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The COVID-19 Pandemic and the Resilience of the Pharmaceutical Supply Chain: Lessons from Past Experiences and Strategies for the Future

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About this report

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1 Original submission

0 comments

No public comments in this round.

2

Revision 1

AUTHORS' RESPONSE TO REVIEWERS

Authors' reply to reviewers

The next pages contain the authors' point-by-point reply to the comments of this revision round, as submitted with the revised manuscript. It is published as the authors wrote it.

To: Editor-in-Chief:

Dear Editor-in-Chief

Thank you so much for the meticulous reviewers' comments. All changes were highlighted. Please find below answers one by one to their questions:

Reviewer 1:
I would like to thank the authors for shedding light on the resilience of the pharmaceutical supply chain during a pandemic situation. The authors have conducted a comprehensive investigation into one of the most pressing global issues, particularly in Iran, where unique economic and political challenges have exacerbated vulnerabilities within the supply chain. By addressing this highly relevant topic and offering actionable insights to enhance supply chain resilience, this work makes a valuable contribution to both academia and industry, providing important lessons for future disruptions.

1. *I believe that small improvements in the manuscript could help with easier comprehension for readers. For example, it would be beneficial to define terms like "ORG" and "PRO" when introducing the vulnerabilities, starting from line 170.*

Reply: Appreciate the nice comments. All were added.

Reviewer 2:

First of all, I would like to thank the editor for giving me the opportunity for reviewing this manuscript and the authors for conducting this research. The research addresses a new topic with a high practical value.

Abstracts:

2. *Conclusion: I suggest the following corrections: According to questionnaires the quantitavie findings, capabilities had a higher score, which could conclude SC in that sector of PSC had better resilience against the pandemic. Concerning Considering contextual focus, mixed-method approaches, comprehensive analysis of vulnerabilities and capabilities, and sector-specific insights, all of which contribute to advancing the understanding of supply chain resilience within Iranian pharmaceutical manufacturing, this study is a novelty and can be promotive for new research in other sectors of PSC.*

Reply: Appreciate for nice comments. All were added.

The main body:

3. *- Lines 64 to 81: I suggest that set these lines in one paragraph. I mean that simply connect the paragraphs.*

4. - Lines 95-96: I suggest the following change:
A resilient pharmaceutical industry can offer accessible, high-quality healthcare services, especially during pandemics.

5. - Lines 106-108:
1. Please match the tense of the sentences explaining the study objectives (two following sentences):
2. Please state the objectives (the two above-mentioned sentences) more clearly; I suggest the following changes:
Consequently, in this study, we tried to recognize the situation of the resilience of the PSC in Iran, during the COVID-19 pandemic. We also aimed to elicit lessons from past experiences and make strategies for the future.

6. - Lines 121-122: I could not understand the sentence; what do you mean by "conversational factors" ? Can you eliminate the word "conversational" ?

7. - Lines 126-131: Move these sentences to the line 116.
8. - Lines 147-149: I suggest the following change:
Ten eligible individuals assessed face and content validity. Participants They provided feedback on elements to be included or excluded from the questionnaire. Finally, all participants agreed upon the questionnaire's suitability (4).

9. - Line 173: Please correct the phrase "Information Technological".
10. - Lines 274,275: I did not understand the sentence "At the end of each row, the test verifies that the response of each pair of occupations is equal for these constructs by a confidence level of 95%.". Is this sentence needed? I suggest that eliminate it.

11.- Table 3: I suggest that report the "Mean Ranks" as a table in the appendix.
12. - Lines 363,364: The sentence seems incomplete. Please revise it.

Reply: I appreciate the nice comments. All of your hints were added.

Checklist Review

1. **STROBE Guidelines for Observational Studies**
- **Title and Abstract**: The title indicates the study's focus on the PSC during the

COVID-19 pandemic. The abstract summarizes the background, objectives, methods, results, and conclusions effectively.
- **Introduction**: The background provides context on the challenges faced by the PSC during the pandemic, particularly in Iran, and clearly states the study's objectives.
- **Methods**:
- **Study Design**: The study is described as a qualitative-quantitative analysis, which is appropriate.
- **Setting**: The study is conducted in Iran during the COVID-19 crisis, but specific locations and dates could be more detailed.
- **Eligibility Criteria**: The criteria for selecting participants (23 PSC specialists and 547 individuals in pharmaceutical manufacturing) are mentioned, but more detail on selection methods would enhance clarity.
- **Data Sources/Measurement**: Qualitative data were collected through interviews, and quantitative data through surveys, with methods of analysis specified (MAX QDA for qualitative and SPSS for quantitative).
- **Bias**: There is no mention of efforts to address potential biases in participant selection or data collection.
- **Statistical Methods**: The statistical methods used for the quantitative analysis are briefly mentioned but could benefit from more detail regarding how confounding factors were controlled.
- **Results**: The results section summarizes findings from both qualitative and quantitative phases, presenting key themes and median scores effectively.
- **Discussion**: The conclusions drawn from the results are discussed, but limitations of the study are not explicitly addressed.

Reply: I appreciate the nice comments. All of your hints were added in each section.

2. **PRISMA Guidelines for Systematic Reviews**
- **Title**: The title does not explicitly identify the study as a systematic review, which may not apply here since the study is not a systematic review.
- **Abstract**: The abstract provides a balanced summary of the study.
- **Introduction**: The rationale for the study is clear, but it does not follow the systematic review structure.
- **Methods**:
- The study does not seem to follow a systematic review methodology, so many PRISMA items may not be applicable.
- **Results**: The results are presented, but again, they do not align with systematic review reporting.
- **Discussion**: The implications for future research are mentioned, but the systematic review context is not applicable.

Summary of Findings
- The study adheres well to many aspects of the STROBE guidelines for observational studies,

particularly in the introduction and results sections. However, it lacks detail in the methods regarding bias and statistical analysis.
- The PRISMA guidelines are not applicable as this is not a systematic review.

Reply: I appreciate the nice comments. However, this study is not a systematic review.

Recommendations
1. **Enhance Methodological Details**: Include more information on participant selection, bias mitigation strategies, and statistical methods used.
2. **Address Limitations**: Explicitly discuss the limitations of the study to provide a balanced view of the findings.
3. **Clarify Study Design**: Ensure that the study design is clearly articulated, especially if it incorporates elements of systematic review methodologies.

This review highlights the strengths and areas for improvement in the reporting of the study, ensuring it meets the necessary standards for scientific rigor and transparency.

Reply: I appreciate for nice comments. All of the comments were added in each section.

The COVID-19 Pandemic and The Resilience of The Pharmaceutical Supply Chain: Lessons from The Past Experiences and Strategies for Future

Abstract

Background: The Pharmaceutical Supply Chain (PSC) faced many challenges, especially during the Covid-19 crisis. Because of the supply chain's vulnerabilities, it needs capabilities to deal with them. In Iran, special economic and political issues have intensified the vulnerabilities of the PSC.

Objectives: This study investigates the issues that the COVID crisis caused in the PSC, characterizes them, and then recommends the appropriate courses of action to address supply chain disruptions in the future.

Methods: This is a qualitative-quantitative analysis study conducted in Iran during the COVID-19 crisis. Qualitative thematic analysis was performed from July 2022 until May 2023. Semi-structured, in-depth, face-to-face interviews with 23 Iranian PSC specialists were

implemented until saturation was reached. The qualitative phase was analyzed by The MAX QDA 2021. The quantitative phase intersected with a survey of 547 individuals working in pharmaceutical manufacturing in Iran. The questionnaires were analyzed by IBM SPSS 26.
Results: The research results in the qualitative phase achieved 2 main themes including Vulnerabilities and Capabilities and fifteen subthemes for a solution to enhance the resilience nature of the pharmaceutical chain. In the quantitative phase by 64 questionnaires, findings highlight major vulnerabilities and capabilities to make a resilient supply chain. The total vulnerabilities' median score was 5.12 and the total capabilities' median score was 5.39.
Conclusions: According to questionnaires, the quantitative findings, capabilities had a higher score, which could conclude SC in that sector of PSC had better resilience against the pandemic. Considering contextual focus, mixed-method approaches, comprehensive analysis of vulnerabilities and capabilities, and sector-specific insights, all of which contribute to advancing the understanding of supply chain resilience within Iranian pharmaceutical manufacturing, this study is a novelty and can be promotive for new research in other sectors of PSC.
Key Words
Covid-19, Pharmaceutical Supply Chain, Resilience, Vulnerabilities, Capabilities

1. Background

Today's competition is no longer between companies but between their respective supply chains (SCs) (1). SC refers to an elaborate system of linked organizations for delivering products, services, money, and information from suppliers to customers (2).

The pharmaceutical supply chain (PSC) manages the transformation of raw materials into finished products and their distribution to end buyers (timely delivery of essential drugs in compliance with standards)(3). The PSC must be highly flexible (because of health or safety risks due to breakdowns or defects) and require continuous tracking systems to maintain the uninterrupted flow of essential goods (4).

Every process and decision within an organization is exposed to uncertainty in the business environment. While procedure errors cause unexpected events due to incorrect computations and judgments, these doubts call for continuous monitoring and management. Late recognition of such happenings may have significant impacts (5). There are no secure systems worldwide, including the PSC (4).

The pharmaceutical sector faces various challenges, particularly in marketing, research and development (R&D), pharmaceutical lifecycle management, government regulations, patent durations, production expenses, and SC management. Among the intricate nature of competition, the resiliency of the SC has particular importance (4).

Resilience is defined as the inherent capacity, capability, and skill of a system to endure, evolve, and prosper while confronting tumultuous changes or the ability of the system to survive and change to new situations. Of course, the system grows even in chaos (6).
Resilience in SC management is a key skill and involves managing risks, opening more than one distribution path for suppliers, and friendship with stakeholders (7). Supply chain resilience (SCR) denotes the SC's capability to absorb changes efficiently without much trouble while staying afloat amidst uncertainties and unforeseen hitches. It implies bouncing back after disturbances and carrying out routine operations with little harm (8). The strength and durability of a company’s operations are closely linked to the resilience of its SC. Because a company relies on its suppliers for uninterrupted processes and on its customers for sustained revenue, the robustness of the entire SC directly influences its overall resilience (9).

The ideas of SCR have gained more attention because of the growing challenges in SCs such as different global happenings, disasters, and emergencies. (10)

Several novel contagious diseases during the last thirty years have badly affected public health and safety systems. By incorporating resilience into health systems, the adjustment capacity and reaction to emerging health hazards are substantially enhanced, thus the system’s ability is reinforced to sustain operations and effectively counteract new health threats (11). During COVID-19, businesses were disrupted everywhere, and most importantly, the global SC. Over 94% of Fortune 1000 companies reported SC disruptions caused by the pandemic. Nearly all companies, particularly multinational corporations (MNCs), experienced problems related to SC disruptions. The pandemic disrupted the chain supply, demand, and logistics dimensions.

Production shutdowns in countries that were the cornerstone of global production networks led to shortages in items from hand sanitizer to surgical masks (12). The abrupt lockdowns, border closures, and the prohibition of movement caused many logistical problems (13, 14). Many MNCs tried to modify their SC strategies, from global to domestic so local suppliers integrated into the global value chain (15, 16).

Scholars agree that SCs need to be more flexible to cope with the volatility and variety of disruptions (17, 18). Such SCs would be more responsive, reducing uncertainty and risk and addressing a wide range of the disruptive effects that occurred as a result of the COVID-19 pandemic. Stock policies should be adjusted to the ever-changing business conditions developed during the pandemic (13, 15). It is essential to do a detailed analysis of COVID-19 pandemic-related disruption across the SC and how it impacts this. We should notice the complexity of the situation and the confusion due to the pandemic. Furthermore, a comprehensive view of the disruptions caused by the COVID-19 pandemic and its implications on the whole SC environment is required (19).

The COVID-19 pandemic exerted a substantial impact on the pharmaceutical sector in low-income countries, particularly limiting access to high-quality and affordable medications (20, 21), and negatively affecting the socioeconomic status and livelihoods of people in these societies (22). Moreover, it was imperative to improve medication accessibility in areas with limited resources (20, 21).

A resilient pharmaceutical industry can offer accessible, high-quality healthcare services, especially during pandemics. As highlighted by recent events, PSC may experience severe disruptions for various reasons. For example, many barriers may prevent the development and advancement of innovative technologies, including oversubscription to traditional manufacturing and distribution channels, such as China and India, which results in the vulnerability of the global SC rendering (23, 24). In pandemics, PSC is responsible for administering advanced SC management systems to resist disruption and ensure a dynamic flow of high-quality pharmaceutical products. It is also suggested that the pharmaceutical industry diversify manufacturing and distribution routes. Thus, when these routes are temporarily or completely unavailable, the firms do not suffer (24).

COVID-19 was the most notable crisis in the last few years. Considering the significant impact of the pandemic on the PSC and recognizing the necessity of mitigating risks posed by other unpredictable events in the future, resilience is the most important factor. Consequently, in this study, we tried to recognize the situation of the resilience of the PSC in Iran, during the COVID-19 pandemic. We also aimed to elicit lessons from past experiences and make strategies for the future.

2. Methods

The present mixed-method research was carried out in 2022-23 in Iran. The quantitative phase was undertaken in a survey as a self-administered questionnaire derived from the qualitative phase and completed by 547 eligible participants. In order to eliminate the bias of the study, a purposive sampling method was used in the qualitative phase, and the questionnaire was designed and approved by PSC experts.

2.1. Qualitative phase

We initiated semi-structured interviews with experts according to the Pettit et.al resilience framework (8). 23 individual face-to-face interviews were held with the inclusion of subjects meeting the defined inclusion criteria from July 2022 until May 2023 in Tehran, Iran. The inclusion criteria are purposive sampling. Participants in the study included health policymakers, insurance experts, raw material suppliers, pharmaceutical company managers, distribution company managers, and pharmacists in both public and private pharmacies with a minimum of five years of practice and a well-established national reputation as authorities in the relevant field. To choose individuals who would cover the greatest diversity, purposive and snowball sampling techniques were used. Sampling continued until data saturation.

Concept of resilience in the SC:

1. Vulnerabilities: factors that dispose an organization to disruption

2. Capabilities: characteristics that empower an enterprise to navigate and surmount disruptions, thereby sustaining the functionality of its SC (8).

Interviews identified factors related to vulnerabilities and capabilities based on Iran's special conditions.

The investigation and dissemination of this study were conducted using the standards for reporting qualitative research (SRQR) (25) and the consolidated criteria for reporting qualitative research (COREQ) (26) as the instruments.

Firstly, in-depth, semi-structured interviews were held with the first author, M.A.A, in a face-to-face setting, using a pre-tested interview guide. This guide consisted of 14 questions on the resilient PSC in Iran during the COVID-19 crisis. Each interview lasted an average of 75 minutes.

Data collection was done concurrently with its analysis following thematic analysis. Goldsmith's five-step framework analysis method was applied to the data analysis (27). Guba and Lincoln's four standards were applied to determine the validity of data (28). The software utilized for analyzing data was MAX QDA 2020.

2.2 Quantitative phase

A cross-sectional survey was employed in 32 top pharmaceutical manufacturing companies by market share to collect data in this phase using a self-administered questionnaire from June 2023 until December 2023 in Iran. The final questionnaire consisted of 64 questions. According to Pettit et.al (8) and Ekanayake et.al (29), the two main components of the questionnaire were vulnerability and capability (Included 32 questions divided into seven and eight categories). The questionnaires were sent to senior managers, technical managers, marketing department, commerce department, technical/engineering department, finance department, R&D department, production department, quality assurance, and quality control departments. Data were measured using the 7-point Thurstone scale. Some questions aimed at gathering the respondents' demographics (Appendix 1).

Before conducting the survey, a pilot study was conducted. Cronbach's alpha indicated an acceptable internal consistency (Appendix 2). Ten eligible individuals assessed face and content validity. They provided feedback on elements to be included or excluded from the questionnaire. Finally, all participants agreed upon the questionnaire's suitability (4).

To determine the number of participants in the quantitative phase, Cochran's formula was used and at least 385 people were required. So, we distributed questionnaires to 960 jobs, and 547 responses were received, achieving a 57% response rate. The questionnaires were analyzed using SPSS software (version 25).

3. Result

3.1. Qualitative phase

The interviewees consisted mainly of CEOs of manufacturing and distribution companies, officials of the Food and Drug Organization, the Vice President of Food and Drug at one of the Universities of Medical Sciences, board members of the Syndicate of Human Drug Industry Owners, and the Syndicate of Pharmaceutical Active Ingredients Manufacturers, managers of certain insurance companies, members of the Iranian Pharmacists Association, and managers of public and private pharmacies. Respondents ranged in age from 39 to 69 years. All participants were male, and most had a degree in pharmacy, with a few holding a PhD in pharmacy.

The findings determined vulnerabilities and capabilities that represent main themes, and include 15 subthemes (seven vulnerabilities, eight capabilities) related to the resiliency of PSC during the COVID-19 crisis. Additionally, various codes were identified to denote coping strategies to enhance resilience within the PSC. Examples of the interviewees' sentences (Appendix 3):

3.1.1 Vulnerabilities

1. Organizational (ORG)

This refers to the organization's inability to establish protocols and efficiently manage its workforce.

2. Information Technology (IT)

It is associated with limited and slow access to information, as well as incompetent information technology (IT) infrastructure.

3. Procedural (PRO)

It refers to failings in the planning, implementation, or achievement of results, as well as interruptions in transportation. A few PSC members highlighted planning gaps, and sometimes have worked over twenty years, in senior positions in the programs. In a related context, it is important to note that discussions on how goods are delivered are mostly aimed at the pharmaceutical industry in Iran and other parts of the world.

4.Financial (FIN)

This particular category embraces extreme events that are likely to cause financial distress to businesses, among which can be currency fluctuations and lack of liquidity. A notable point is

the fact that during the pandemic, distributors wanted to buy drugs mainly from manufacturers of COVID-19 therapeutic agents.

5. Control / Supportive (C/S)

This category is associated with insufficiency in the oversight and support provided by policy-making bodies.

Unfortunately, for a variety of reasons, there were problems with the surveillance of commodities.

6. Supplier / Customer (S/C)

This category includes vulnerability related to suppliers and customers, with factors such as lack of trust between suppliers or customers, involvement of inadequate staff, including product or contract fraud, and supply and demand mismatches.

7. Environmental / External (E/E)

Frequent changes in external factors beyond the control of the firm may impose effects that are not directly aimed at the organization but impose restrictions or constraints on the firm's operations (8).

The welfare and health of the target population may be compromised by economic constraints. In the case of Iran, the findings of the literature review indicated that the sanctions had worsened the lives of the country's population through negative impacts on the affordability, availability, and quality of medical care.

3.1.2 Capabilities:

1. Flexibility (FLX)

Flexibility includes the ability to mobilize resources when needed quickly. Either the order fulfillment process or the sourcing process can be used to demonstrate flexibility (8).

This can replace the resources, apply innovations, provide a system responsible for temporary changes, and be capable of different orders.

2. Agility (AGL)

The capacity to promptly adjust to modifications, either by restoring the initial condition or by rearranging the system (30, 31). Agility cannot be constrained to a single firm; it must be present throughout the SC (2).

3. Visibility (VSB)

The capacity to look into a complete SC comprehensively (2). The implementation of successful risk mitigation methods is contingent upon enhanced visibility throughout the entire chain (32). Furthermore, another critical factor contributing to visibility within SCs is the monitoring signs of change in the market.

4. Redundancy (RDN)

This involves utilizing inventory and capacity strategically so that they can be used in the case of an interruption (2). To enhance resilience, it is essential to increase SC redundancy (33). This includes some issues such as the existence of several suppliers, the possibility of moving between them, benefiting from safe reserves, and controlling market fluctuations by excess inventory.

5. Market position (MP)

It refers to a company's or its products' standing in particular marketplaces (8).

One of the subfactors is customer loyalty, which goes beyond simply serving as a gauge for future purchase intentions. In addition to serving as an indicator of potential repurchases, customer loyalty also acts as a buffer against lost sales during disruptions and aids in the recovery of lost revenue. Various surveys across diverse industries consistently demonstrate that retaining an existing customer is financially more advantageous, typically five to seven times more than acquiring a new customer (34).

6. Adaptability (ADP)

The ability to re-route when confronted with new possibilities or challenges. Those companies that are flexible, respond and manage changes better, and maybe act appropriately (35).

7. Financial strength (FS)

The skills for dealing with fluctuations or money incomes and outflows (8). For market advancement, maintaining a strong cash flow through the upkeep of financial reserves and money is essential (36). Despite the uncertainty, this improves SC performance (37).

8.Collaboration (COL)

It is a key component of SC capabilities for SCR and is described as the capacity to cooperate effectively with others for their mutual benefit (37).

Governments have also urged private businesses across various industries to modify their production methods to produce medical and respiratory equipment in response to the COVID-19 pandemic. Furthermore, to guarantee that developing countries have fair and creative access to

COVID-19 diagnosis tools, treatments, and vaccinations, UNICEF collaborates with governments and the commercial sector (38).

3.2 Quantitative phase

The Thurstone scale included seven points, where '1' represented the lowest value and '7' the highest value, for the respondents' answers. Consequently, if the median score is above 4.0 was regarded as a positive score, which means valuable opinions. Table 1 summarizes the statistics for the vulnerabilities and capabilities. Mean, median, mode, and standard deviations were calculated by taking the average for the respective constructs.

Table 1: Descriptive Statistics of Research Constructs

Main constructs	Constructs	Numbers		Mean	Median	Mode	Standard Deviation
		Valid	Missing				
Vulnerabilities	Total	547	0	4.97	5.12	5.12	0.88
	ORG	547	0	4.30	4.50	5.00	1.10
	IT	547	0	6.30	6.00	6.00	2.34
	PRO	547	0	5.00	5.33	5.50	1.10
	FIN	547	0	5.70	5.75	7.00	1.08
	C/S	547	0	5.13	5.50	5.75	1.07
	S/C	547	0	4.75	5.00	5.00	1.03
	E/E	547	0	4.82	5.00	5.50	1.06
Capabilities	Total	547	0	5.14	5.39	4.95	0.99
	FLX	547	0	4.79	5.00	5.40	1.07
	AGL	547	0	5.27	5.33	6.00	1.26
	VSB	547	0	5.04	5.25	5.50	1.17
	RDN	547	0	5.08	5.25	6.50	1.23
	MP	547	0	5.23	5.33	6.00	1.26
	ADP	547	0	5.32	5.50	5.00	1.10
	FS	547	0	5.54	6.00	6.00	1.17
	COL	547	0	4.89	5.00	4.50	1.05

Note: ORG: Organizational, IT: Information Technology, PRO: Procedural, FIN: Financial, C/S: Control-Supportive, S/C: Supplier-Customer, E/E: External-Environmental, FLX: Flexibility, AGL: Agility, VSB: Visibility, RDN: Redundancy, MP: Market position, ADP: Adaptability, FS: Financial Strength, COL: Collaboration.

According to the Kolmogorov-Smirnov test, the data have a non-normal distribution (all constructs: sig = 0.000) (Appendix 4); therefore, using the median to check the data is preferable. Based on the questionnaire, all constructs have a median score above 4 in the vulnerabilities and capabilities sections. Specifically, in the case of vulnerabilities, IT (6.00) scored the highest, followed by FIN (5.75), C/S (5.50), PRO (5.33), S/C (5.00), E/E (5.00), and ORG (4.50). In terms

of capabilities, FS (6.00) was rated the highest, followed by ADP (5.50), AGL (5.33), MP (5.33), VSB (5.25), and RDN (5.25). The lowest scores were for FLX (5.00) and COL (5.00).

As shown in Table 1, a general examination of vulnerability and capability reveals that respondents placed a higher value on capability (5.39) than vulnerability (5.12).

The results of this table suggest that individuals involved in the pharmaceutical manufacturing firms in Iran place the second highest value on financial vulnerability. In contrast, financial strength is the most valued of the capabilities.

As shown in Table 2, the non-parametric Kruskal-Wallis test was used to check whether each part of the vulnerabilities and capabilities was different in each occupational sector.

Table 2: Kruskal-Wallis test

Main constructs	Constructs	**Test Statistics** [a,b]		Asymp. Sig.
		Kruskal-Wallis H	df	
Vulnerabilities	ORG	11.33	5	0.05*
	IT	17.32	5	0.00*
	PRO	12.28	5	0.03*
	FIN	10.52	5	0.06
	C/S	2.30	5	0.81
	S/C	12.69	5	0.03*
	E/E	11.28	5	0.05*
Capabilities	FLX	6.61	5	0.25
	AGL	9.84	5	0.08
	VSB	15.22	5	0.01*
	RDN	19.47	5	0.00*
	MP	22.55	5	0.00*
	ADP	29.95	5	0.00*
	FS	30.95	5	0.00*
	COL	8.91	5	0.11

Note: a. Kruskal Wallis Test; b. Grouping Variable: occupation; c: *P≤0.05

The ORG, IT, PRO, S/C, E/E, AGL, VSB, RDN, MP, ADP, and FS results are considered significant (sig. < 0.05). This means that they are distinct from the occupational domain.

As shown in Table 3, the Mann-Whitney test makes it possible to compare each pair of occupations across the ten constructs (Appendix 5).

Table 3: Mann-Whitney test

Occupations \ Constructs	Sig.									
	ORG	IT	PRO	S/C	E/E	VSB	RDN	MP	ADP	FS
Commerce Marketing	**0.07**	0.05	0.01	0.02	0.00	0.01	0.00	0.01	0.01	0.00
Commerce Finance	0.00	0.04	0.00	0.04	**0.07**	0.01	0.01	0.00	0.01	**0.06**
Commerce Technical/Engineering	0.02	0.02	0.03	0.05	0.00	0.03	0.00	0.00	0.00	0.00
Commerce QC	0.00	0.00	0.03	0.00	0.02	0.01	0.01	0.00	0.00	0.02
Commerce Production	0.05	**0.07**	0.00	0.03	0.02	0.05	0.01	0.00	0.00	0.01
Marketing Production	**0.06**	0.05	0.03	0.05	0.00	0.00	0.04	0.04	**0.06**	0.03
Finance Production	0.00	0.04	0.02	0.01	0.02	0.02	0.04	0.04	0.01	0.02
Production Technical/Engineering	0.01	0.03	0.00	0.02	0.03	0.02	0.03	0.01	0.04	0.00
Production QC	0.01	0.00	0.00	0.00	**0.06**	0.02	0.00	0.04	0.00	0.00
Marketing QC	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.00	0.00
QC Finance	0.01	0.00	0.02	0.01	0.02	**0.06**	0.00	0.02	0.00	0.01
QC Technical/Engineering	**0.06**	0.00	0.05	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Technical/Engineering Marketing	0.01	0.02	0.01	0.01	0.01	0.02	0.04	0.01	0.04	0.01
Technical/Engineering Finance	0.01	0.05	0.01	0.05	0.00	0.00	0.03	0.03	0.00	0.00
Finance Marketing	0.00	0.03	0.05	0.01	0.00	0.00	0.04	0.02	0.02	0.01

The results indicated that within the organization construct, the responses for the three job pairs including the commerce-marketing, the marketing-production, and the QC-technical/engineering job pair were different. The commerce-production job pair displayed a different reaction concerning the technology construct. Other constructs are the external/environmental construct in two job pairs including the commerce-finance, and the production-QC, the visibility construct in the QC-finance job pair, the adaptability construct in the marketing-production job pair, and the financial strength construct in the commerce-finance job pair.

4. Discussion

The study's results revealed PSC's flaws and problems during the COVID-19 pandemic and proposed ways to strengthen PSC's resilience, especially for manufacturers. These flaws affected every aspect of the PSC and led to a broad view in this field, which is why these deficiencies were used in this study to increase the PSC's resilience in the pharmaceutical industry sector. The sub-themes and codes that were emphasized in the interviews also achieved high scores in the quantitative phase. This unity between the qualitative and quantitative phases demonstrates the robustness and accuracy of this study.

The result from Table 1 showed a higher value for capabilities (5.39) against vulnerabilities (5.12), which represented the SCR in pharmaceutical manufacturing companies was acceptable. FS, ADP, AGL, and MP, played a significant role in the high score of capabilities.

Based on the results of the Kruskal-Wallis test, the 10 yielded different results across the occupational groups achieved. Based on the Mann-Whitney test results in Table 3, it is evident that the seven pairs of occupational groups yielded different outcomes.

Information technology infrastructure plays a central role in ensuring the effectiveness of an organization’s information system. Any organization must identify and improve these fields and infrastructures which can respond quickly to environmental opportunities and threats. In addition, IT provides several benefits to manufacturers, including enhancing SC agility, reducing cycle time, achieving higher efficiency, and ensuring timely product delivery to customers (39). In addition to addressing this as a vulnerability (6.00), the questionnaire also includes capability sub-constructs such as the speed of information exchange (agility) (6.00), the ability to monitor and track materials (visibility) (6.00), to keep abreast of market changes (visibility) (6.00), and to manage customer relationships (market position) (6.00). These subconstructs achieved high scores, so IT has a great impact and relevance on them.

Sanctions as sub-constructs (6.00), either during or before the COVID-19 crisis, emerged as a key element affecting the vulnerability of the PSC and other industries.

In macroeconomic crises or unstable conditions, the political-economic sanctions on certain underdeveloped or developing countries can significantly weaken the PSC and make it more susceptible to internal and external disruptions (40). These adverse effects are amplified within the health system and directly affect people's access to essential medicines and medical devices (41). Despite claims of exemptions for medicines and medical equipment from politico-economic sanctions, patients' access to necessary medicine and medical supplies is significantly inhibited by transport barriers, difficulties in cash transfers, and restrictions on investment (42). Similar to this research, Kokabisaghi stated: that political and economic sanctions have severely affected the macroeconomic and have led to a decrease in the value of the country's currency, and export earnings, restrictions on the import of raw materials needed by the industry, an increase in inflation, the bankruptcy of industries and unemployment, which obviously, results in vulnerability in the resilience of the PSC (43). Ghiyasi et.al found that the embargo affected asthma treatment access; this dropped access to imports by 19% and to locally manufactured medications by 42%. This finding is compatible with the experts' views of this study (44). Moret et.al emphasized the harmful impact of sanctions on Syrian and Iranian citizens' ability to get and use medications. The qualitative stage focused on the specific case of sanctions and financial instability, highlighting the impact of economic sanctions on the country's business cycle (45).

This study found that financial concerns had the second highest questionnaire scores in the vulnerabilities (5.75) and highest in the capabilities (6.00) sections. The financial vulnerabilities are comparable to Jabridoost's study, which found that financial risk constituted the highest risk (46).

In the common subconstructs between our study and the pre-COVID-19 study on the resilience of PSC in Malaysia (47), external/environmental, flexibility, and collaboration scores on the questionnaire were acceptable, however, the visibility and adaptability scores were unacceptable. At first, we used expert interviews to gather strategies for addressing the COVID-19 situation then regarding the interviews we used quantitative methodology but, in that study, it was just quantitative research.

In contrast to our study, Pettit's research (48) found in seven instances of vulnerabilities, the external/environmental category received the highest rating, or rank 1, while the customer/supplier category received rank 6. Market Position received ranks one through fourteen

in the capability instances, followed by financial strength at rank three, visibility at rank nine, flexibility at rank ten, adaptability at rank eleven, redundancy at rank thirteen, and collaboration at rank fourteen. The current COVID-19 crisis, which highlighted the significance of SCR through problems in Iran and the world, was the basic motivation for our research. We decided to study the PSC resilience during the COVID crisis by the nation's PSC experts, followed by a questionnaire. This research is inspired by Pettit's study on the resilience of the SC in various industries.

In the interviews, non-expert decisions were mentioned, and many interviewees emphasized that this made the SC vulnerable during the COVID crisis. This subconstruct received a score (6.00) in the questionnaire. Non-expert decisions were driven by the lack of attention to experts' opinions, such as the slower declaration of an epidemic in the country, and the very high number of vaccine production platforms without feasibility studies, pharmacoepidemiological, and other studies.

5. Conclusion

The rising complexity and uncertainty in the business environment have made disaster mitigation strategies reach their limits, highlighting the importance of a SCR as a key driver of future business success. The COVID-19 pandemic is unarguably responsible for the increased attention and accelerating progress in this field. Resilience may not be a single-step approach but a continuous process.

This research emphasizes the role of an organization's financial characteristics in terms of weaknesses and strengths. Strengthening this point and speeding up the information flow using rapid response mechanisms permanently will enable PSC, mainly in crisis circumstances like pandemics and sanctions, to be more resilient. The study focused on the manufacturers as its focal point within the PSC. It is suggested that similar studies be carried out in other parts of the PSC to get a complete picture.

5.1. Limitations and Future Research Directions

The limitation of our study is the unique conditions of the COVID-19 pandemic, as well as the investigation of a part of the SC (pharmaceutical manufacturing companies). This study was conducted after the subsidence of the COVID-19 pandemic, so information bias was inevitable.

Future research would explore the applicability of the identified resilience strategies in other industries. Additionally, longitudinal studies could assess the long-term effectiveness of resilience strategies implemented by pharmaceutical companies. Overall, this study can be a basis for further research on SCR in the pharmaceutical sector and underscores the importance of proactive resilience strategies in mitigating the impact of future disruptions.

5.2. The novelty of this study lies in several key aspects:

Contextual Focus on the Iranian PSC: This study specifically examines the resilience of the PSC within Iran's society. While there is existing literature on SCR, particularly in the pharmaceutical sector, the focus on Iran provides unique insights into the challenges and strategies for resilience in a specific geopolitical and economic context. This contextual specificity enhances the relevance and applicability of the findings for stakeholders within Iran's pharmaceutical industry.

Mixed-Methods Approach: Using both qualitative insights from expert interviews and quantitative data from surveys, this all-encompassing method enables a full investigation of resilience variables within the PSC. With these findings from multiple sources, the study offers a precious understanding of resilience dynamics, enriching the scholarly discourse on SCR.

Overall, the novelty of this study lies in its contextual focus, mixed-methods approach, comprehensive analysis of vulnerabilities and capabilities, and sector-specific insights, all of which contribute to advancing the understanding of SCR within the Iranian pharmaceutical industry.

2 Revision 1

1 comment · 29 Sep 2024

Associate Editor

ACCEPT 29 Sep 2024

Dear Authors,
According to reviewers' feedback on the manuscript, the manuscript is now accepted for publication. I just recommend that the authors carefully review the manuscript for any remaining minor edits required at the proof stage.
Best regards,