impact of war on the Pharmaceutical Supply Chain in Ireland though Ireland was the country who supported Ukraine in many means especially many refugees settled in the Ireland and the government is taking care of them. Hence, this research will study the intensity of the impact of the war in Ireland for the supply of medicines and how people and professionals reacted to it. Also, what measures the various vendors, firms implemented to neutralise the issue and it will also provide an opinion what can be done in dealing with various such situations and how the companies or vendors or others are ready to face such kind of emergencies.

Chapter 3: Research Methodology

Understanding the research approach that will be applied is crucial in order to examine how pandemics and wars affect the Pharmaceutical Supply Chain. The systematic strategy or techniques used to perform and analyze research are referred to as research methodology, and they are essential to the validity and dependability of the research findings.

There are two key philosophical ideas that are closely related to science: ontology and epistemology. While epistemology is concerned with the nature of knowledge and how we can acquire it, ontology is concerned with the nature of existence and reality. Because science seeks to understand the laws and principles that govern the natural world, these ideas are closely related to it. By deciding on a research issue, planning experiments, and analyzing the results, scientists use both ontology and epistemology to direct their work.

Deductive (Figure 3.1) and Inductive (Figure 3.2) thinking are the two primary methods that scientists employ to acquire knowledge. Deductive reasoning tests specific hypotheses based on existing beliefs, whereas inductive reasoning develops new concepts or theories by making generalizations based on data. To create relevant research initiatives, understand the differences, and reach significant conclusions (Kenaphoom, 2021).

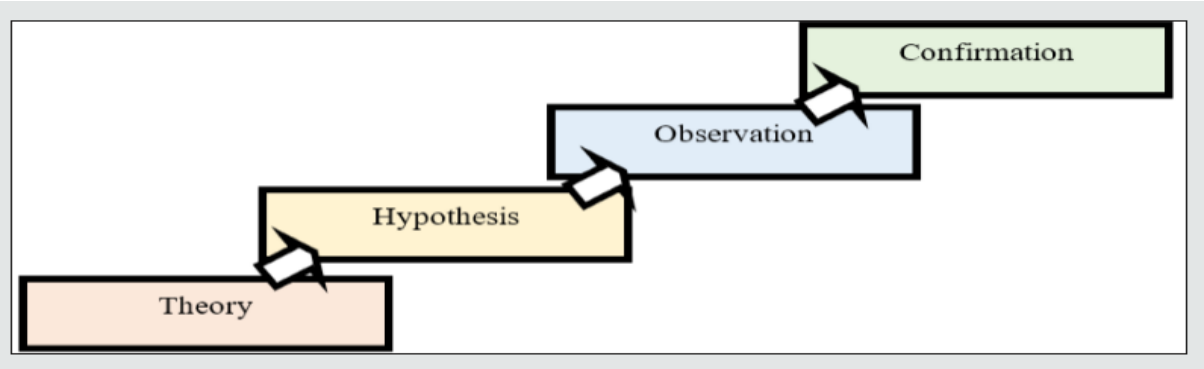

Figure 3.1: Deductive reasoning

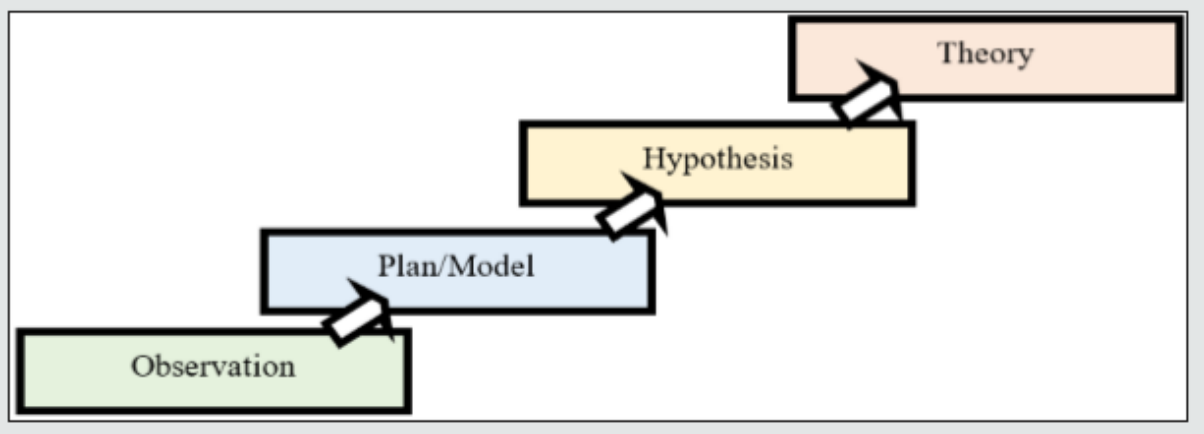

Figure 3.2: Inductive reasoning
(Kenaphoom, 2021)

As the data obtained in this study is related to the self-perceived impact and reaction of the professionals and public regarding the Pharmaceutical Supply Chain, the mixture of qualitative and quantitative methods of research are used. Capturing the readiness to face emergencies like the Russia-Ukraine war for particular organisations and how they faced challenges during the emergency is also the focus. Hence, this study followed the Realism approach and concept of Phenomenologism. Phenomenologism is the basis of qualitative research methodology and it is the philosophical approach that emphasizes the subjective experience of phenomena and consciousness, rather than objective reality. Realism holds the reality exists independently of the mind. This aided in evaluating the primary research data because it represented the actual experiences of people from various professional backgrounds as well as the practical knowledge that pharmaceutical or medical device companies acquired during the conflict to address a variety of problems that may have been brought on, if any, by the Russia-Ukraine war (Kenaphoom, 2021).

As per the design of this study, a descriptive qualitative survey was designed by a phenomenological approach to know the experiences the professionals had related to the Pharmaceutical Supply Chain during the Russia-Ukraine war. Key Pharmaceutical professionals, i. e. pharmacists, nurses and staff related to the supply chain who directly or indirectly work with the medicines, were included in the study, as the disturbance in the supply chain affects their work. Healthcare executives or data provider sites were

enquired/referred to whenever needed for information provided in relation to the supply chain of medicines.

There were different sets of questionnaires for the following groups:

Group	People involved	Type of questions	Research Method
1	General public	Survey with Semi-structured questions	Anonymised survey
2	Pharmacists/OTC assistants/warehouse workers/retailers	Survey with Semi-structured questions	Non-anonymised survey
3	Nurses, Hospital Pharmacists/other Medical professionals working in Hospitals	Survey with Semi-structured questions	Partially-anonymised survey
4	Supply chain managers/associates	Interview with open and semi-structured questions	Non-anonymised

Table 3.1: Groups for the survey

Google forms were used to design such survey forms and answers or responses were tracked and analysed. As confidentiality is of utmost importance here, at the start of the questionnaires consent was provided from the researcher that the confidentiality of the respondent was assured. A pilot survey was run with 5- 7 people to assure that the questions are not ambiguous, not affecting or biasing the respondents in any way. Also, the questions for the interviews were sent to 2 external reviewers and their feedback was incorporated to the final version of the questionnaires for surveys and interviews.

Email and Social media platforms (such as LinkedIn, Facebook, Twitter, Reddit) were used to interact and share the questionnaires with healthcare or General Public.
The research questions were prepared by considering factors as described by (Burges, 2001)

Guidelines to Design Questionnaires for the Survey

1. Aim of the research should be clearly defined
2. Introductory questions

3. Researcher information should be with the respondent
4. By considering various possibilities for the answer, questions will be of mixed type
    - Open
    - Closed
    - Multiple selection
    - Opinion
5. Questions should be specific to avoid confusion
6. Questions involving negatives should be avoided
7. Double questions should be avoided
8. It will be taken care that, the question is not leading to a specific answer

Reason to choose the groups

As all in the general public are end-point users of medicines at some stage, therefore might be impacted by disrupted Pharmaceutical Supply Chain in case of emergencies. Hence, it was decided that the survey was included general public to know their side of the story and the specific challenges they had to face in Ireland. The survey questions were circulated to potential participants of all profiles, ages, genders and nationalities, to analyse the self-perceived impact on general public due to the war and regarding the Pharmaceutical Supply Chain. A few questions in the survey were kept open-ended as an opportunity to identify any other issues which that could have been faced by the public and which may constitute the scope of further research.

Questions to general public, Nurses, Pharmacists, and warehouse or other workers related to the supply chain:
To the first three groups, at the start, introductory questions were asked including age group and nationality, as well as years of experience in current role/profession. Additionally, main questions were asked regarding the products they felt were in shortage during the Russia-Ukraine war which were broken down into various categories of medicines. They had freedom to answer whatever they felt the shortage was as the option with open-ended answers was also enabled. In the opinion of the researcher, all participants, including general public, and professionals such as nurses, pharmacists, or warehouse workers, can provide good ideas on

to manage such shortages. It was indeed asked of all of them regarding their personal ideas in terms of action plans and management for shortage, as well as actions taken by their organisations as well. Readiness was also specifically asked, as one of the main objectives in this thesis is to assess how the organizations or hospitals were ready, based on the opinion of professionals. A quite assorted battery of questions was included in the survey, with open and close ended, multiple choice, and likert scale options to collect all the data.

To the group which included Supply chain associates and managers, the following questions were asked with flexibility by taking interviews. As per their availability, they were given the option to complete the consent form and questionnaires and send them back through email or LinkedIn if time did not permit them for the interview. Open-ended questions were also added to get detailed insights and all the possible aspects. As this was a crucial part of the research effort was taken to take these interviews by interacting with them offline or online as per the availability and it was recorded if permitted by participants. The data obtained from the interviewees was their own experience. Interview questions were prepared and circulated along with the ethics documents with signature of the researcher on the consent form to maintain the confidentiality of the information. These interviews were conducted online on Zoom calls.

Details of the participants with whom interviews were conducted are as follows:

Participant	Designation	Contact Source	Date
Participant 1	Quality and Supply Chain Specialist	LinkedIn	4th April 2023
Participant 2	Supply Chain Specialist	LinkedIn	7th April 2023
Participant 3	Supply Chain Manager	Workplace	11th April 2023
Participant 4	Master data specialist (SAP consultant)	LinkedIn	28th April 2023
Participant 5	Lead Supply Chain specialist	LinkedIn	28th April 2023
Participant 6	International Marketing Supply Chain Analyst	Networking	29th April 2023

Table 3.2: Participant's Information

Questions included in the interviews are listed below:

1. Country of your work and can you please describe your role, years of experience?

2. Do you think that Pharmaceutical/Medical devices supply chain was disturbed due to the Russia-Ukraine war? (Yes/No)

3. If yes, rate the extent of disturbance of Pharmaceutical/Medical devices supply chain from 1 to 10 where 1 is No/minimum disturbance

4. What was the scenario during Russia-Ukraine war for your company, hospital, organisation (From February 22, For example, which type of products were in shortage/processes were affected/wastage?)

5. From which company/companies/vendor/country the shortage was? How long the shortage lasted?

6. As a manager/associate, how you handled? Or what was BCP plans?

7. Did you preferred any new technologies such as Blockchain? Your opinion about what could be done in your organisation?

8. Do you think your organisation/hospital is now ready with better back-up or BCP plans/any amendments after war? Rate the readiness from 1 to 10 where 1 is no/least ready

9. Do you think European countries, and other nations which are actively involved in Pharma business, efficiently collaborated with each other regarding Pharmaceutical Supply Chain during war? What's your opinion about developing countries?

10. What actions can European/other nations which are actively involved in Pharmaceutical Business take to boost supply chain network and enhance risk management?

Procedure of Primary research

For group 1 and 2 (General public and Pharmacists/wholesalers/retailers). The main criteria for completing survey forms for participation was they are residing in Ireland. The Google survey form was sent to people who are staying in Ireland or shifted to Ireland during the war. The link for the forms was circulated to my acquaintances and professional network, who recirculated it further.

For group 3 (Nurses, Hospital Pharmacists/other Medical professionals), as it is against the ethics to ask nurses from hospitals the data regarding shortages of products in hospitals and nursing homes, respective authorities such as HRs were approached by sending Emails and they were requested to send the link to nurses to fill the data. The respective link was replicated so that the researcher should know which link was sent to which hospital. Hence this survey form or group is tagged as partially anonymised. It means the researcher can know from which hospital the responses are without asking for details of nurses and other healthcare professionals. The survey forms was set as only one reply per participant is allowed.

For Group 4, In order to achieve the objective, the request was sent to many supply chain professionals with the main objective of the research and asked them if they can give an interview. The questions of interviews were open-ended questions so that it is easy to get different opinions and inputs from them. Even though the predetermined list of questions was used, as per the responses of the participants it was amended to get a better knowledge of the Pharmaceutical Supply Chain industry and what happened during the Russia-Ukraine crisis, and how the companies managed to tackle the situation.

The ethical guidelines were kept in mind and the participants were told about the consent form. Before the interview, the consent form was sent to them so that they can get ready for the interview. No one was forced to give the interview. Participants were asked for the date and time as per their availability so that no one should get disturbed from their work schedule.

The interviews were conducted as per the time given by the participant to the researcher and they were not diverted from it. The link for Zoom meeting were sent to participants in advance to avoid wastage of time during the fixed time for the interview.

The below principles involved in research ethics are strictly followed:

1. Respect of participate and their time
2. Confidentiality
3. They have freedom to choose about the interview method
4. Data privacy

All the details were provided in the consent form regarding data privacy and data storage and participants were requested to read it before signing the consent form.

Ethics and data protection

The study was approved by Griffith College and all the data files will be stored with the Griffith College safely without affecting the confidentiality of respondents anytime. There will be no personal data from any of the participants, gathered or used for the research. All the data gathered by the researcher will be deleted from personal gadgets after submitting the dissertation to the college, and thereafter the data will be stored only within the college for 2 years after the declaration of the result of the researcher. This information is clearly stated in the ethical documents, hence every respondent to the surveys and interviews should be aware of this fact.

Chapter 4: Findings and Analysis

This chapter evaluates the response of the general public, Pharmacies, and details of interviews taken to study the Impact, reaction, and resiliency factors In Ireland due to the disturbed Pharmaceutical Supply Chain during the Russia-Ukraine war. As mentioned earlier in the 'Gap in the Research' section, there is no sufficient literature available on the solutions Pharmaceutical companies have drawn to manage their supply chain during the Russia-Ukraine war. The survey data from the general public and Pharmacies were exported in Microsoft Excel and analyzed. To analyze various factors related to the responses obtained for example, whether responses to shortages of products are gender-related or related to the knowledge of people in the supply chain, the software Datatab was used. By using it analysis was done whether there is any relationship between above mentioned factors and the responses obtained. Finding and analysis was divided into following 3 parts:

- Findings and Analysis of a Survey for General Public
    - Data Visualisation
    - Statistical tests
- Findings and Analysis of a Survey for Pharmacies
    - Data Visualisation (Statistical analysis was not carried out for the group due to limited number of responses)
- Finding and Analysis of Interviews

Interviews are thoroughly analyzed and interpreted. The response of each participant is represented in quotes which are evaluated critically and interpreted.

Findings and Analysis of a survey for General Public

From the survey prepared a total of 76 responses were received. People from different nationalities participated in the survey and all reside in Ireland. The majority of those were master's students, two Ph.D. and two post-doc professionals including other responses. The survey questions can be found in Appendix section, mainly focused on research objectives which includes finding the products that were in shortage, especially medicines for people during the Russia-Ukraine war, their challenges, and any idea they can suggest to balance the

supply chain during such a crisis. Here, responses to each survey question are described and examined.

Question 1

I am over 18, I have read and understood the information and I voluntarily agree to participate in the study.

This question was mandatory and asked to confirm that the responder is 18 year old.

Question 2

Gender

This question was aimed to identify if the responses are gender biased. The options provided for the question were male, female, prefer not to say, and none of the above. A balanced distribution of gender was observed among responders.

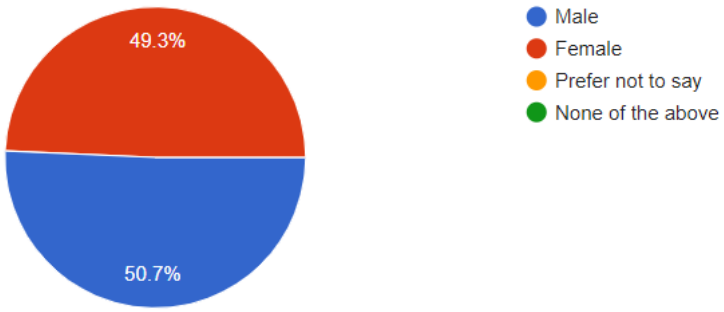

Figure 4.1: Gender

Question 3

Nationality

The question was asked to get a basic idea about the nationalities of the respondents. There can be many immigrants in Ireland and problems of each nationality abroad can be different, especially in a crisis like the Russia-Ukraine war. Many nationalities participated in the survey but the majority of responders were Indian though the researcher tried hard to reach to as many people as possible.

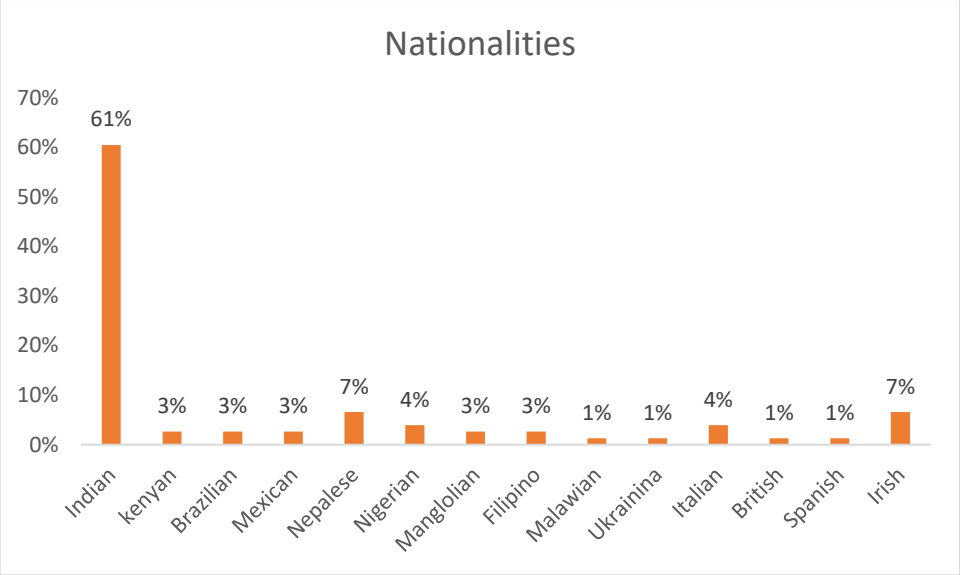

Figure 4.2: Nationality

Question 4

Age

This question was also an introductory question and people from different age groups responded to the survey. A range of age groups was provided from the typical segmentation of the general population of different ages. Although majority of people were from the 25-34 age group, the researcher managed to get the response almost all the age groups.

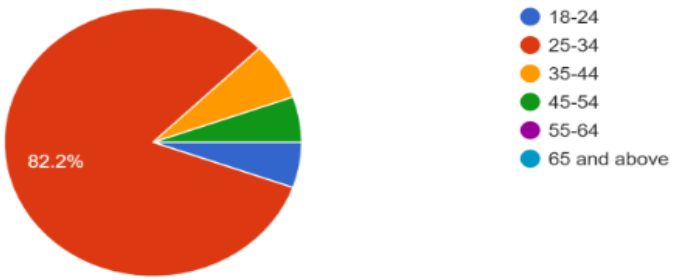

Figure 4.3: Age groups

Question 5

Highest level of education

This was asked to check the education of respondents. The Pharmaceutical Supply Chain is a massive phenomenon, hence it was expected that the respondents would have at least rudimentary understanding of it in order for their comments or responses to be taken into consideration as valid. Survey respondents represented a range of educational backgrounds,

including those with diplomas, bachelors, masters, PhD, and post-doc degrees. The majority of respondents indicated that their highest degree was a master's.

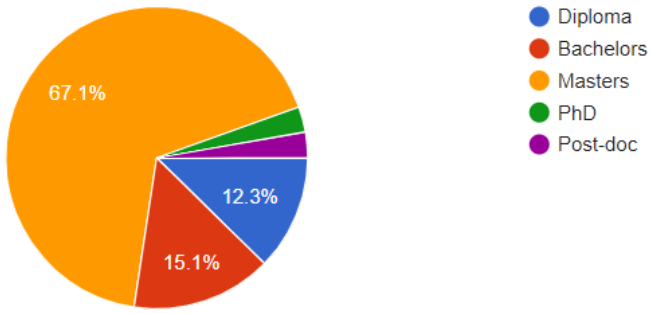

Figure 4.4: Qualification

Question 6

Your main occupation

This research was focusing people from all backgrounds to assess the challenges faced by people from different fields. Also, to analyze the shortages of products of people from different professional backgrounds. The survey was not confined to working professionals only. Homemakers were also included in the survey. People from various professions were responded to the survey but data was mined to students, medical professionals and other active jobs, unemployed/homemaker and self-employed. Students and people involved in active jobs in various fields responded more in the survey as those were approachable for the researcher.

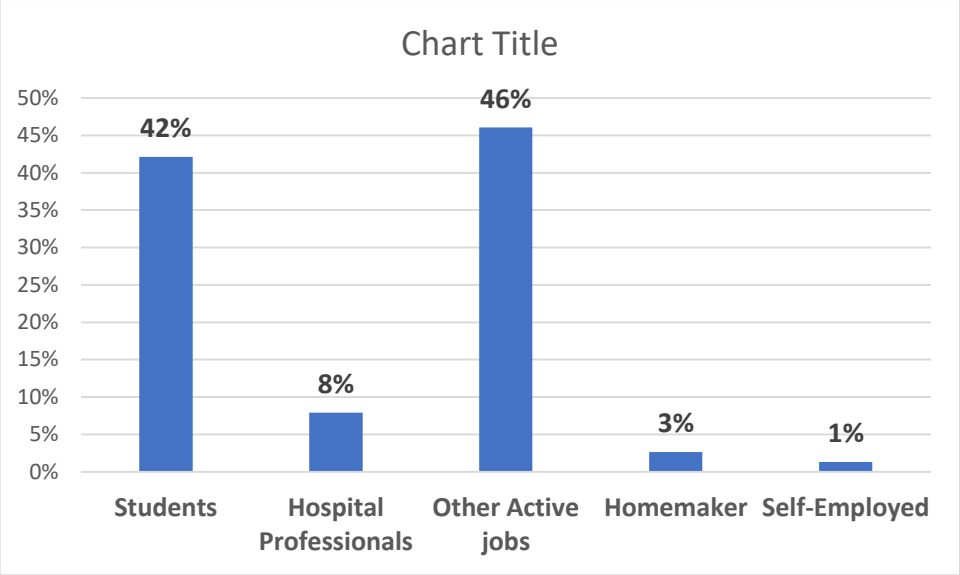

Figure 4.5: Main Occupation

Question 7

Have you heard about the Pharmaceutical Supply Chain?

This was one of the main questions to start which is related to the objective because people should know what the research is about and while analyzing it is important to assess how many people from the general public can have an idea about the Pharmaceutical Supply Chain. Even though the Pharmaceutical Supply Chain is a huge concept, the results of the survey show that consumers still have a general understanding about it.

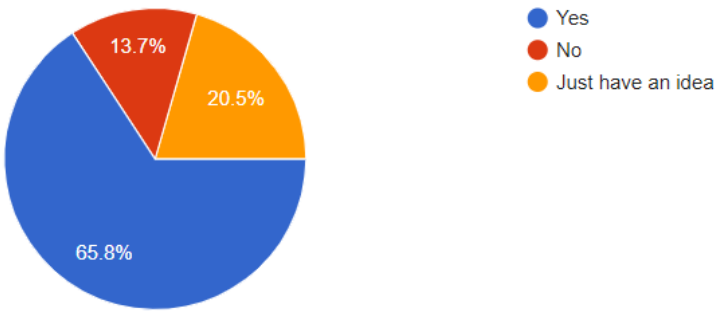

Figure 4.6: Awareness of PSC

Question 8

Rate yourself in the knowledge of Pharmaceutical Supply Chain.

This was a crucial topic to ask since more informed people would be better able to describe product shortages in-depth and offer a variety of solutions to such a situation.

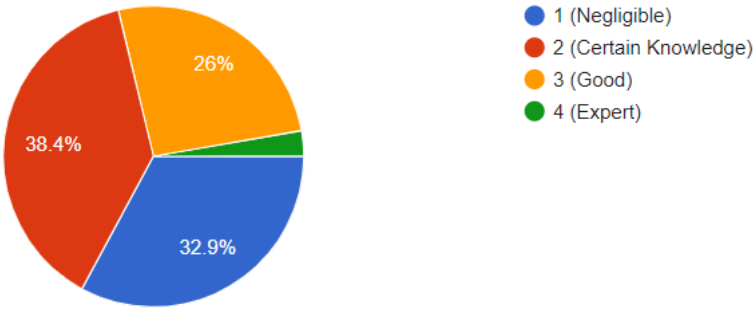

Figure 4.7: Knowledge of PSC

Question 9

How did you learn about it?

It was asked to assess the number of students who had learned it in school, which can indicate that they had a thorough understanding of the subject. Additionally, many use social media to learn more about the subject. Although many people were not learning about PSC in school, it was found that they were aware of it because to social media.

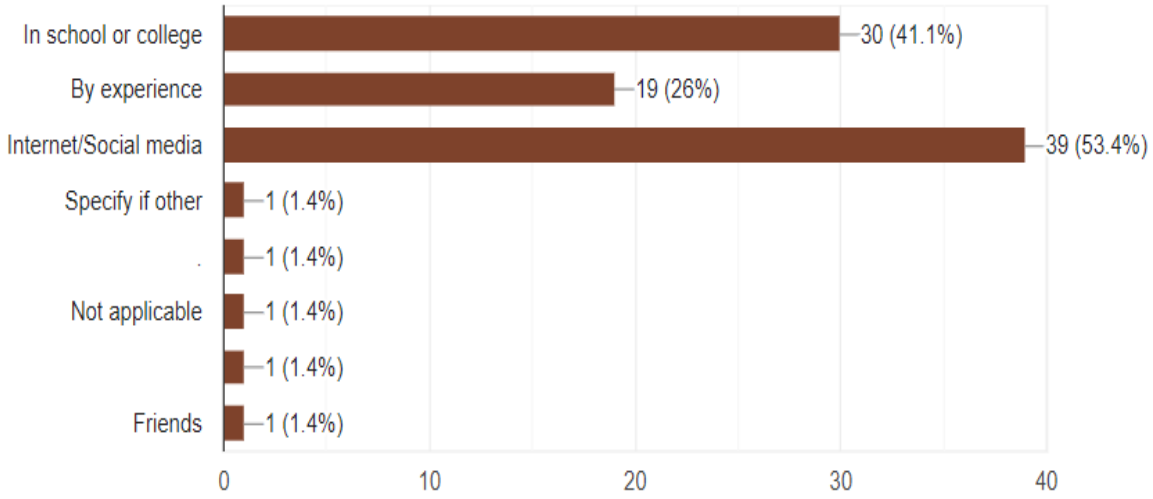

Figure 4.8: How did you learn about PSC

Question 10

Did you think that the Pharmaceutical Supply Chain was disturbed during Russia-Ukraine war?

This was a crucial question in the survey and the majority of the people responded as Yes. It means the people were feeling the shortages of medicines or other products.

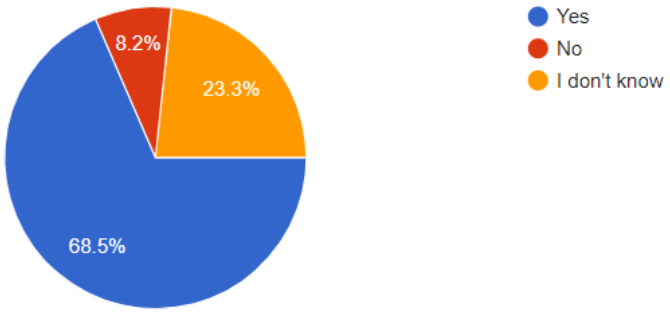

Figure 4.9: Experience of disturbance of PSC

Question 11

If yes, rate the disturbance of Pharmaceutical Supply Chain according to you in between 1-10.

It was important for the research purpose to know the extent disturbance of the supply chain therefore the scale was provided to rate the disturbance. Maximum people felt that there

was disturbance at 8 out of 10 which was significant. Majority of people rated it as 8 which shows the significance disturbance.

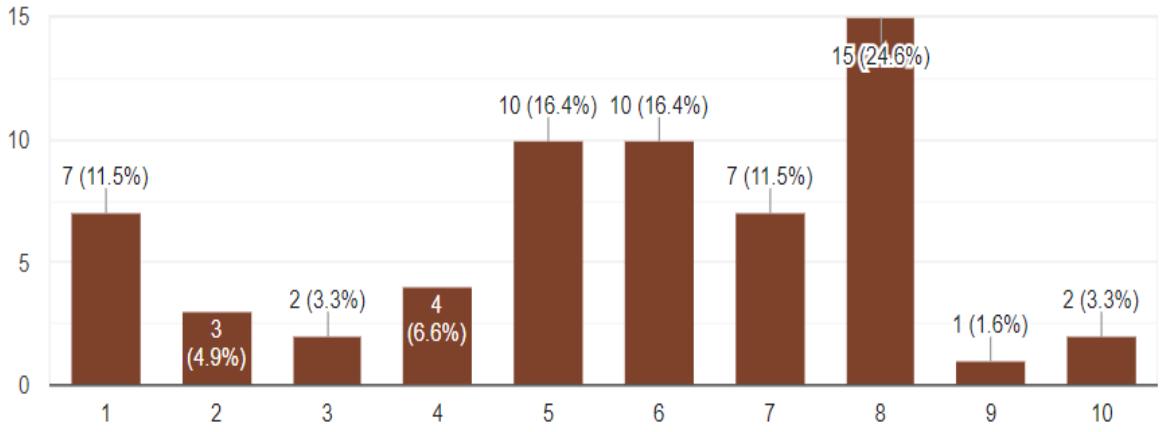

Figure 4.10: Rating for disturbance of PSC

Question 12

Which category of products were in shortage for you from February 2022 when Russia-Ukraine war started?

There were multiple options for the question to choose. Also, free to choose multiple options as there can be demand of different products on daily basis to the person as per the profession/occupation. As per responses obtained, pain killers were rated as being the greatest shortage followed by antibiotics, flu medicines and vaccines (As the Russia-Ukraine war has a temporal relationship with Covid-19 vaccinations). Additionally, other products such as medicines for mental illness, chronic illness were also in shortage in varying degrees.

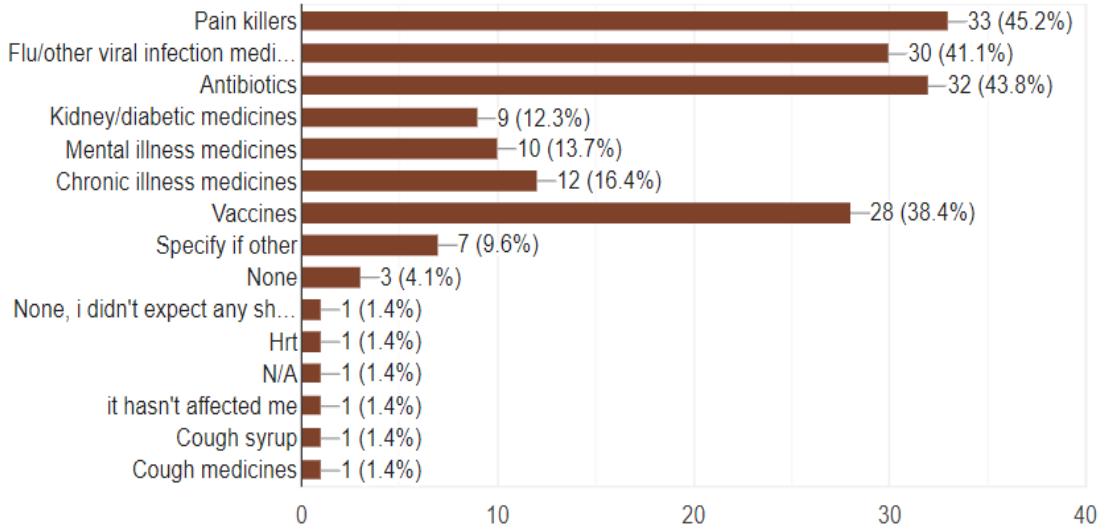

Figure 4.11: Medicines in Shortage

Question 13

Did you feel shortage of products of any other products other than medicines?

It was asked to analyze whether there was a shortage of only medicines or supply chain of other products was also affected. As per the response, It is hardly surprising that nearly all participants was facing shortages in other product categories (other than pharmaceuticals), primarily food and hygiene.

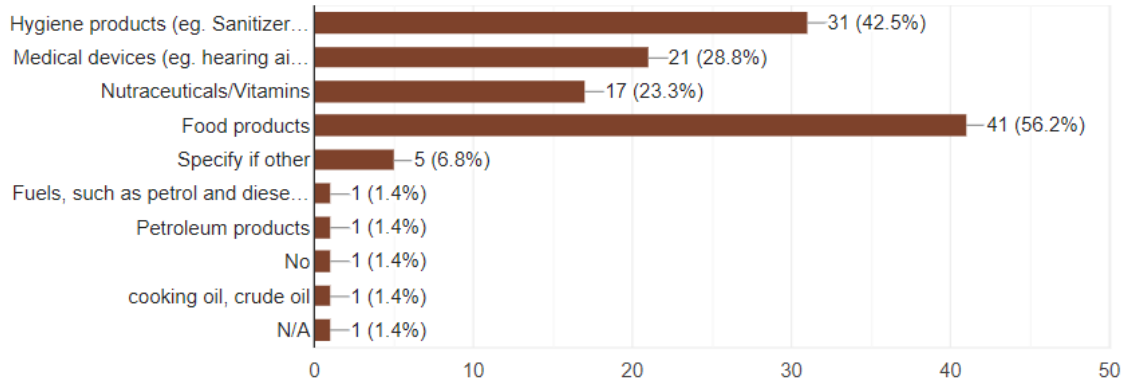

Figure 4.12: Non-medicinal products in shortage

Question 14

Any idea/suggestions about managing shortage of various products in conditions line war or similar emergencies?

This was asked to get ideas from the people about managing the shortages in the crisis. Three were many suggestions from the people especially those who have knowledge of the Pharmaceutical Supply Chain or overall about the supply chain process.

There were ideas/suggestions about managing shortages are summarised as follows:

- Enhance Digitalisation: Enhancing digitalization in the PSC can improve transparency, efficiency, and real-time monitoring, enabling rapid response to future crises. Indeed digital tools can provide end-to-end visibility, reduce wastage, improve inventory management, and ensure timely delivery of drugs to patients in need
- Getting supplies from Asian countries if possible: Utilizing the fact that several Asian nations, including China and India, produce goods of high quality at affordable prices can always be advantageous for pharmaceutical or other businesses.
- Creating free trade agreement with maximum countries: Free trade fosters a competitive environment for customers where nations compete to offer their resources at the most affordable costs. As a result, producers are able to offer finished goods at lower prices, ultimately giving all consumers more purchasing power.

Statistical tests

Statistical tests were performed using Datatab software. Microsoft excel sheet of survey response was imported into the software and the groups or factors were compared to check whether these factors are responsible for responses or whether they are related. Accordingly, interpretations were drawn.

1. Test for significant relationship between Gender and if People think that there was a disturbance in Russia-Ukraine war

Level of significance 0.05

Observed frequencies

		Do you think that Pharmaceutical Supply Chain was disturbed due to the Russia-Ukraine war?			
		Yes	No	I don't know	Total
Gender	Male	30	3	6	39
	Female	23	3	11	37
	Total	53	6	17	76

Expected frequencies

		Do you think that Pharmaceutical Supply Chain was disturbed due to the Russia-Ukraine war?			
		Yes	No	I don't know	Total
Gender	Male	27.2	3.08	8.72	39
	Female	25.8	2.92	8.28	37
	Total	53	6	17	76

Chi Square test

Chi^2	2.34
Df	2
P	.31

The result of the chi-square test indicates that there is no significant relationship between gender and the perception of disruption in the Pharmaceutical Supply Chain due to the war among the general public.

Interpretation: The finding may indicate that the Russia-Ukraine war's impact on the Pharmaceutical Supply Chain was perceived similarly across different genders. However, it's important to note that this result only applies to the specific population surveyed and may not be generalizable to other populations or contexts.

2. Knowledge of Pharmaceutical Supply Chain (Have you heard about PSC) and they think whether PSC was disturbed during the war.

Level of significance 0.05

Observed frequencies

	Do you think that Pharmaceutical Supply Chain was disturbed due to the Russia-Ukraine war?			
	Yes	No	I don't know	Total
Have you heard about Pharmaceutical Supply Chain? Just have an idea	11	1	4	16
Yes	38	5	7	50
No	4	0	6	10
Total	53	6	17	76

	Do you think that Pharmaceutical Supply Chain was disturbed due to the Russia-Ukraine war?			
	Yes	No	I don't know	Total
Have you heard about Pharmaceutical Supply Chain? Just have an idea	11.16	1.26	3.58	16
Yes	34.87	3.95	11.18	50
No	6.97	0.79	2.24	10
Total	53	6	17	76

Chi Square test

Chi^2	10.62
df	4
p	.031

There was a statistically significant relationship between the people who have knowledge of Pharmaceutical Supply Chain and their thoughts as the disturbance in Pharmaceutical Supply Chain.

Interpretation: To claim that there was a disturbance, it is crucial to understand the Pharmaceutical Supply Chain. According to the survey results and the Chi square test, consumers could indicate that there was a disruption in the supply chain because they were aware of the PSC.

3. Rate yourself in knowledge of PSC and they think whether PSC was disturbed

Level of significance 0.05

Observed frequencies

	Do you think that Pharmaceutical Supply Chain was disturbed due to the Russia-Ukraine war?			
	Yes	No	I don't know	Total
Rate yourself in the knowledge of Pharmaceutical Supply Chain	1 (Negligible)	15	0	10	25
	2 (Certain Knowledge)	22	3	4	29
	3 (Good)	16	2	2	20
	4 (Expert)	0	1	1	2
	Total	53	6	17	76

	Do you think that Pharmaceutical Supply Chain was disturbed due to the Russia-Ukraine war?			
	Yes	No	I don't know	Total
Rate yourself in the knowledge of Pharmaceutical Supply Chain	1 (Negligible)	17.43	1.97	5.59	25
	2 (Certain Knowledge)	20.22	2.29	6.49	29
	3 (Good)	13.95	1.58	4.47	20
	4 (Expert)	1.39	0.16	0.45	2
	Total	53	6	17	76

Chi square test

Chi^2	15.47
df	6
p	.017

There was a statistically significant relationship between ‘rate yourself in the knowledge of Pharmaceutical Supply Chain’ and ‘do you think that Pharmaceutical Supply Chain was disturbed due to the Russia-Ukraine war?’

Interpretation: Knowledgeable respondents had a favourable response when asked about the disruption of the supply chain during the Russia-Ukraine war. Most respondents with specific PSC knowledge and a sizable portion of all respondents chose "Yes" when asked whether the supply chain should be disrupted.

Findings and Analysis of a survey for Pharmacies

Pharmacies are the market leaders in the healthcare industry because they are the first place that customers go when they have any problems, from slight discomfort to serious illnesses. Therefore, it was essential to understand the difficulties the Pharmacies are encountering amid the Russia-Ukraine war.

The survey which was carried out for Pharmacies/related warehouse or workers/retail shops. 8 Pharmacies replied to the survey and showed following data.

After the introductory questions following main questions were asked.

Question 1: Was there disturbance in Pharmaceutical Supply Chain due to the Russia-Ukraine war?

From the responses, 100 per cent responders responded that there was disturbance in Pharmaceutical Supply Chain.

Question 2: Rate the disturbance of Pharmaceutical Supply Chain during the Russia-Ukraine war on the scale of 1 to 10.

To rate the disturbance of Pharmaceutical; supply chain, responders responded as follows which shows that PSC was disturbed at least at the level of 5 on the scale of 1 to 10.

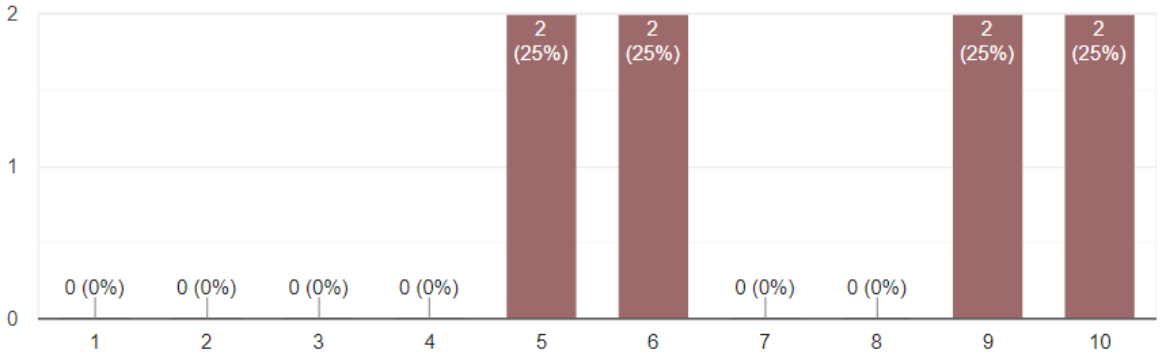

Figure 4.13: Rate of disturbance of PSC by pharmacies

Question 3: Open question was asked to check which medicines were in shortage.

Pharmacies responded that all the essential medicines including OTC (Over-the-counter) and prescription medicines were in shortage. Mainly Pain killers, antipyretics, antibiotics, vaccines, decongestants and eye drops.

Question 4: How you managed the shortage at your level?

In the case of shortage, as a resolution, OTC assistants or Pharmacists asked substitution from prescriber, used closest alternative medication available, told patients to try in other pharmacies or wait if possible, contacted suppliers well in advance for restock.

Question 5: Do you have customers/clients who requires particular medication (like high blood-pressure, diabetes, kidney) medications daily?

All above Respective Pharmacies had regular patients of high-blood pressure, diabetes or kidney diseases. For the availability of such medications when war started they had shortages of those medicines as well.

Question 6: If yes, did you have enough supply of such medicaments for these clients during war? (From February 22)

As per following, 42.9 per cent pharmacies were in shortage and others had enough supply of those medicines.

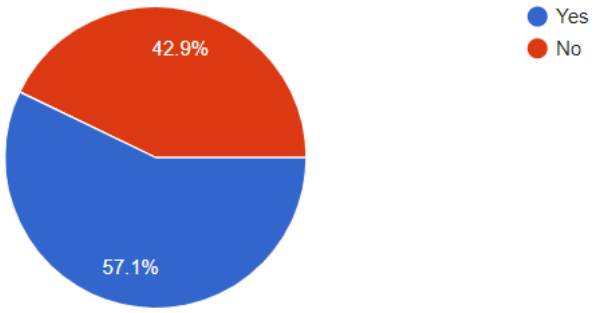

Figure 4.14: Regarding supply of medicines which patients needs on daily basis (in pharmacies)

Question 7: Open question was asked as did you experience shortage of any other supply other than medicines (E. g. Medical devices or PPE kit/masks or any Neutraceuticals/Vitamins or food products or any other)?

Regarding shortages of other products than medicines in Pharmacies, respondents emphasised on shortage of Neutraceuticals, PPE and Covid-19 antigen kits and masks.

Readiness of Pharmacies in such emergencies

Question 8: It was asked that, do you think your organisation/Pharmacy was ready with back-up plans for shortages.

Additionally, regarding readiness of Pharmacies, 37.5 per cent of Pharmacies were ready with back-up plan in such emergencies and 62.5 per cent Pharmacies were not ready.

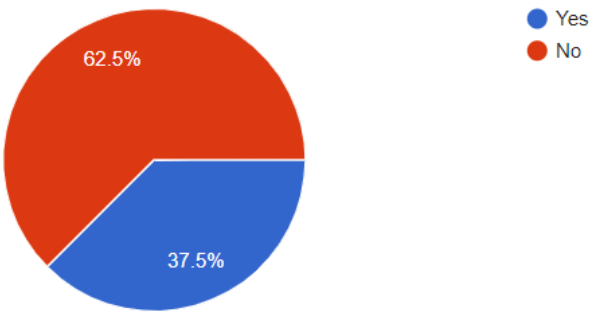

Figure 4.15: Readiness of Pharmacies in crisis

Question 9: What was the strategy at organisational level to manage or avoid the shortage?

For the question related to strategies' at organisational level to manage such crisis Pharmacists responded following:

- Organising alternatives
- Stock-up early
- Giving medicines to the patients for a particular period. For example, give medicines to the patient for a month and not fir 6 months so that other patients should also get those.

For any idea/suggestions Pharmacies responded as follows:

- Better supply and demand planning
- Multiple supply sources
- Keeping connections with core industries
- Using Operational excellence principles

Finding and Analysis of Interviews

An essential part of this research was the interviews with experts in the Pharmaceutical Supply Chain, who provided information on how the Russia-Ukraine War affected the sector. Despite difficulties in recruiting, only 6 out of 22 experts who were contacted agreed to participate, the responses were rich and varied. The interviews' open-ended and adaptable questions allowed for a thorough examination of important topics, such as supply chain

interruptions, coping strategies, and suggestions for fostering resilience. This section summarizes the important findings from the interviews with the six experts (referred to as Participants 1 to 6 in this section).

Out of 22 Participants which were contacted through LinkedIn, 6 were agreed to the interview. 3 participants gave an interview through Zoom call and 3 preferred to fill out the questionnaires as per their availability.

The responses from different interviews were as follows:

Question 1: Country of your work and can you please describe your role, years of experience?

Participant 1 for the study is working in start-up medical devices company in Ireland since four years ago as a Quality and Supply Chain Specialist. Responsibilities include preparing and packaging orders management which includes the creation of sales orders in both QMS (Quality Management System) format and ERP (Enterprise Resource Planning) format with delivery notes. Also, responsible for the coordination of logistic carries. Other responsibilities are related to complaint handling such as CAPA (Corrective and Preventive Actions), DCT (Decentralised Clinical Trials) activities, protocol and report writing.

Participant 2 started career as a stock control analyst, then as a customer planner in a company and looked out Asia, America and Africa regions and Nordic countries (Denmark, Norway, and Sweden) and after a couple of years started working as a supply chain specialist in current company. The company had branches in Limerick and Meath. Responsibilities included looking after inventory for the wholesale division in Dublin, Ireland. Assigning new products location and order management are daily tasks. They work on SAP and if any order is missing coordinate with the customer service team to track and investigate the missing product or resolve discrepancies. Participant 2 leads a group of 3 people in the company, working on order management.

Participant 3 is working in a Private hospital for almost 12 years and as a supply chain manager for the last 5 years in the same hospital. Responsibilities include supply chain management of pathology-related products (Implants, sutures, dressings, anaesthetic items, needles and

syringes and other surgery-related items) and the Pharmaceutical products they order directly from the Pharmacies.

Participant 4 is working in a Pharmaceutical Company based in Ireland and is experienced as an SAP (Systems, Applications and Products in Data Processing) consultant in the Supply chain (Master data specialist) since 4 years ago. Responsible for planning, production maintenance, material management, warehouse management, and the data management related to all these. The company is making packing components like blenders and stoppers.

Participant 5 working in Cork, Ireland as a Lead Supply Chain specialist for warehousing and logistics in a Pharmaceutical Company.

Participant 6 is working in Dublin, Ireland as an International Marketing Supply Chain Analyst and the role's responsibilities include sourcing MRO (Materials needed for routine maintenance, repair and operations) spares for site, inventory Management, Data Analysis for MRO stores sourcing, Spares Creation, as well as routine administrative duties.

These interviews provide a comprehensive view of the impact of the Russia-Ukraine War on the PSC, capturing insights from various perspectives. While the coverage is strong, it is worth noting that additional perspectives from other key players in the industry, such as regulatory agencies and wholesalers, may have provided further depth to the findings.

Interpretation: For the interviews, the researcher has covered 3 Pharmaceutical industry experts (Participant 2, 5 and 6), 1 medical devices company expert (Participant 4) and another from a Start-up Medical Devices Company (Participant 1), and 1 supply chain manager from Hospital (Participant 3), all in Ireland.

Question 2: Do you think that Pharmaceutical/Medical devices supply chain was disturbed due to the Russia-Ukraine war? (Yes/No)

Participant 1 *Yes*

Participant 2 *Yes*

Participant 3 *Yes*

Participant 4 *Yes*

Participant 5 *Yes*

Participant 6 *No major disruption, No for our site*

Interpretation: 83 per cent of participants which means vast majority of people responded as 'YES for the disruption of Pharmaceutical Supply Chain. Participant 6 voted for no/no major disturbance which showed the company should be at the best level in making BCPs. In the opinion of the researcher, as the company is very big and has a good reputation in Pharmaceutical Business. Also, as it is the old company they must have many vendors and contacts in almost all the countries. Also, I feel that the company must have faced many crises in the past and hence was ready enough to face the Russia-Ukraine war and its consequences.

Question 3: If yes, rate the extent of disturbance of Pharmaceutical/Medical devices supply chain from 1 to 10 where 1 is No/minimum disturbance

Participant 1 5-6 (5.5)

Participant 2 8

Participant 3 3-4 (3.5)

Participant 4 7

Participant 5 7

Participant 6 1

The participants described the scenario of a disturbance in their workplaces while responding to follow-up questions demonstrates how significant the disruption was for the businesses.

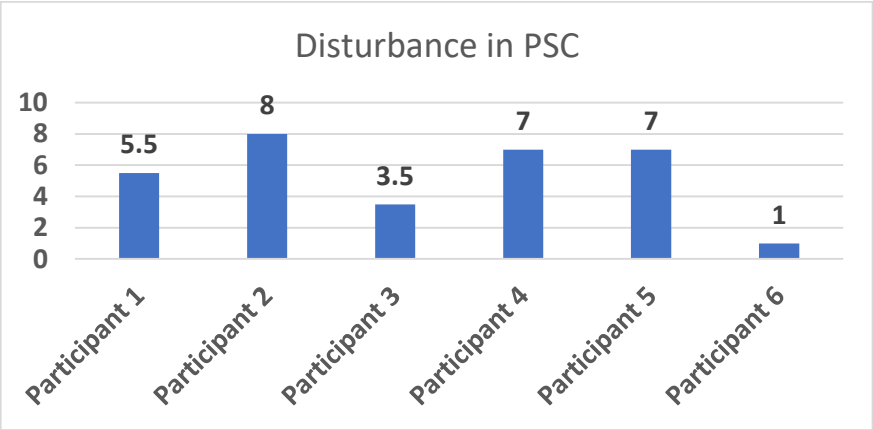

Figure 4.16: Disturbance of PSC rated by Interview Participants

Question 4: What was the scenario during Russia-Ukraine war for your company, hospital, and organisation (From February 22, For example, which type of products were in shortage/processes were affected/wastage?)

Participant 1 *Products such as electrical components i.e. Bluetooth modules, capacitors, LEDs and plastic components used as the shell of our devices (similar to the plastics of a remote control) were in shortage.*

Participant 2 *We previously sold our product directly into Russia. But due to conflict it was decided to choose an intermediate location and it was Slovenia and Lavina and then Russia. But there were transportation issues and fear and high chances of not reaching supply to Russia.*

Participant 3 *Previously if the products used to get delivered in 24 to 48 hours, it used to take a week due to the disturbance*.

Participant 4 *We have some sites in Germany which is our sister site and Germany had many Ukrainian drivers' who went to their families, due to which products were delayed to Ireland due to transportation issues. We were not having enough sterilisable bags which we use for packaging and it was delayed for 22 days (here we lost the shelf life of the product and there was a wastage) and few pellets were damaged during transportation facility, as we changed the transportation vendor which was not good. There was an issue or shortage of Wax as well. We had an issue 5-6 months after the war started, and it lasted for 45 days.*

Participant 5 *Many companies which provide us with single-use consumables are now struggling to acquire small parts that come from Russia, Ukraine and close areas. This means long lead times or shortages for some items*

Participant 6 *As the company has vast vendor relations all over the world there was merely any shortage of material and no operations were halted*.

Interpretation: Above finding shows clearly that, Pharmaceutical firms were not the exception of huge disruption and they had to suffer a lot. For instance, if the shipment generally takes a couple of days there the companies had to wait for a month in some instances and also had wastage of products. Because of such disruption, there was delay for delivery of finished products and further Pharmacies and customer also suffered.

Question 5: From which company/companies/vendor/country the shortage was? How long the shortage lasted?

Participant 1 *EU and US-based vendors and plastic from Asian countries.*

Participant 2 *I was dealing with finished products. So we would ship the API's (Active Pharmaceutical Ingredients) from America to Italy and then from Italy, obviously that they will*

then use them along with the other ingredients needed to make the finished packs. It also happens that people overbuy the products which creates shortages though it's not the case. But then the shortage can be caused by people's perception that there's going to be a shortage. For example, if you remember, around COVID homes, when people would go and buy all the water, there was enough water for everyone, because people were scared that they wouldn't be there now stuck, and started stockpiling those resources. So it's the same kind of constraints or issues you run into in any supply chain.

Participant 3 *After Brexit we had shipping difficulties from the UK so we try to buy products from EU or Irish depots. Even shipping from Germany took a month. But, as we are a Private hospital we have our storage space and buffer space. We can only hold four weeks supply of something, which means every four week we need supply (if there is extra it's difficult to store in our storage space), We also have a lot of stuff coming from Netherland but that was not impacted by the war. May be I think it because we are at the receiving end. In Netherlands there can be issues if they ask APIs from other countries.*

Participant 4 *Germany, Denmark and Poland*

Participant 5 *German companies*

Participant 6 *No Shortage was faced by any vendors or from any country*

Interpretation: The interviews revealed that shortages in the Pharmaceutical Supply Chain affected different countries of origin and were caused by a variety of factors, including shipping difficulties after Brexit, overbuying due to people's perceptions of shortage, and delays in shipping from certain countries. Some participants reported shortages from EU and US-based vendors and plastic from Asian countries, while others cited Germany, Denmark, and Poland as the source of shortages. Interestingly, one participant reported no shortages at all. These results suggest that disruptions in the Pharmaceutical Supply Chain can arise from a range of factors, including shipping delays, stockpiling, and issues in sourcing APIs from certain countries.

Question 6: As a manager/associate, how you handled? Or what was BCP plans?

Participant 1 *The Company was cognizant this time due to previously affected due to Covid-19, we have opted multiple suppliers' especially local one in Covid-19 and we are continuing it*

Participant 2 *The supply chain was Manufacturer was in Italy and then we transported products to above mentioned countries and then Russia. Also, regarding selling we had third party who*

purchased the products from us in Slovenia. So we were securing our supply by third party to avoid certain risks.

Participant 3 *So if we held five boxes or something now, we might be holding seven or eight, and then reordering them just to make sure that we don't run out due to the delivery times been lengthened.*

Participant 4 *There was a wastage for some products and we could not do anything as we lost shelf life of a product which we wanted to use for vaccines.*

Participant 5 *Use an alternative that can be manufactured elsewhere. Rush through the qualification and use under change control*

Participant 6 *No changes were observed and hence no changes were observed in BCP plans*

Interpretation: Companies were already alert due to Covid-19 disruption and were cognizant of it. As a change in BCP plans they opted for multiple suppliers, involved third parties from the country which is out of the conflict (at least to a certain extent), and ordered more products from vendors at a time if they have storage space or they looked for more storage space. Few could not do anything but bear the loss due to the loss of shelf life of their products (Not finished product).

Question 7: Did you preferred any new technologies such as Blockchain? Your opinion about what could be done in your organisation?

Participant 1 Not answered

Participant 2 *The application we use, it didn't differ but we worked with more speed comparatively*

Participant 3 Genesis

Participant 4 SAP

Participant 5 *Not Blockchain. We use SAP as a purchase order platform and then tracking via individual couriers*

Participant 6 *No new technologies were implemented nor considered. The system we have was more than efficient to handle the current processes*

Interpretation: From the above responses, I feel that companies already had to change many plans or procedures internally hence they could not change the technical part as it is difficult to adapt (including training people and getting habituated takes time) as quickly as possible in such

chaos. Hence, companies tried to look for vendors, storage space, etc. rather than changing the software they are using or amending it.

Question 8: Do you think your organisation/hospital is now ready with better back-up or BCP plans/any amendments after war? Rate the readiness from 1 to 10 where 1 is no/least ready

Participant 1 7, *I think in our company we are more aware that supply chain issues may occur again in the future - we were first effected by the covid-19 pandemic and were just getting back on our feet after the long lead times as a result of that and then the war started (or at least was made public knowledge). So I think we are more cognizant of having multiple suppliers – now it's not who has the most competitive price, lead times are now a massive factor. We have started to try and source from local reputable companies who have a stock of components as supply is starting to be as big a factor as cost cutting.*

Participant 2 7.5 *but it is mainly depends on region. If you know that the particular countries can have conflicts or natural prone to natural disaster the supply chain needs to be planned accordingly for safety stock in nearby countries.*

Participant 3 7 *to* 8 (7.5) *as we have all the safety plans in place for natural disaster, bomb threats and annual review of those done every year. Our health and safety systems here are pretty, pretty strong*

Participant 4 5

Participant 5 8 *Yes, project is in progress to dual/multi source all items rather than relying on one supply chain*

Participant 6 10, *We have an efficient BCP plan and we are ready for any situation to come up, Considering Covid and Russia – Ukraine war our current plans worked out very well and I can Say we are fully ready.*

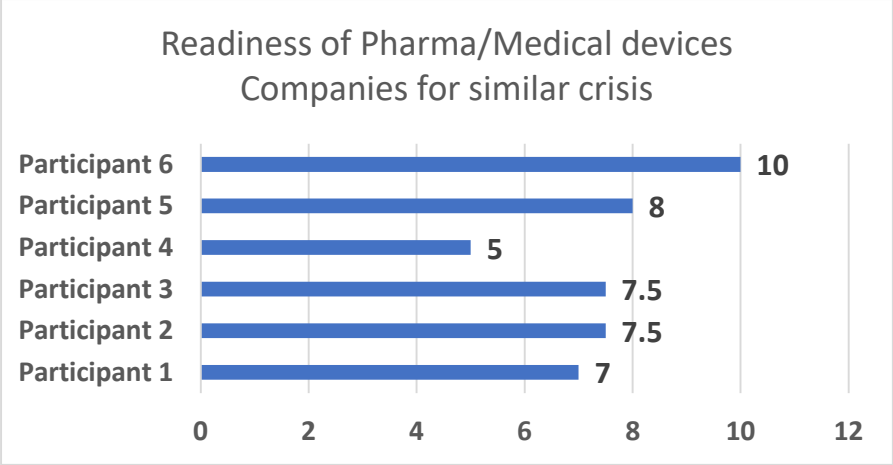

Figure 4.17: Readiness of companies in crisis, rated by interview participants

From the above responses, the researcher feels that the organizations which is a start-up company and which are very old in Pharmaceutical Business could cope well. Because the start-up company is not MNC and they had vendors in a couple of countries only. Also, Old companies which are big players already had a good experience with many crises they were ready to face the war and they amended their way of work as quickly as possible to neutralise the disturbance (though the disturbance was huge for them as well). In contrast, companies that are approximately 5-8 years old suffered as they are already struggling for their quality of products, establishing themselves in the Pharma business well, and just suffered from Covid-19 and Brexit. For them, Russia-Ukraine was a huge crisis and they were not ready as compared to established firms. The hospital in the response was a receiver site and their sender sites are mainly based in the UK, Netherlands, and other parts of Ireland hence it was not very difficult for them to face the Russia-Ukraine crisis.

Question 9: Do you think European countries, and other nations which are actively involved in Pharma business, efficiently collaborated with each other regarding Pharmaceutical Supply Chain during war? What's your opinion about developing countries?

Participant 1 *I wouldn't have insight into this side of things but things are different with us as our company is not MNC but a start-up*.

Participant 2 *Yes. But generally if companies are changing something it takes time to adapt. It may take six or seven months for a change to be enacted. Because there's so much background and back office stuff that happens to make sure all the pre-approval, under trainings and*

understanding on both parties on this case, country sides are implemented, when you're dealing with a speed, it's going to strain that communication because everything is just rushed, rushed, people don't really, maybe are not given an adequate time to really understand the new process and how it works and such you know,

Participant 3 *Yes*. For some products we deal with manufacturers directly and some products to vendors. Many of the manufacturers are in Asian countries as well. If vendors can't help us them only we contact to manufacturers.

Participant 4 *Yes*. *There was no miscommunication or communication gap.*

Participant 5 *I think European countries try to actively collaborate regarding supply chains however securing future business seems to be pretty important to these vendors. Meaning if a big pharmaceutical company is buying consumables from a company with supply chain problems you might decide to purchase elsewhere, which means some vendors might not be as transparent as you would want. As I work in such a highly regulated area, purchasing from developing countries has financial advantages but comes at a cost from a quality perspective.*

Participant 6 *Yes there had been great collaboration from all over and I think developing countries are playing a huge role as majority of raw material and manufacturing is moving to them.*

Interpretation: From the above responses, the researcher feels that all the European countries collaborated well with each other in the war phase and they should keep the same spirit for every crisis.

Question 10: What actions can European/other nations which are actively involved in Pharmaceutical Business take to boost supply chain network and enhance risk management?

Participant 1 *Not answered*

Participant 2 *So nowadays, there is a lot of talk and kind of legislation around falsified medicines, I think it is very, very important for that to continue to be at the forefront, because we don't want, you know, see people taking drugs that are not authentic, because the reward that they're putting their trust in the manufacturer, that obviously, this is going to do what it says. So that's one thing I would say, also building, having the necessary infrastructure in place So, you know, it is about checks and balances, having the right QA systems in place to make sure what's coming in is correct and proper vetting.*

Participant 3 *We have a fairly robust health and safety systems in place, we have very good reporting systems here. So we can monitor how quickly stock is moving, we have our Genesis systems control system which we implemented few years ago. It helps in products traceability, product recalls, and expiry date and for other things.*

Participant 4 *From the perspective of supply chain. Ireland does not have any kind of good logistic companies. If European countries wants to work, they need to make sure that they have the best companies. And that should go smoothly, you know, so that's, that's what I think, from the perspective of supply chain.*

Participant 5 *Communication and flow of information is key. When a batch is being manufactured a delay of a day can cost hundreds of thousands. Currently, buyers are having meet ups and phones calls to figure out vendors supply chains and potential risk. This needs to move away from email/phone and move to something more proactive (system based) rather than reactive.*

Participant 6 *I think efficient inventory management is essential to have adequate supply but also considering storage costs. Also, vendor relationships are important as we should always have a backup supplier from other countries as well as to counter situations like Russia-Ukraine war.*

Interpretation: From the above responses, the researcher can draw a few valuable suggestions from the experts that having a good infrastructure in terms of the right checks, and balances, QA (Quality Assurance) system, reliable software for traceability and record keeping, good communication platforms to avoid many phone calls, and emails for the same thing, efficient inventory management and vendor relationships, backup/multiple suppliers are the key to survive in such crisis. Additionally, one expert also suggested having a good and more number of logistic companies based out of Ireland can make a difference.

From all above survey findings and interviews it is concluded that, the Russia-Ukraine war undoubtedly caused a significant disruption in the Pharmaceutical Supply Chain and other items. From the general public, which relies on pharmacy shops for all of its medical needs, to the large pharmaceutical companies, which had to relocate their clinical trial participants to other nations in order to continue those studies, pharmacy assistants and other related

warehouse workers struggled mightily to meet the needs of all the patients waiting for the medications.

Chapter 5: Conclusion and recommendations

The conclusion drawn from all the evidence and analysis is that the unexpected Russia-Ukraine war crisis developed as the general public was recovering their health, emerging from the depressive lockdown, reuniting with friends and family, and attempting to resume normal life as before which is fear free, and it once more disturbed everyone from the general public to large firms who were serving them with the big question as 'what to do next'?

Due to the fact that the crisis was very different from the effects of Brexit and Covid-19, managing it could be challenging for large corporations and governments in a variety of areas, including transportation infrastructure, public policies, the migration of Ukrainians to Ireland, taking care of hospitality, and most importantly, providing the necessary medications and supplies as soon as possible to those with chronic illnesses.

The research carried out by survey method to know the experience of general public showed that there was a shortage of pain killers (45.2 %), antibiotics (32 %), flu medications (30 %), Kidney and diabetic medicines or Blood pressure medicines (9 %), mental illness (10 %) and chronic illness (12 %) and definitely vaccines (28 %) as there was vaccination planned or going on across the globe and manufacturing and transport of vaccines were at the peak. These figures shows that there was a significant shortage of medicinal products. Additionally, there were many clinical trials that got disturbed, and as the participants from Clinical trials migrated to other countries, the patients did not get the medicines on time and it led to interruption of the trials, as stated in the literature review. Additionally, not only medicinal products but other products such as Food (56.2 %), hygiene products (42.5 %), Medical devices (28.8 %), and nutraceuticals/vitamins (23.3 %) were in shortage with other products in less or negligible amount. A maximum number of people and the people who had knowledge of the Pharmaceutical Supply Chain at least at an certain level responded as 'Yes' to the disturbance of the Pharmaceutical Supply Chain therefore the results can be considered as valid.

All participants report shortages of medicines at the Pharmacy shops in Ireland which indicates that there was an evident disturbance in the supply chain due to the Russia-Ukraine war. It shows that the residents in Ireland including immigrants suffered from shortages of

many products such as medicinal and non-medicinal products. The immigrants who had ailments such as Kidney illness suffered after immigration (Vanholder *et al.*, 2022). Also, as per the result of this research, 100 per cent of pharmacies in Ireland have regular patients with Kidney, diabetes, and other ailments who need to take respective medicines daily. Out of which 42.9 per cent of Pharmacies were in shortage of these medicines during the war highlighting significant scarceness and again proving the disturbance of the Pharmaceutical Supply Chain.

As per the analysis of interviews taken, the supply chain professionals also agreed on the disturbance of the Pharmaceutical/Medical devices supply chain for their firms. As a plan to bounce back, many pharmaceutical firms involved third parties, opted for a different or maximum number of suppliers to avoid the delay, changed the supply chain and implemented it quickly, used an alternative site to manufacture products, and amended the inventory. At the same time, the organizations were quite ready to face the emergencies as they already faced Covid-19 and were vigilant for similar situations. But as both crises were different, Pharmaceutical firms had to suffer. As per the research, companies in Ireland are ready to face such situations quite well now. The average of their readiness is 7.5 as per Finding and Analysis section. It shows that Brexit and crises like Covid-19 and war have made the companies adaptable and agile comparatively to face different situations and to manage the continuity of their business well. But still, there is always a space for improvement and the companies should be flexible enough to manage various emergencies.

It can be deduced from this study that the government plays a crucial role in such crisis. The policies from the government can have flexibility regarding transportation rules in case of emergencies. It should allow immediate access of goods to avoid the delay of raw materials to the company to manufacture the finished products or deliveries of finished products to various organisations.

As per one of the interviewees, there are courier companies in Ireland that could not fulfil their demand as desired. If the government can take the initiative and apply strict rules regarding transport to such companies may be the quality for such companies can be better and firms will get desired transportation facilities. As per the experience of different professionals, it was observed that failure in the supply chain can cause in case of emergency if the company is over depending on the same suppliers for many years, if they are producing

maximum raw materials in the same country which in turn relying on the same country for all the materials with respect to the transport and not adaptable to change.

Technical advancement is a crucial factor in terms of developing a reliable supply chain and companies should implement new technologies for the same. Technologies that have good traceability of products can be a good suit for the supply chain including avoiding counterfeit products which can affect the market and trust in the company for the customers.

Multisectoral engagement is another factor that is essential. Hence, different sectors should be collaborated well with each other for example, Food and Pharmaceuticals for the transport of many materials as it needs the same storage conditions such as cool or cold temperatures. Therefore, collaboration and having a good reputation with other companies can be beneficial in a crisis. There should be collaborative agreements between different industries for situations such as war and others. Moreover, as per the researcher, Ireland could have storage facilities which should be maintained regularly and can be used in such emergencies which can be under control of the government can they can allow various companies to use it in such crisis as per the need.

Limitations

The researcher attempted to reach out to as many people as possible, particularly those of diverse nationalities, however the vast majority of those who answered were from India. Perhaps alternative channels would be used to reach the more number of individuals.

For the survey created for the group which included Nurses, Hospital Pharmacists/other Medical professionals', authorities from the hospitals were contacted but as they are responsible for confidentiality of the patients and other related data therefore it was not possible to get the data from the staff members from various hospitals. Hence the survey (Group 3) was neutralised from the results part.

Scope of further research

If Social Science departments or students can get access to the data from hse.ir and related government organisations or nurses associations and they can conduct the research and

know the challenges faced by the medical staff during the war. Also, if they can reach to Ukrainian refugees in Ireland it is easy to get the idea regarding their challenges during the war and the current scenario. Also, trend analysis can be studied further for each month which can tell that how much time the Pharmaceutical companies exactly took to bounce back the crisis and can study how to reduce the wastage of different materials can be avoided in such situations.

As per opinion of the researcher, the International peace is of utmost important at this time but we can't avoid disputes between few countries or emergencies like tsunami, cyclone, Covid-19 or other related strains, cyber issues, power issues, oil and fuels crises. As each crisis is different, the business continuity plans in various situations should be ready with the companies as they cannot apply same rule for all the crises. Pharmaceutical Supply Chain needs to be more adaptable and nimble than in the past and should always be prepared.

References

Allam, Z. (2022) Resources | Free Full-Text | The Rising Impacts of the COVID-19 Pandemic and the Russia–Ukraine War: Energy Transition, Climate Justice, Global Inequality, and Supply Chain Disruption. Available at: https://www.mdpi.com/2079-9276/11/11/99 (Accessed: 15 February 2023).

Anghel, V. and Jones, E. (2023) 'Is Europe Really Forged through Crisis? Pandemic EU and the Russia – Ukraine War'. Journal of European Public Policy, 30(4), pp. 766–786. DOI: 10.1080/13501763.2022.2140820.

BBC. (2022) 'Ukraine War: Germans Struggle with Influx of Ukrainian Refugees'. BBC News, 30 November. Available at: https://www.bbc.com/news/world-europe-63792498 (Accessed: 19 February 2023).

Cano. (2020) MNEs Struggle to Prepare for Northern Ireland Post-Brexit Compliance - ProQuest. Available at: https://www.proquest.com/openview/712e755106ca0be23caf92a28f21806f/1?pq-origsite=gscholar&cbl=30282 (Accessed: 19 April 2023).

Celi, G. et al. (2022) 'The Asymmetric Impact of War: Resilience, Vulnerability and Implications for EU Policy'. Intereconomics, 57(3), pp. 141–147. DOI: 10.1007/s10272-022-1049-2.

Correia, N. (2019) 'The Impact of Brexit on the UK Pharmaceutical Industry'.

Coyle, D. (2022) 'Ireland's Struggle with Supply of Essential Medicines, as 189 out of Stock – The Irish Times'. Available at: https://www.irishtimes.com/business/2022/12/16/price-is-the-bottom-line-as-ireland-struggles-with-supply-of-essential-medicines/ (Accessed: 26 January 2023).

CSO Ireland. (2020) Health Expenditure in Ireland 2020 - CSO - Central Statistics Office. Available at: https://www.cso.ie/en/releasesandpublications/ep/p-sha/systemofhealthaccounts2020/healthexpenditureinireland2020/ (Accessed: 15 February 2023).

Dhawan, M. et al. (2022) 'Russo-Ukrainian War amid the COVID-19 Pandemic: Global Impact and Containment Strategy'. International Journal of Surgery (London, England), 102, p. 106675. DOI: 10.1016/j.ijsu.2022.106675.

Duthois, T. (2022) Which Countries Are Sending Weapons and Military Aid to Ukraine?. euronews. Available at: https://www.euronews.com/next/2022/03/04/ukraine-war-these-countries-are-sending-weapons-and-aid-to-forces-fighting-the-russian-inv (Accessed: 26 January 2023).

Easton, J. (2022) The Impact of the War in Ukraine on the Conduct of Clinical Trials. Available at: https://4418697.fs1.hubspotusercontent-

na1.net/hubfs/4418697/The%20impact%20of%20the%20war%20in%20Ukraine%20on%20the%20conduct%20of%20clinical%20trials%2C%20Sep-2022.pdf (Accessed: 13 April 2023).

Faggioni, F., Rossi, M. and Sestino, A. (2023) 'Supply Chain Resilience in the Pharmaceutical Industry: A Qualitative Analysis from Scholarly and Managerial Perspectives'. International Journal of Business and Management, 18, pp. 129–146. DOI: 10.5539/ijbm.v18n1p129.

Fatyga, E., Dzięgielewska-Gęsiak, S. and Muc-Wierzgoń, M. (2022) 'Organization of Medical Assistance in Poland for Ukrainian Citizens During the Russia-Ukraine War'. Frontiers in Public Health, 10, p. 904588. DOI: 10.3389/fpubh.2022.904588.

Gereffi, G. (2020) 'What Does the COVID-19 Pandemic Teach Us about Global Value Chains? The Case of Medical Supplies'. Journal of International Business Policy, 3(3), pp. 287–301. DOI: 10.1057/s42214-020-00062-w.

Government of Ireland. (2022) UA10 - Relationships Between Arrivals From Ukraine - Datasets - Data.Gov.Ie. Available at: https://data.gov.ie/dataset/ua10-relationships-between-arrivals-from-ukraine?nocache=true (Accessed: 15 February 2023).

Hervey, T. et al. (2021) 'Health "Brexternalities": The Brexit Effect on Health and Health Care Outside the United Kingdom'. Journal of Health Politics, Policy and Law, 46(1), pp. 177–203. DOI: 10.1215/03616878-8706663.

Hindustan times. (2014) '"Missing" Train Traced after 17 Days in Bihar'. Hindustan Times, 12 September. Available at: https://www.hindustantimes.com/india/missing-train-traced-after-17-days-in-bihar/story-OgKANs32xalyXx89CWRjyL.html (Accessed: 19 February 2023).

Hodson, D. and Quaglia, L. (2009) 'European Perspectives on the Global Financial Crisis: Introduction*'. JCMS: Journal of Common Market Studies, 47(5), pp. 939–953. DOI: 10.1111/j.1468-5965.2009.02029.x.

IFPRI. (2022) Which Countries Are Affected by the Ukraine Crisis? (Data Indonesia) | IFPRI : International Food Policy Research Institute. Available at: https://www.ifpri.org/news-release/which-countries-are-affected-ukraine-crisis-data-indonesia%C2%A0 (Accessed: 19 February 2023).

Isański, J. et al. (2022) 'Social Reception and Inclusion of Refugees from Ukraine. UKREF Research Report 1(2022)'. Available at: https://repozytorium.amu.edu.pl/handle/10593/26829 (Accessed: 26 January 2023).

Jaberidoost, M. et al. (2013) 'Pharmaceutical Supply Chain Risks: A Systematic Review'. DARU Journal of Pharmaceutical Sciences, 21(1), p. 69. DOI: 10.1186/2008-2231-21-69.

Kenaphoom, S. (2021) 'Introduction to Research Philosophy'. 5(4).

Khatua, Apalak. et al. (2021) (19) 'Artificial Intelligence, Social Media and Supply Chain Management: The Way Forward'. Electronics, 10(19), p. 2348. DOI: 10.3390/electronics10192348.

Klinge. (2019) Pharmaceutical Transportation By Air Vs. By Ocean | Klinge Corp. Available at: https://klingecorp.com/blog/ocean-shipping-vs-air-shipping-pharmaceuticals/ (Accessed: 26 January 2023).

Kumar, A. et al. (2020) 'COVID-19 Impact on Sustainable Production and Operations Management'. Sustainable Operations and Computers, 1, pp. 1–7. DOI: 10.1016/j.susoc.2020.06.001.

Lozano-Diez, J., Marmolejo-Saucedo, J. and Rodriguez-Aguilar, R. (2020) 'Designing a Resilient Supply Chain: An Approach to Reduce Drug Shortages in Epidemic Outbreaks'. EAI Endorsed Transactions on Pervasive Health and Technology, 6(21), p. 164260. DOI: 10.4108/eai.13-7-2018.164260.

Mishra, H.P. et al. (2022) (2) 'Drug Development Hit by War'. Journal of Pharmacovigilance and Drug Research, 3(2), pp. 11–15. DOI: 10.53411/jpadr.2022.3.2.3.

Omar, I.A. et al. (2022) 'Blockchain-Based Supply Chain Traceability for COVID-19 Personal Protective Equipment'. Computers & Industrial Engineering, 167, p. 107995. DOI: 10.1016/j.cie.2022.107995.

Pache, G. (2022) 'The Invasion of Ukraine by Russian Troops: A Violent Shock for Supply Chains'. Available at: http://smqnet.com/journals/smq/Vol_10_No_1_June_2022/1.pdf (Accessed: 15 February 2023).

Talbot, A. et al. (2022) 'The Impact of the 2022 Ukraine/Russian Conflict on Cancer Clinical Trials'. Journal of International Medical Research, 50(12), p. 03000605221143284. DOI: 10.1177/03000605221143284.

Tsagkaris, C. et al. (2022) 'Immunization in State of Siege: The Importance of Thermostable Vaccines for Ukraine and Other War-Torn Countries and Territories'. Expert Review of Vaccines, 21(7), pp. 1007–1008. DOI: 10.1080/14760584.2022.2067146.

Vanholder, R., Gallego, D. and Sever, M.S. (2022) 'Wars and Kidney Patients: A Statement by the European Kidney Health Alliance Related to the Russian-Ukrainian Conflict'. Journal of Nephrology, 35(2), pp. 377–380. DOI: 10.1007/s40620-022-01301-4.

Waters, C.D.J. (2003) Logistics: An Introduction to Supply Chain Management. Houndmills, Basingstoke, Hampshire ; New York: Palgrave Macmillan.

Appendix

Survey forms and questionnaires for 2 different groups are as follows:

Survey form for Non-healthcare professionals/General public

War cannot stop us from assisting you

Want to read more about it, please click here

I am over 18, I have read and understood the information and I voluntarily agree to participate in the study. *

- Yes
- No

Gender *

- Male
- Female
- Prefer not to say
- None of the above

Nationality

Short answer text

Age *

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 and above

Highest level of education *

- Diploma
- Bachelors
- Masters
- PhD
- Post-doc

Your main occupation: E. g. student, homemaker, active job, self-employee (please specify job area) *

Short answer text

Have you heard about Pharmaceutical Supply Chain? *

- Yes
- No
- Just have an idea

Rate yourself in the knowledge of Pharmaceutical supply chain *

- ○ 1 (Negligible)
- ○ 2 (Certain Knowledge)
- ○ 3 (Good)
- ○ 4 (Expert)

How did you learn about it? *

- ☐ In school or college
- ☐ By experience
- ☐ Internet/Social media
- ☐ Specify if other

☐ Other...

Do you think that Pharmaceutical supply chain was disturbed due to the Russia-Ukraine war? *

- ○ Yes
- ○ No
- ○ I don't know

If yes, rate the extent of disturbance of Pharmaceutical supply chain according to you, in-between 1 to 10

	1	2	3	4	5	6	7	8	9	10	
Not affected	○	○	○	○	○	○	○	○	○	○	Enormously affected

Which category of products were in shortage for you from february 2022 when Russia-Ukraine war started? (Can choose multiple options) *

- [ ] Pain killers
- [ ] Flu/other viral infection medicines
- [ ] Antibiotics
- [ ] Kidney/diabetic medicines
- [ ] Mental illness medicines
- [ ] Chronic illness medicines
- [ ] Vaccines
- [ ] Specify if other

Did you feel shortage of any other products other than medicines? (Can choose multiple options) *

- [ ] Hygiene products (eg. Sanitizer, masks)
- [ ] Medical devices (eg. hearing aids, contraceptives)
- [ ] Nutraceuticals/Vitamins
- [ ] Food products
- [ ] Specify if other

Any idea/suggestions about managing shortage of various products in conditions like war or similar emergencies? *

Long answer text

Survey for Pharmacies

For the pillars of the Pharmaceutical supply chain

For more information, please click here

Email *

Valid email

This form is collecting emails. Change settings

I have read and understood the information and I voluntarily agree to participate in the study *

- ○ Yes
- ○ No

Gender *

- ○ Male
- ○ Female
- ○ None of the above
- ○ Prefer not to say

Your job role *

- ○ Pharmacist/OTC assistant

- ○ Warehouse worker
- ○ Wholesaler
- ○ Retailer

How much experience you have in this field? *

- ○ Less than 1 year
- ○ 1-5 years
- ○ 6-10 years
- ○ Over 10 years

Have you heard about Pharmaceutical Supply Chain? *

- ○ Yes
- ○ No

How did you learn about it? *

- ☐ In school or college
- ☐ By experience
- ☐ Internet/social media
- ☐ Specify if other
- ☐ Other...

Do you think that Pharmaceutical supply chain was disturbed due to the Russia-Ukraine war? * (from February 2022)

- ◯ Yes
- ◯ No
- ◯ I dont know

If yes, rate the extent of disturbance of pharmaceutical supply chain in your opinion on the scale of 1 to 10 *

	1	2	3	4	5	6	7	8	9	10	
Not disturbed	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Enormously disturbed

Which category of products were in shortage in your organisation? *

Long answer text

Can you specify companies from which the shortage was?

Long answer text

What you did in case of shortage at your level? *

Long answer text

Do you have customers/clients who requires particular medication (like high blood-pressure, diabetes, kidney) medication/s daily? *

- ◯ Yes
- ◯ No

If Yes, did you have enough supply of such medicaments for these clients during war? (from February 22)

- Yes
- No

If No, How you managed the shortage at your level? (Please describe briefly)

Long answer text

Did you experience shortage of any other supply other than medicines (E. g. Medical devices or PPE kit/masks or any Neutraceuticals/Vitamins or food products or any other)? *

Long answer text

Do you think your organisation/Pharmacy was ready with back-up plans for shortages? *

- Yes
- No

What was the strategy at organisational level to manage or avoid the shortage? *

Long answer text

Your personal opinion, idea/suggestions on what strategy organisation can adopt to deal with such emergencies *

Long answer text