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ORIGINAL PAPER

PROMOTING HEALTHCARE TECHNOLOGIES THROUGH SUSTAINABLE SUPPLY CHAIN OPERATIONS: AN EMPIRICAL ANALYSIS OF KEY SUCCESS FACTORS USING THE ISM-MICMAC APPROACH

Muhammad Waqas[1], Zhang Yu[2,3], Syed Abdul Rehman Khan[4], Muhammad Tanveer[5], Abdul-Rahim Ahmad[6]

1) Department of Business Administration, Ghazi University, Dera Ghazi Khan, **Pakistan**
2) School of Economics and Management, Chang'an University, Xi'an, **China**
3) Department of Business Administration, ILMA University, Karachi, **Pakistan**
4) School of Management and Engineering, Xuzhou University of Technology, Xuzhou, **China**
5) Department of Business Administration, Imam Mohammad Ibn Saud Islamic University, Riyadh, **Saudi Arabia**
6) Computer Information Systems, King Faisal University, Hofuf, **Saudi Arabia**

Abstract. This study analyses key successful factors (KSFs) affecting health supply chains using a novel ISM-MICMAC methodology. Initially, KSFs were collected from past articles, which were later analyzed through the ISM-MICMAC methodology. Healthcare technologies (HCTs) are regarded as innovative and fastest-growing technologies and have seen advancement in the last few decades. Successful and sustainable delivery of health services is only possible through an effective supply chain and logistics network. However, HCTs confront pressure in healthcare supply chains due to different issues. Therefore, it is essential to evaluate KSFs affecting the successful delivery of HCTs supply chains. After obtaining data from experts, interpretive structural modeling (ISM) results indicated that initial capital, top management commitment, training & experience, new technology and information, information quality, and strategic partnership with suppliers are the most crucial KSFs HCTs supply chain in the Pakistani context. Furthermore, MICMAC analysis categorized KSFs with the help of their driving and dependence power. These results support health strategists and policymakers to understand the severity of the identified top five KSFs and act as a moderator to take care of these KSFs, which would ultimately contribute to the successful delivery of the health care supply chain and improvement of critical health services. This study's results would also be helpful for the supply chain managers of the manufacturing industry in the Pakistani context. This research is one of the initial studies to precisely explore KSFs affecting health supply chains using a novel ISM-MICMAC and categorize KSFs with the help of their driving and dependence power by applying MICMAC analysis in the Pakistani SCM context.

Keywords: Management, environment, key success factors; review; healthcare supply chain; logistics; health sector, sustainability, sustainable supply chain management

INTRODUCTION

Healthcare technologies (HCTs) help to improve and protect the lives of affected individuals from different diseases (N. C. f. H. Statistics, 2010). This sector has a comprehensive range of products such as hospitals, beds, blankets, syringes, injections, sticking plasters, tablets, latex gloves, and syrups; mobility items such as wheelchairs, walkers, scooters, hearing aids items; personal care aids items such as dressing bandages, commodes, and bath chairs; high technology equipment such as joints replacement for hips and knees, pacemakers, ventilators, intelligent contact lenses and kidney machines (Hartford, 2014). The industry of HCTs is perceived as advanced, fast-growing, and artistic across the world, especially in developed countries such as Germany, the United States of America (USA),

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Canada, the United Kingdom (UK), and China (Okpala, 2018; Vogenberg & Santilli, 2018). However, Pakistan has approximately 800 healthcare equipment production units exporting items worth more than $200 million to over 60 countries (Waheed, 2017). Pakistan's healthcare expenditure is $9.2 billion (H. Ali, 2016), and the direct and indirect workforce employed by this industry is approximately more than 0.5 million (Ahmed & Batool, 2017). Pakistan has 1219 hospitals, 733 rural health centers (RHCs), 5345 primary health units (BHUs), 5654 dispensaries, and 727 maternity & child welfare centers (MCWC), and 127807 beds (P. B. o. Statistics, 2017). Despite the remarkable developments in the healthcare industry internationally, the Pakistani healthcare production industry faces several challenges in its supply chain operations due to deficiencies in supply chain management (SCM) infrastructure (Khan, Razzaq, Yu, & Miller, 2021) and (Fahimnia, Jabbarzadeh, Ghavamifar, & Bell, 2017). Although the public has continuous pressure on the government to reduce the prices of medicines and fees, on the other hand, the expenditure on HCTs is higher (Jamshed, Hassali, Ibrahim, & Babar, 2011).

Furthermore, to sustain and increase the market share, healthcare product manufacturers depend on their product innovation and face different issues, e.g., the short lifecycle of products, the limited period for new product development, and approvals from regulatory authorities (de Faria & Wieck, 2015; Thatte, Hussain, de Rosas-Valera, & Malik, 2009). Moreover, Chinese, German, and Indian medical firms are also lined up in the Pakistani healthcare industry to capture the market with cost-efficient products and force Pakistan manufacturing firms to produce and distribute low-cost products globally (Nadvi & Halder, 2005). In the current situation, research discussing healthcare SCM has become critical. The demand for the advancement of healthcare aids products delivery systems has gained greater attention from professionals because of apparent failures in medical aid delivery systems (Kumar, Dieveney, & Dieveney, 2009; Pettit & Beresford, 2009; Scheibe & Blackhurst, 2018). García-Villarreal, Bhamra, and Schoenheit (2019) found a shortfall of defined strategies of SCM in the healthcare sector. The primary deficiencies were reported to be a lack of efficient planning, lack of top management support, lack of sales forecasts, lack of formulated strategies, and lack of coordination with suppliers and processes during the pandemic outbreak (Khan, Yu, Umar, de Sousa Jabbour, & Mor, 2021).

Generally, logistics activities in emergency and critical situations are frequently significant and challenging for healthcare SC (Haszlinna Mustaffa & Potter, 2009). For an effective and successful supply chain, there should be a great and robust understanding of barriers and drivers directly or indirectly involved in the processes. Increasing the SC's efficiency needs uncertainty to be decreased or even removed from its operations; however, this may not be wholly eradicated in many healthcare cases (Hasani, Zegordi, & Nikbakhsh, 2015). These barriers and issues are severe in the healthcare SC scenario when products provide relief to patients in critical situations, control and expedite healthcare product delivery, and efficient SC infrastructure is inevitable. Identifying the key success factors (KSFs) attached to a healthcare SC is vital to develop a more robust understanding of the issues impeding SC's effective implementation. However, as compared with commercial SC, there are certain KSFs that contribute to the ultimate success of HCTs and healthcare product delivery. Considering the shortage of studies concerning KSFs in the health care supply chain in developing countries, lower attention to medication errors, and wrong product delivery in an emergency, the primary objectives of this study are:

- To evaluate the main KSFs in the healthcare supply chain in previous studies
- To formulate a contextual connection among KSFs as well as form their hierarchical structure
- To classify the selected KSFs according to their driving and dependence power

According to the literature, the author's first attempt to identify the KSFs in Pakistani healthcare SC by using ISM and MICMAC analysis. Initially, KSFs were identified from the extensive literature through experts' opinions,

and this issue is related to multiple-criteria decision-making (MCDM). Therefore, the levels of the hierarchal structure of KSFs were calculated by applying ISM and MICMAC to evaluate their contextual relationship through driving and dependence power.

This research extended the literature in the Pakistani context in the following ways:

- Initially, this research classifies the main KSFs in the healthcare supply chain in the Pakistani context. The identified KSFs can be considered a foundation that can be removed on a priority basis to implement the healthcare sector's supply chain effectively.
- Secondly, the combination of ISM and MICMAC analysis is suggested to evaluate KSFs in healthcare SC. This study adds theory because the recommended method is rationally and practically solid to evaluate KSFs and verify their findings in different contexts.
- Lastly, this research will be regarded as a standard to effectively help supply chain managers and government authorities implement KSFs in healthcare SC.

The rest of the article is organized in the following sections: a literature review is displayed in section 2; section 3 portrays a brief methodology overview. Results, analysis of data, and discussions under the light of detailed literature on KSFs in healthcare SC are presented in section 4.

LITERATURE REVIEW

In the literature review, the field of SCM performed exceptionally well in operation management (Waqas, Honggang, Ahmad, Khan, & Iqbal, 2021). However, after searching the detailed literature, limited literature was focused on identifying KSFs of healthcare SCM (García-Villarreal et al., 2019); Yadav & Singh, 2020). Unfortunately, no study has been found to identify KSFs in Pakistan healthcare technology SC.

The supply chain is "A process involving three or more parties in the smooth flow of products, services, or information from origin to the customer"(Schäfer, 2022). Three significant parties in the healthcare supply chain are as follows 1. Producers (companies involved in manufacturing HCTs, manufacturing companies in health care including pharmaceutical companies, producers of medical and surgical instruments, and lastly, medical devices); 2. Purchasers (purchasing agents, e.g., distributors, government, or public organizations) and 3. Health care service providers (e.g., hospitals).

Furthermore, in this process, customers and financial intermediaries also create an important role as local government, patients and individuals are customers, and insurance companies, banks, and health maintenance organizations are financial intermediaries. More details can be found in Figure1. Elhidaoui, Benhida, El Fezazi, Kota, and Lamalem (2022) and Smith, Nachtmann, and Pohl (2012) provided a more comprehensive picture of the health care supply chain by showing the leading players involved and product flow in a single place. The detailed healthcare supply chain is shown in Figure 2.

Key success factors (KSFs)

Daniel (1961) introduced the concept of KSFs in his study. Huotari and Wilson (2001) proposed that if certain KSFs become critical within any organization, the chances of failure of that organization would increase. Although in the context of HCTs and the healthcare supply chain, profit is not considered a primary motive of the supplier. If KSFs are not defined well, failure might be expected in the delivery process of healthcare products to whom they are required in an emergency, or the distribution of wrong products may also happen (Vaz & Araujo, 2022). Different researchers have put forward various definitions of KSFs. Every business has its key factors. Their proper identification and implementation can ensure any business's better performance in any market (Rockart, 1979). According to (Zaman, Wang, Rasool, uz Zaman, & Raza, 2022), these identified factors are KSFs and elaborate them as different activities or processes that should receive greater attention from top management for successful implementation. (Guerrero, Gómez, Victorica,

López, & Fong, 2022) found that KSFs are those activities that ensure achieving a distinctive business position in the market. Identification and implementation of KSFs at the initial stages of formulation of strategies can increase the business performance and help the top management allocate resources and monitor the business activities better (Thomassey, 2010). The concept of KSFs has been applied successfully in different domains. In literature, research papers on KSFs can be found on project management (Rasool et al., 2022), epidemic emergency management systems (Song, Zhao, Mubarak, & Taresh, 2022), information management systems (Muhammad, Miah, Isa, & Samsudin, 2022), supply chain management (Power, Sohal, & Rahman, 2001), knowledge management (Akhavan, Jafari, & Fathian, 2006), brownfield redevelopment (Ahmad, Zhu, Shafait, Sahibzada, & Waheed, 2019; Weng, Zhu, Song, & Ahmad, 2019), public-private partnerships (PPP) (Kavishe & Chileshe, 2018), total quality management (TQM) (Seetharaman, Sreenivasan, & Boon, 2006) and (Khan, Godil, Yu, Abbas, & Shamim, 2021), implementation of six sigma initiatives (Fadly Habidin & Mohd Yusof, 2013), implementation, execution and adoption of Internet-of-Things (IoT) systems (Luthra, S., Berwal, Y. P. S., & Motia, K., 2021), adoption of Social Media Marketing Technology (SMMT) by Micro, Small, and Medium Enterprises (MSMEs) (Eze, S. C., Chinedu-Eze, V. C., & Awa, H. O., 2021), use of e-learning in higher education (Priatna, T., Maylawati, D., Sugilar, H., & Ramdhani, M. (2020), and among many others fields.

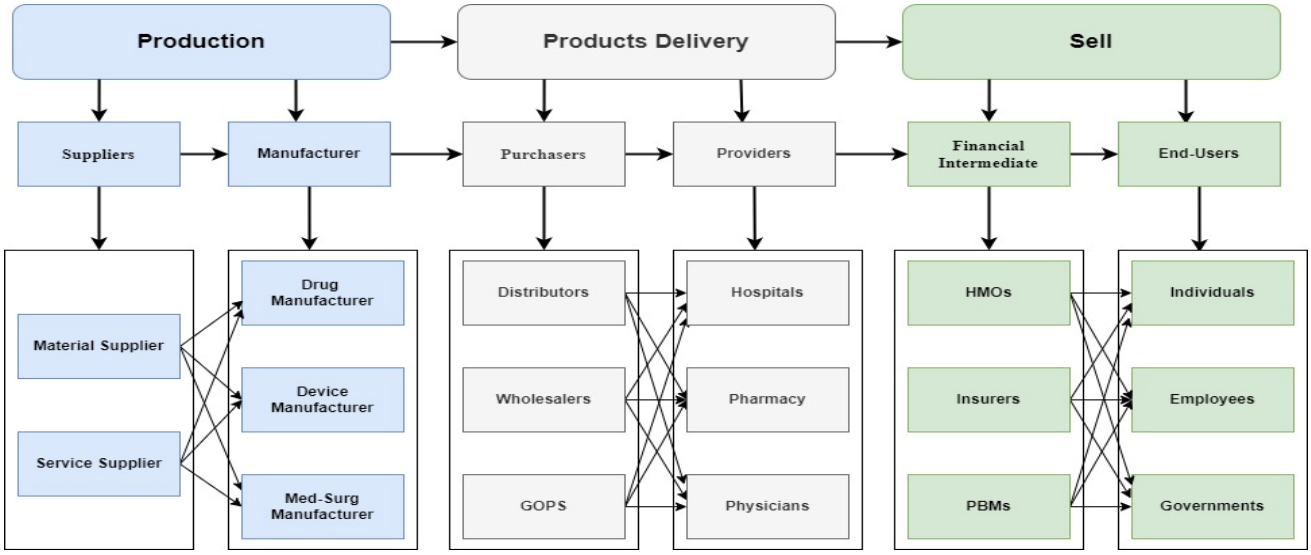

Fig 1. Value chain of the healthcare industry

KSFs in supply chain management and healthcare sector

The implementation of KSFs in the field of SCM is limited. Although few earlier studies on the performance of KSFs in this healthcare have been found, no analysis has been found in Pakistan. Power et al. (2001) investigated 962 manufacturing firms in Australia to identify and verify KSFs that differentiate organizations from more agile to less agile. In handling SCM, the following are the proposed factors in their study: "agile supply chain, supplier relations, computer-based technologies, technology utilization, just-in-time methodology, resource management, continuous improvement enablers, participative management style, customer satisfaction, product innovation, and delivery performance." According to Tan, Yen, and Fang (2002), KSFs customer-centric strategy, people's commitments, improved or redesigned process, software, technology, and infrastructure to supply chain management in the E-commerce arena.

(Heydari & Bakhshi, 2022) researched the selection of small third-party logistics providers in the manufacturing industry of Hong Kong. (Wuni & Shen, 2022) identified the top five critical success factors for an efficient small third-party logistics provider systems, such as information technology, strategic planning, capacity planning, inventory management, and transportation system. (Atıcı, Adem, Şenol, & Dağdeviren, 2022) Examined the KSFs for enterprises' resource utilization. They identified the nine most critical barriers to organization resource implementation: correspondence, process, interaction and expectation success, organizational relating, IT infrastructure, strategic relating, managerial relating, and operational relating. (Thomassey & Zeng, 2021) highlighted CSFs for web-based SCM. They uncovered the top five factors using exploratory factor analysis (EFA): communication, education and training, hardware and software reliability, top management commitment, and data security. Rao Tummala, Phillips, and Johnson (2006) comprehensively addressed operational KSFs related to SCM implementation in the manufacturing industry. They identified the following essential factors: Improving inventory, reducing the cost of operations, cross-functional communication, creating corporate culture lead time, and customer satisfaction. According to Kuei, Madu, and Lin (2008) findings, SC leadership's quality, relationship with suppliers, consumer focus, quality of IT system, and focus on integration process are identified CSFs for SC quality management.

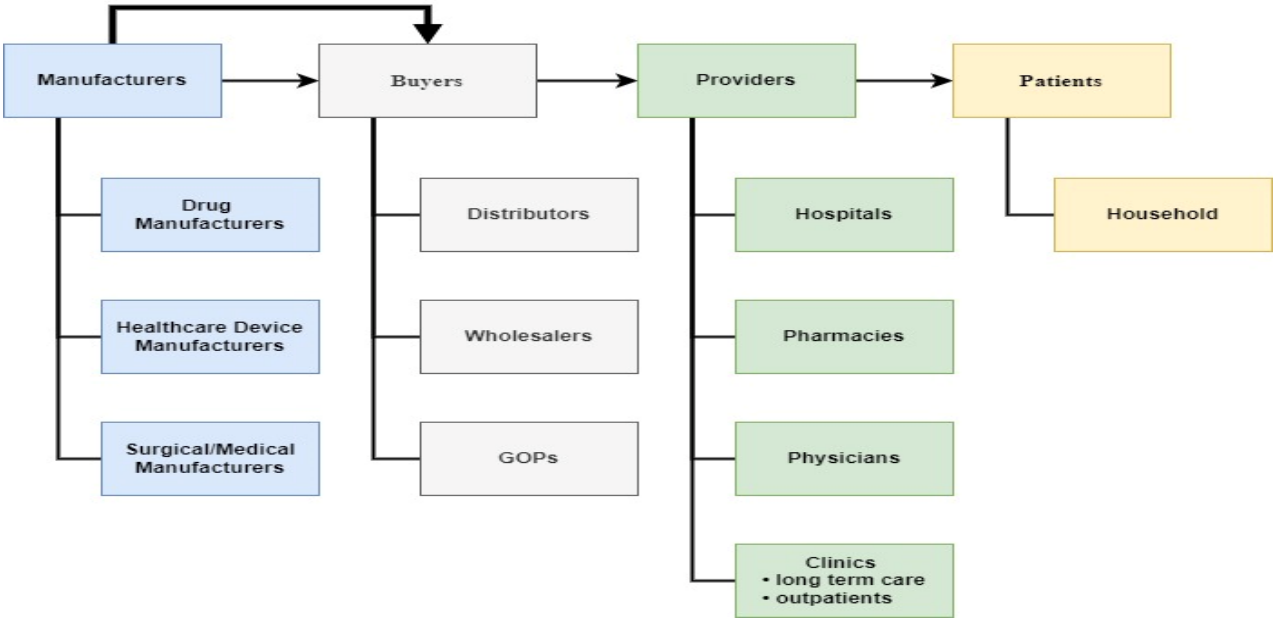

Fig 2. A comprehensive overview of healthcare SCM

(Prajapati, Kant, & Shankar, 2021) Identified enablers are prompting the performance of reverse SC. Their study findings suggest that organizational commitment, technological capacity, service quality, government policy, reverse SC cost, perceived usefulness, ease of use, and reverse SC performance are significant enablers of promoting reverse SC performance. Pettit and Beresford (2009) emphasized critical success factors for humanitarian-based SC. They identified the following CSFs: strategic planning, transportation planning, relationship with suppliers, management of resources, capacity planning, continuous improvement, HRM technology utilization, and information management. Azmat, M., Atif, M., & Kummer, S. (2019) investigated (internal and external) critical success factors significantly affecting (faith-based and non-faith-based) humanitarian organizations' supply chain. They identified six significant external CSFs: beneficiaries' religion, beneficiaries' culture, influence/restrictions of donors, policies of hosting countries/governments, supply lines' blockage and rough terrain, and limited/constrained resources. Furthermore, they identified four significant internal CSFs: a collection of information, structure of the organization,

collaboration/coordination, and communication within the organization. Additionally, they also explored any significant differences among CSFs between religious and nonreligious organizations.

Wittstruck and Teuteberg (2012), and Schipper and Silvius (2021) considered KSFs for sustainable SCM. They described the following factors as critical: adoption of standards, signaling, information management, establishing ecological cycles, commitment, and mutual learning. Routroy and Pradhan (2013); Sarfraz et al. (2022b) considered thirteen KSFs for supplier development in the Indian manufacturing industry. The main factors include the long-term strategic goals, top management commitment, information sharing, supplier certification, innovation capability, external environment, supplier status, and direct involvement. Ab Talib, Abdul Hamid, and Thoo (2015) researched on the literature review survey by investigating twenty-six research papers. They identified four key enablers to SCM: top management commitment, information management, human resource management, and collaborative partnership.

Khan, Haleem, Khan, Abidi, and Al-Ahmari (2018) found that effective and efficient communication systems, employee training, well-established IT infrastructure, top management commitment, choosing suitable technology for traceability systems, halal SC awareness, customer satisfaction, coordination with suppliers, standardization, and government support key success factors to halal supply chain implementation. Yuen, Wang, Ma, Lee, and Li (2019) investigated 164 container shipping companies and identified and verified key enablers for supply chain integration using structural equation modeling. His study results found that the key enablers are relationship management, performance measurement, information management, strategic alignment, and organizational commitment. Finally, M. Waqas, Q.-l. Dong, N. Ahmad, Y. Zhu, and M. Nadeem (2018) identified the 47 most significant barriers to reverse logistics implementation in the Pakistani manufacturing industry and identified the top five factors as follows: lack of capital, limited planning, and forecasting, uncertainty related to economic issues, complexity in operations and lack of taxation knowledge on return products. Kaupa, F., & Naude, M. J. (2021-b) studied CSFs related to the SCM of necessary medicines in Malawi's public healthcare system. The findings indicate that critical success factors include understanding different disease types and how they spread, sufficient financial resources, collaboration with involved SCM parties, and an effective system for purchasing and distribution. In another study, Kaupa, F., & Naude, M. J. (2021-a) investigated the barriers/obstacles in supplying the necessary medicines in Malawi's public healthcare system. Limited financial and human resources and a lack of collaboration among stakeholders were identified as the primary impediments to purchasing and SCM in Malawi's public healthcare system. The study's findings indicate that the identified barriers are critical impediments to achieving SCM's excellence, mainly in supplying essential medicines in Malawi's public healthcare system. The study recommends the following primary solutions for overcoming these challenges: development of human resources capacity, financial resource mobilization, and collaboration among stakeholders. Bentahar, O. (2018, January) investigated the factors that contribute to the success of the healthcare sector's purchasing groups. The findings indicate that the critical success factors for purchasing groups are top management commitment, communication, anticipated benefits, collaboration, equitable distribution of savings, and indicators of performance and their measurements. Sánchez-Flores, R. B., Cruz-Sotelo, S. E., Ojeda-Benitez, S., & Ramírez-Barreto, M. (2020) conducted a systematic literature review on sustainable supply chain management (SSCM) to investigate its evolution in emerging economies. They considered and analyzed 56 papers published from 2010 until April 2020. Some of the covered papers are related to the healthcare sector, such as Subramanian, L., Alexiou, C., Steele, P., & Tolani, F. (2020), and Scavarda, A., Daú, G. L., Scavarda, L. F., & Korzenowski, A. L. (2019). Furthermore, Table 1 shows the summary of KSFs in the supply chain and healthcare sectors.

Interpretive Structural Modeling in SCM and healthcare sectors

(Agrawal, Wankhede,Wankhede & Nair, 2021) Applied ISM to identify the drivers that can hinder green supply chain management (GSCM) in the UAE manufacturing firms and rank them according to their significance. Mathiyazhagan, Govindan, NoorulHaq, and Geng (2013) used ISM to investigate the contextual relationship among the main barriers to GSCM implementation in India's manufacturing industry. Vivek and Kumar (2019) scrutinized GSCM enablers and constructed the contextual relationship-based model among different enablers in the field of FMCG by using ISM. Vishnu, Sridharan, and Kumar (2019) Identified and verified the risk drivers in supply chain management, formulated the mutual relationship model, and categorized the drivers according to their dependence and driving power using ISM and MICMAC techniques. Kannan, Pokharel, and Kumar (2009) used ISM and MICMAC approaches to prioritize the third-party logistics provider to choose the best 3PL Indian manufacturing industry. S. M. Ali, Arafin, Moktadir, Rahman, and Zahan (2018) explored the most critical barriers to implementing reverse logistics in the Bangladeshi computer supply chain and uncovered the interrelationship among selected variables through ISM methodology. Rane and Kirkire (2016) explored the barriers to ISM and developed the contextual relationship among identified barriers in the Indian medical device manufacturing industry. Jain and Ajmera (2018) tried to determine the mutual relationship among variables and ranked them according to their importance in ISM in India's healthcare sector. Bahari, Jafni, Ismail, Hashim, and Hussain (2018) tried developing the reciprocal relationship model among readiness factors that influence Malaysia's healthcare using ISM and MICMAC approaches. Karamat, Shurong, Ahmad, Waheed, and Mahmood (2018) attempted to identify the

Table 1. Identified KSFs in healthcare technology and supply chain management field

Studies	Field	Identified KSFs
(Prajapati et al., 2021) and Power et al. (2001)	SCM	Supplier relations, computer-based technologies, technology utilization, just-in-time methodology, resource management, continuous improvement enablers, participative management style, customer satisfaction, product innovation, and delivery performance.
(Chatterjee & Chaudhuri, 2022),Tan et al. (2002)	Customer relationship management	Customer-centric strategy, commitments from people, improved or redesigned process, software technology and infrastructure.
Gunasekaran and Ngai (2003); (Singh, Dasgupta, & Routroy, 2022)	Reverse logistics	Information technology, strategic planning, capacity planning, inventory management and transportation
Al-Mashari, Al-Mudimigh, and Zairi (2003)	Enterprise resource planning	Correspondence success, process success, interaction success, expectation success, organizational relating, IT infrastructure, Strategic relating, managerial relating and operational relating.
(Thomassey & Zeng, 2021), Ngai, Cheng, and Ho (2004)	Web-based SCM	Communication, training and education, software and hardware reliability, top management commitment, and data security

Gottschalk and Solli-Sæther (2005)	IT-based SCM	Management competency, management of stakeholders, transaction cost reduction, reduction of production cost, and contract maturity.
Rao Tummala et al. (2006)	SCM	Improving inventory, reducing the cost of operations, cross-functional communication, Creating corporate culture lead time, and customer satisfaction.
Kuei et al. (2008)	Quality management of SCM	Quality of SC leadership, relationship with suppliers, consumer focus, IT system quality, and focus on the integration process.
Hong, Suh, and Hou (2008)	Reverse SC	Organizational commitment, technology capacity, service quality, government policy, reverse SC cost, perceived usefulness, ease of use, and reverse SC performance.
Pettit and Beresford (2009)	Humanitarian SC	SC strategy, strategic planning, transportation planning, relationship with suppliers, management of resources, capacity planning, focus on continuous improvement, HRM technology utilization, and information management.
Lönngren, Rosenkranz, and Kolbe (2010)	Construction of supply chain	IT application solution, task management, and trust among partners.
(Waqas, Honggang, Ahmad, Khan, Ullah, et al., 2021), Lee, Lee, and Schniederjans (2011)	SC innovation Healthcare	SC innovation, collaboration with suppliers, supply chain efficiency, quality management practices, and firm performance.
Wittstruck and Teuteberg (2012)	SCM	Adoption of standards, signaling, information management, the establishment of ecological cycles, commitment, and mutual learning.
Routroy and Pradhan (2013)	SCM	The long-term strategic goal, top management commitment, information sharing, supplier certification, innovation capability, external environment, supplier status, and direct involvement.
Grimm, Hofstetter, and Sarkis (2014)	Supplier management	Costs, lack of capital, lack of skills, lack of top management commitment, investment reluctance, lack of power, stakeholder partnerships, lack of trust between supply chain partners, lack of information, transparency, language differences and geographical distance.
Ab Talib et al. (2015)	SCM	Top management commitment, information management, human resource management, and collaborative partnership.
Mangla, Govindan, and Luthra (2016)	Reverse logistics	HR and organizational factors, regulatory pressure, global competitiveness factors, economic considerations, and strategic factors.
(Khan, Godil, Jabbour, et al., 2021)Raut, Narkhede, and Gardas (2017)	SSCM	Global environmental pressure and scarcity of natural resource resources.
Khan et al. (2018)	Halal supply chain	Training of employees, efficient and effective communication, dedicated IT infrastructure, top management support, Selection and selection of Suitable Technology for Traceability Systems, halal awareness, customer satisfaction, coordination with

		suppliers, standardization and Codification, and government support.
Karamat et al. (2019)	Knowledge management in healthcare	Maintain green competitive advantage, setting a standard for other organizations, Effective decision making, Intra organizational communication in healthcare, and collaboration with other healthcare organizations.
Yuen et al. (2019)	Supply chain integration	relationship management, performance measurement, information management, strategic alignment, and organizational commitment.

Enablers of knowledge management implementation in the Pakistani healthcare sector using ISM-MICMAC. Sadeh and Garkaz (2019) uncovered influential quality factors in the Iranian medical tourism sector by applying ISM-MICMAC framework. Rane and Kirkire (2017) developed the interaction between risk sources and categorized them according to their dependence and driving power in the Indian medical device development sector. Furthermore, Table 2 contains more details about ISM and MICMAC approaches in SCM and healthcare sectors in different countries

Table 2. Studies used ISM in the field of healthcare and SCM

Ref.	**Field**	**Objective**
(Rane & Kirkire, 2016)	Healthcare	Exploring barriers to ISM and developing a contextual relationship among identified barriers in the Indian medical device manufacturing industry.
(Diabat & Govindan, 2011)	SCM	Identifying factors that can hinder the implementation of GSCM in UAE manufacturing firms and ranking them according to their significance by using ISM.
(Jain & Ajmera, 2018)	Healthcare	Using ISM, we identify the mutual relationship among affected medical tourism in India's healthcare sector and rank them according to their importance.
(Mathiyazhagan et al., 2013)	SCM	This study investigates the contextual relationship among the main barriers to GSCM implementation in India's manufacturing industry.
(Bahari et al., 2018)	Healthcare	It is developing the mutual relationship model among readiness factors that influence personal healthcare in Malaysia.
(Vivek & Kumar, 2019)	SCM	Scrutinized GSCM enablers and constructed the contextual relationship model among different enablers in FMCG.
(Ajmera & Jain, 2019b)	Healthcare	Evaluate and prioritize the critical factors that impact the quality of life of Indian diabetic patients by using the ISM technique.
(Vishnu et al., 2019)	SCM	Identify and verify the risk drivers in supply chain management, formulate the mutual relationship model, and categorise them according to their dependence and driving power using ISM and MICMAC techniques.

(Karamat et al., 2019)	Healthcare	Analyze the barriers and drivers to knowledge management and rank on their driving and dependence power in the Pakistani healthcare sector.
(Kannan, Pokharel, & Kumar, 2009)	Reverse logistics	ISM and MICMAC approach prioritizes the third-party logistics provider to choose the best 3PL in the Indian manufacturing industry.
(Rane & Kirkire, 2017)	Medical device development	Identify and develop the interaction between risk sources and categorize them according to their dependence and driving power in the Indian medical device development sector.
(S. M. Ali et al., 2018)	Reverse logistics	Using the ISM approach, this study explores the most critical barriers to reverse logistics in Bangladeshi computer supply chain.
(Sadeh & Garkaz, 2019)	Healthcare	This study investigates influential quality factors in Iranian medical tourism by applying ISM and MICMAC frameworks.
(Sindhwani, Mittal, Singh, Aggarwal, & Gautam, 2019)	Manufacturing systems	This study establishes an interrelationship and evaluates barriers' driving and dependence power by applying total ISM and MICMAC in the Indian manufacturing industry.
(Bouzon, Govindan, & Rodriguez, 2015)	Reverse logistics	Using ISM, we evaluate and analyze the contextual relationship among barriers to reverse logistics implementation in the Brazilian manufacturing industry.
(Ajmera & Jain, 2019a)	Healthcare	This study aims to identify the most influential factors in implementing lean principles in the Indian healthcare sector.
(Shibin et al., 2016)	GSCM	We explore barriers and enablers in flexible GSCM networks and highlight the mutual relationship among selected barriers and enablers through expert opinion by using ISM.
(Talib, Rahman, & Qureshi, 2011)	Total quality management	This study examines the barriers to TQM in the service sector and identifies the mutual relationships among selected obstacles by using the ISM methodology.
(Karamat et al., 2018)	Healthcare	To identify the enablers of knowledge management implementation in the Pakistani healthcare sector using ISM and MICMAC.
(Malviya & Kant, 2017)	SCM	This study's main objective is to identify and examine the interaction among enablers of GSCM implementation and their driving and dependence power by applying ISM and MICMAC approaches.

Research gap

Pakistan is emerging as a significant worldwide center for healthcare facilities. The Pakistani healthcare supply chain faces numerous barriers regardless of this remarkable growth. There is a need to effectively promote KSFs in the supply chain of the healthcare industry of Pakistan. However, countries across the globe face similar KSFs during the implementation of the healthcare sector's supply chain. However, the differences in industrial culture, socio-economic conditions, and rules and regulations can change each KSFs' treatment in every country. A comprehensive literature on identifying KSFs has witnessed the popularity area among scholars in various countries. More importantly, developing reliable solutions to endorse the healthcare industry's efficient and cost-effective supply chain. The earlier segments lead the current study to identify the below-given research gaps:

- There is a shortage of research evaluating KSFs in the healthcare supply chain, particularly in Pakistan.
- Pakistan seeks solutions to selected KSFs to implement a better healthcare sector's supply chain to serve patients in critical and emergency conditions cost-effectively. Identification and verification of KSFs in the supply chain are minimal due to researchers' low interest; the Pakistani healthcare supply chain faces many challenges, especially in emergencies.
- ISM and MICMAC methodology has been widely applied in diversified fields, but their application in the healthcare supply chain is minimal. According to the writer's knowledge, no earlier study has used the combination of ISM and MICMAC methodology to evaluate the KSFS in the healthcare supply chain in the Pakistani context.

METHODOLOGY

The framework of a four-stage methodology has been applied to evaluate the KSFs in healthcare SC. At the first stage, KSFs in healthcare SC were identified, which were further screened out with the Delphi method's facilitation at the second stage. ISM-based contextual relationship model was established at the third stage to intensify the understanding of the levels of hierarchal structure of KSFs. Finally, MICMAC was applied to classify and develop clusters of KSFs in healthcare SC. The main stages involved in the methodology have been shown in the dotted box, along with the substages and other activities, as shown in Figure 3.

Furthermore, the description of each stage is also explained in the following sections.

Identification of KSFs

For reviewing the literature of KSFs, this research has applied a systematic literature review (SLR) technique, as suggested by (Thürer, Tomašević, Stevenson, Qu, & Huisingh, 2018). The literature review survey was done from September 2019 to October 2019. The related research papers were collected from literature through the undermentioned criteria:

1. The research papers must contain key success factors/ critical success factors in the healthcare supply chain. Moreover, the leading keywords used for paper selection are: 'healthcare', 'supply chain', 'medical technology', 'medical tourism industry, 'KSFs', 'barriers', 'CSFs', 'obstacles'. A combination of leading keywords used for paper selection is (1) key success factors in the healthcare supply chain, (2) barriers/ obstacles in the healthcare supply chain, (3) critical success factors in the healthcare supply chain, (4) quality factors in medical sectors, (5) impeding factors in healthcare supply chain, (6) KSFs/CSFs in healthcare supply chain and developing countries.
2. The primary research databases, including Google Scholar, Springer, Scopus, Taylor & Francis, Science Direct, and Emerald Insight, were considered the primary sources of publication collection. The selected articles were evaluated in the screening process by finding the keywords in the title, abstract, and text to find the relevant research papers. In the process, the forward & backward snowball research

technique was also applied to screened articles, as suggested by (Danglot et al., 2019). However, another criterion, "inclusion/exclusion applied to refine the research articles more appropriately described as (i) published articles written in the English language, (ii) peer-reviewed research articles, proceedings of the conference, and chapters published in books were considered.

3. The criteria mentioned above helped select the relevant research articles for this study; the chosen articles contained the literature related to KSFs/CSFs, barriers, challenges, and obstacles to the healthcare supply chain. The Main KSFs in the healthcare supply chain has been given in Table 2.

The different leading journals belonging to this study were the primary source for finding relevant published articles are *production planning & control, environmental research and public health, international Journal of healthcare management, international journal of physical distribution & logistics management, Journal of cleaner production, Journal of environmental management and renewable, sustainable energy review and Journal of business & industrial marketing.*

Questionnaire formation and data collection

The nature of this study is empirical, and previous studies found KSFs in developed countries. The lack of KSFs studies in Pakistani literature and selecting the most appropriate experts for this study was problematic. Therefore, pilot testing was applied to choose the proper respondents. The experts from the field were approached through text messages, phone calls, and emails and arranged an appointment in office for inquire their willingness to participate. Finally, six experts with an excellent background in the supply chain were engaged in this study for data collection, and semistructured interviews were performed. The respondents include: 1) two professors of SCM, 3) one production manager, 4) one procurement manager, 5) one transportation manager, and 6) data analyst. All participants had comprehensive knowledge about SCM and were well aware of the selected KSFs in the healthcare supply chain. The following questions were asked by the participants in a group discussion:

Q1. What are the key success factors for a manufacturer in the healthcare supply chain? (Content confirmation from Table 1)

Q2. What are the most related KSFs to the healthcare supply chain of Pakistan?

Q3. What is the contextual relationship among different KSFs in the healthcare supply chain? (ISM & MICMAC)

A comprehensive questionnaire was designed on behalf of experts' responses about the importance of each KSFs. Through a qualitative technique, all selected KSFs were evaluated manually. All expected relationships among selected KSFs were discussed in a group discussion with experts. Each expert's response was registered to the structural self-interaction matrix (SSIM) and then converted into ISM based contextual relationship model. Furthermore, the ISM methodology is elaborated in detail:

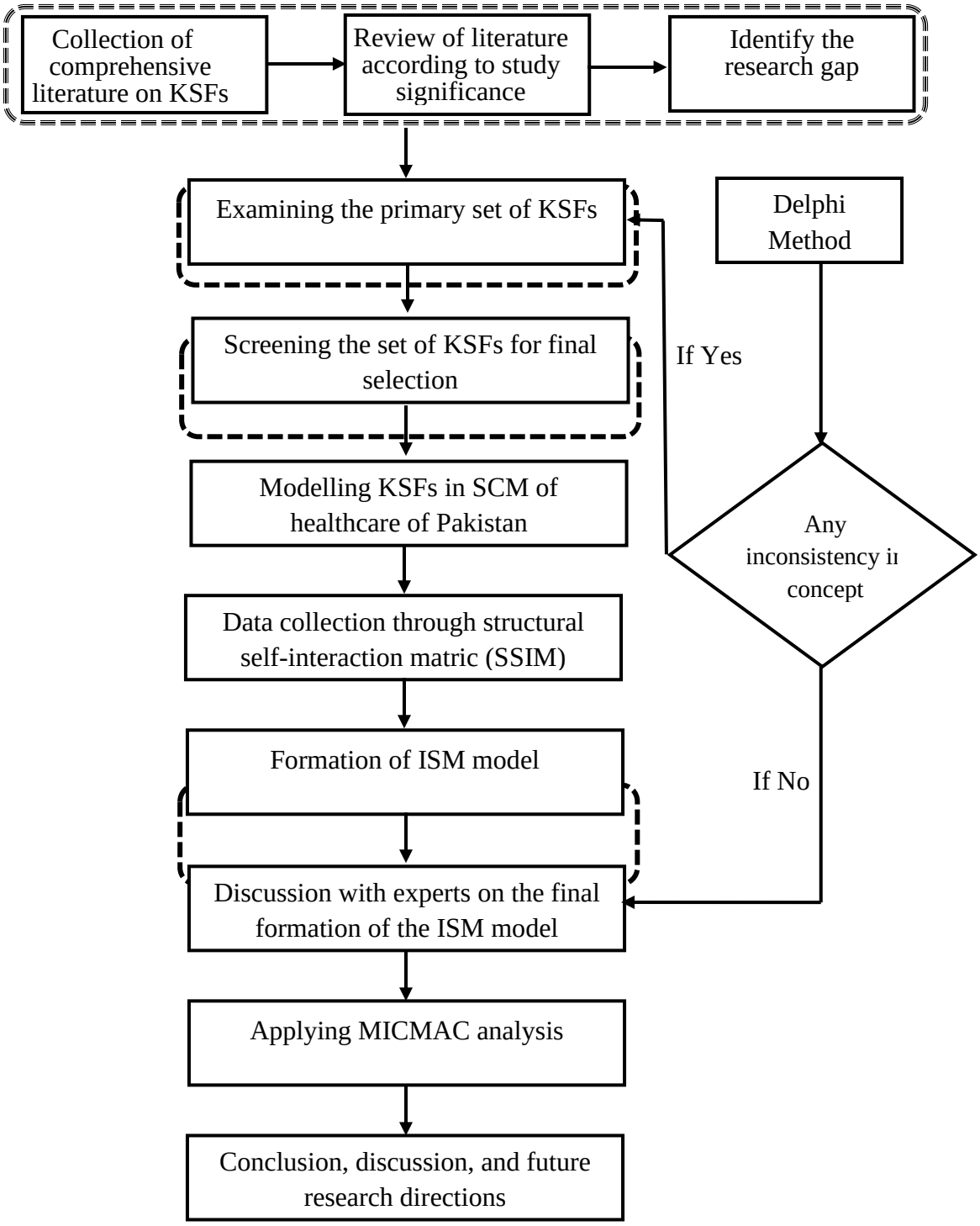

Fig 3. Step by step framework of the study

Interpretive structural modeling (ISM)

Interpretive structural modelling is considered an advanced Multiple-Criteria Decision-Making (MCDM) methodology to examine the relationship among different factors in a complex situation through professional judgment (Warfield & Cybernetics, 1974). ISM analyzed the selected elements in the system to identify a causal interrelationship graph. Furthermore, many characteristics of ISM methodology that verify its appropriateness to apply in this study are as follows:

- ISM enables experts to tap into complex systems factors through practical knowledge and judgment and create an understandable and comprehensive model.
- Complex relationships among different factors can be calculated in a logical order.
- ISM methodology is extensively applied by social science and supply chain management scientists and has also been used by some admired institutions such as NASA (Ansari et al., 2013).
- Since its introduction, it has been widely applied to evaluate the complex system's cause-and-effect associations between selected elements/variables. In this paper, KSFs in the healthcare supply chain are considered as factors.
- It's a beauty of ISM methodology, it doesn't need the earlier background of a system and ranks each factor according to its significance.

However, some drawbacks are also affiliated with ISM methodology, such as the contextual relationship ISM model depends upon the practical knowledge and judgments of professionals relevant to the system. Thus, wrong perceptions or inconsistent professionals' understanding of factors might affect the study's findings. According to (Ansari et al., 2013), ISM is not proficient enough to calculate the associated factors' accurate weights. In this case, the ISM methodology is appropriate for the current study because of its advantages. Identifying KSFs in the healthcare supply chain is a complex issue, and experts' participation is more suitable in this background because of their practical knowledge and experience. In these kinds of situations, data collection from stakeholders regarding the identification of KSFs is uncertain because of respondents' limited ability. However, a broad literature on ISM methodology is presented in Table 2, which confirms its suitability to resolve complex problems in different fields.

The ISM methodology application presents the structural transparency and introduces the hierarchical model to identify the contextual association among selected factors. The steps involved in the ISM methodology are given below:

Step 1: According to the Pakistani context, KSFs in the healthcare supply chain are identified through extensive literature review and filtered through professionals' suggestions.

Step 2: In the first step, the contextual relationship among the selected KSFs was established to confirm which pair of KSFs was studied in the next step.

Step 3: Step three shows the pairwise relationships among selected KSFs through a developed SSIM.

Step 4: From SSIM, an initial reachability matrix (IRM) was identified, and later IRM is examined for transitivity, which is considered a basic assumption of ISM methodology. It defines that if a KSF "A" is associated with "B" and "B" is associated with "C," then "A" must be related to "C."

Step5: With the help of an initial reachability matrix, various iterations were achieved to get the ISM model's level.

Step 7: Finally, the diagram is shaped into an ISM model by replacing KSFs nodes with statements.

Step 8: To improve the ISM model, the model's conceptual inconsistency was rechecked for further modifications, if necessary.

Development of structural self-interaction matrix (SSIM)

In ISM methodology, experts in the field are the primary source to judge the directional relationship between two selected KSFs (i and j). Four symbols identify the directional relationship between selected factors (i and j).

- V: KSFs "i" will help to achieve KSFs "j"
- A: KSFs "j" will help to achieve KSFs "i"
- X: KSFs "i" and "j" will help to achieve each other
- O: KSFs "i" and "j" are not related

According to their best knowledge, the symbols (V, A, X, O) were assigned to each KSFs by experts, as shown in Table 3.

Initial reachability matrix (IRM)

The initial reachability matrix is obtained from the structural self-interaction matrix at this stage. In Table 4, the symbols (V, A, X, O) are translated into a binary matrix (i.e., 0 or 1), an initial reachability matrix. The following translation rules are applied:

If (i and j) cell presents the symbol "V" in SSIM, then 1 will be allotted to (i and j) cell, and 0 will be assigned to (j and i) cell in the initial reachability matrix.

If (i and j) cell presents a symbol "A" in SSIM, then 0 can be allotted to (i and j) cell, and 1 can be assigned to (j and i) cell in the initial reachability matrix.

If (i and j) cell presents a symbol "X" in SSIM, then 1 be allotted to both cells (i and j) and (j and i) in the initial reachability matrix.

If (i and j) cell presents the symbol "O" in SSIM, then 0 will allot to both cells (i and j) and (j and i) in the initial reachability matrix.

The results for IRM are further presented in Table 4.

Final reachability matrix

The IRM for KSFs in the Pakistani healthcare supply chain was obtained from SSIM. Furthermore, by removing the transitivity of IRM, as mentioned in step 4, the final reachability matrix (FRM) was derived and presented in Table 5. However, the dependence and driving power of each selected KSFs have been derived from FRM.

Partitions level

FRM is employed to drive the reliability and antecedent sets of each selected KSFs, as suggested by Warfield and Cybernetics (1974). According to Ahmad, Zhu, Hongli, et al. (2019), the reachability set contains the factor (KSFs) itself and its supporting factors that may help to attain. In contrast, the antecedent set contains the factor (KSFs) itself and other factors that may influence achieving it. Further, the intersection set encompasses all those values included in reachability and antecedent sets. If the reachability set and intersection set contain the same values, it achieves the first level. The same procedure is continued until the achievement of all levels of each KSFs, presented in Table 6. The following identified levels help to construct the ISM-based contextual relationship-based model.

Table 6 shows the lack of initial capital identified as the main KSF in the Pakistani healthcare supply chain, which leads to other selected factors.

Formation of the ISM model

A structural model is constructed from FRM, as presented in Figure 4. Arrows beginning from KSFs i to KSFs j portray the contextual relationship among selected KSFs. The initially formulated diagram is named as diagraph. After eliminating transitivity, the diagraph is converted into an ISM based model for KSFs in the healthcare supply chain, as presented in Figure 5. Furthermore, the MICMAC approach was applied to identify the four clusters of selected KSFs in the Pakistani healthcare supply chain.

MICMAC analysis

According to Waqas, Qianli, Ahmad, Zhu, and Nadeem (2020), MICMAC is an abbreviation for (Matriced' Impacts croises-multipication applique' an classment), (cross-impact matrix multiplication applied to classification). MICMAC research methodology was used to explore more profound insights of selected KSFs in the Pakistani context. MICMAC analysis's key objective was to determine the impact of each KSFs in the healthcare supply chain for their better implementation. However, conferring on the driving and dependence power of each selected KSFs, they have been divided into four groups: autonomous KSFs, linkage KSFs, dependent KSFs and independent KSFs (Govindan, Palaniappan, Zhu, & Kannan, 2012).

However, based on ISM and MICMAC analysis results, the final output of the ISM analysis is shown in Figure 4, which further derives the ISM model (as shown in Figure 5). Lastly, the final findings of the MICMAC approach are presented in Figure 6.

At this stage, clustering for KSFs was done using the MICMAC technique. The driving and dependence power of each KSFs was used. According to the driving and dependence power of each selected KSFs, they have been divided into four groups: autonomous KSFs, linkage KSFs, dependent KSFs, and independent KSFs (Govindan et al., 2012; Kannan, Pokharel, Kumar, & recycling, 2009). Results of four clusters of KSFs by following the rules of MICMAC are described below:

Autonomous KSFs

KSFs with weak driving and dependence power are placed in this Quadrant. These factors are often disconnected from others and may have little links with other factors, but their links can be strong in effect. Quadrant I is presenting autonomous KSFS. In this study, no KSFs were identified in this quadrant, which means that all selected KSFs are more significant to the healthcare supply chain in the Pakistani context.

Dependent KSFs

KSFs with weak driving, but strong dependence power is placed in this Quadrant. These kinds of factors are considered ineffective in attaining other factors. Quadrant-II presents dependent KSFs. In this study, three KSFs named relationship with customers (9RC), transport management (11TM), and sales and production planning (17SA) were identified in quadrant-II.

Linkage KSFs

KSFs with strong dependence and driving power are placed in this Quadrant. These factors are susceptible and unstable because any action taken on them will impact the whole system. Quadrant III presents linkage KSFs. In this study, fifteen KSFs were named, top management commitment (1CT), skilled professionals, SCM (4SP), teamwork (15TW), organizational support (16OS), insufficient strategic planning (18IS), conflict among employees (20CE), reverse logistics infrastructure (10RL), green supply chain management (12GS), resistance to change (19RC), new technology and information systems (3NT), strategic partnership with suppliers (7SS), information quality (5IQ), quality and safety compliance (14QS), inventory management (6IM) and distribution system (13DS) were identified in linkage quadrant according to their driving and dependence power.

Independent KSFs

KSFs with strong driving but weak dependence power are placed in this Quadrant. A KSFs having strong driving power was identified as the study's main factor and placed independent KSFs quadrants. Quadrant IV is presenting driving KSFs. In this study, two KSFs named initial capital (2IC) having driving power 20, dependence power 2, and training & experience (8TE) having driving power 19, dependence power 8, respectively, were identified in quadrant IV. Table 5 presents the driving and dependence power of each selected KSFs. Further detail relating to the formation of the MICMAC analysis model can be seen in Figure 6.

Table 3. Structural self-interaction matrix for KSFs

Codes	KSFs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1CT	Top management commitment		A	V	V	V	V	V	V	O	V	V	V	V	V	V	V	O	A	V	O
2IC	Initial capital			V	V	V	O	O	V	O	V	V	V	V	V	O	V	V	V	O	O
3NT	New technology and information systems (NTIS)				A	V	V	A	O	O	V	V	V	V	V	V	O	O	O	O	O
4SP	Skilled professionals in SCM					V	V	V	V	V	V	V	V	V	V	X	V	V	V	O	V
5IQ	Information quality						V	O	A	O	A	O	O	V	V	O	V	V	V	V	V
6IM	Inventory management							O	A	O	A	O	A	X	A	O	V	V	A	O	O
7SS	Strategic partnership with suppliers								A	O	A	O	A	V	V	O	V	V	A	A	O
8TE	Training & experience									V	V	V	O	O	V	V	V	V	O	V	V
9RC	Relationship with customers										O	O	A	O	O	O	O	O	O	O	O
10RL	Reverse logistics infrastructure											V	A	V	V	V	A	V	A	A	O
11TM	Transport management												A	X	A	O	A	O	A	O	O
12GS	Green supply chain management (GSCM)													V	V	O	A	V	A	O	O
13DS	Distribution system														A	A	A	V	O	O	O
14QS	Quality and safety compliance															A	A	O	A	O	A
15TW	Team work																X	V	X	O	X
16OS	Organizational support																	V	V	V	V
17SA	Sales and production planning																		A	O	O
18IS	Insufficient strategic planning																			V	V
19RC	Resistance to change																				V
20CE	Conflict among employees																				

*Based on experts' response

Table 4. Initial reachability matrix for KSFs

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	0
2	1	1	1	1	1	0	0	1	0	1	1	1	1	1	0	1	1	1	0	0
3	0	0	1	0	1	1	0	0	0	1	1	1	1	1	1	0	0	0	0	0
4	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
5	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	1	1	1	1	1
6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0
7	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0	1	1	0	0	0
8	0	0	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	1
9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	1	1	1	0	0	1	1	0	1	1	1	0	1	0	0	0
11	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
12	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0	1	0	0	0
13	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0
14	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0
15	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1
16	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
18	1	0	0	0	0	1	1	0	0	1	1	1	0	1	1	0	1	1	1	1
19	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1
20	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1

Table 5. Final reachability matrix for KSFs

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Dri.
1	1	0	1	1	1	1	1	1	1*	1	1	1	1	1	1	1	1*	1*	1	1*	19
2	1	1	1	1	1	1*	1*	1	1*	1	1	1	1	1	1*	1	1	1	1*	1*	20
3	0	0	1	1*	1	1	1*	0	1*	1	1	1	1	1	1	1*	1*	1*	1*	1*	17
4	1*	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1*	1	19
5	1*	0	0	1*	1	1	1*	0	0	1*	1*	1*	1	1	1*	1	1	1	1	1	16
6	0	0	0	0	0	1	0	0	0	1*	1*	1*	1	1*	1*	1	1	1*	1*	1*	12
7	0	0	1	1*	1*	1*	1	0	1*	1*	1*	1*	1	1	1*	1	1	1*	1*	1*	17
8	1*	0	1*	1*	1	1	1	1	1	1	1	1*	1*	1	1	1	1	1*	1	1	19
9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
10	1*	0	1*	1*	1	1	1	0	1*	1	1	1*	1	1	1	1*	1	1*	1*	1*	18
11	0	0	0	0	0	1*	0	0	0	0	1	0	1	0	0	0	1*	0	0	0	4
12	1*	0	1*	1*	1*	1	1	0	1	1	1	1	1	1	1*	1*	1	1*	1*	1*	18
13	0	0	0	0	0	1	0	0	0	1*	1	1*	1	1*	1*	1*	1	1*	1*	1*	12
14	0	0	0	0	0	1	0	0	0	1*	1	1*	1	1	1*	1*	1*	1*	1*	1*	12
15	1*	0	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1*	1	19
16	1*	0	1*	1*	1*	1*	1*	1*	1*	1	1	1	1	1	1	1	1	1	1	1	19
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
18	1	0	1*	1*	1*	1	1	1*	1*	1	1	1	1*	1	1	1*	1	1	1	1	19
19	1*	0	1*	1*	1*	1*	1	0	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1	1	18
20	1*	0	1*	1	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1*	1*	1*	1*	1	19
Dep.	12	1	13	14	14	18	14	8	14	17	18	17	18	17	17	17	19	17	17	17	299

Table 6. Level of partition, iterations of KSFs in healthcare supply chain

KSFs	Reachability set	Antecedent set	Interaction set	Level
1	1,3,4,5,6,7,8,9,10,11,12,13, 14,15,16,17,18,19,20	1,2,4,5,8,10,12,15,16,18,1 9,20	1,4,5,8,10,12,15,16,18 ,19,20	VI
2	1,2,3,4,5,6,7,8,9,10,11,12,1 3,14,15,16,17,18,19,20	2	2	VII
3	3,4,5,6,7,9,10,11,12,13,14,1 5,16,17,18,19,20	1,2,3,4,7,8,10,12,15,16, 18,19,20	3,4,7,10,12,15,16,18,1 9,20	V
4	1,3,4,5,6,7,8,9,10,11,12, 13,14,15,16,17,18,19,20	1,2,3,4,5,7,8,10,12,15,16,1 8,19,20	1,3,4,5,7,8,10,12,15,1 6,18,19,20	III
5	1,4,5,6,7,10,11,12,13,14, 15,16,17,18,19,20	1,2,3,4,5,7,8,10,12,15,16,1 8,19,20	1,4,5,7,10,12,15,16,18 ,19,20	IV
6	6,10,11,12,13,14,15,16,17,1 8,19,20	1,2,3,4,5,6,7,8,10,11,12,13 ,14,15,16,18,19,20	6,10,11,12,13,14,15,1 6,18,19,20	1
7	3,4,5,6,7,9,10,11,12,13,14,1 5,16,17,18,19,20	1,2,3,4,5,7,8,10,12,15,16,1 8,19,20	3,4,5,7,10,12,15,16,18 ,19,20	IV
8	1,3,4,5,6,7,8,9,10,11,12, 13,14,15,16,17,18,19,20	1,2,4,8,15,16,18,20	1,4,8,15,16,18,20	VI
9	9	1,2,3,4,7,8,9,10,12,15,16,1 8,19,20	9	1
10	1,3,4,5,6,7,9,10,11,12,13,14 ,15,16,17,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	1,3,4,5,6,7,10,12,13,1 4,15,16,18,19,20	III
11	6,11,13,17	1,2,3,4,5,6,7,8,10,11,12,13 ,14,15,16,18,19,20	6,11,13,	II
12	1,3,4,5,6,7,9,10,11,12,13,14 ,15,16,17,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	1,3,4,5,6,7,10,12,13,1 4,15,16,18,19,29	III
13	6,10,11,12,13,14,15,16,17,1 8,19,20	1,2,3,4,5,6,7,8,10,11,12,13 ,14,15,16,18,19,20	6,10,12,13,14,15,16,1 8,19,20	II
14	6,9,10,11,12,13,14,15,16,17 ,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	6,10,12,13,14,15,16,1 8,19,20	III
15	1,3,4,5,6,7,8,9,10,11,12, 13,14,15,16,17,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	1,3,4,5,6,7,8,10,12, 13,14,15,16,18,19, 20	III
16	1,3,4,5,6,7,8,9,10,11,12, 13,14,15,16,17,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	1,3,4,5,6,7,8,10,12, 13,14,15,16,18,19, 20	III
17	17	1,2,3,4,5,6,7,8,10,11,12,13 ,14,15,16,17,18,19,20	17	1
18	1,3,4,5,6,7,8,9,10,11,12,13, 14,15,16,17,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	1,3,4,5,6,7,8,10,12,13, 14,15,16,18,19,20	III
19	1,3,4,5,6,7,9,10,11,12,13,14 ,15,16,17,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	1,3,4,5,6,7,10,12,13,1 4,15,16,18,19,20	III
20	1,3,4,5,6,7,8,9,10,11,12,13, 14,15,16,17,18,19,20	1,2,3,4,5,6,7,8,10,12,13,14 ,15,16,18,19,20	1,3,4,5,6,7,8,10,12,13, 14,15,16,18,19,20	III

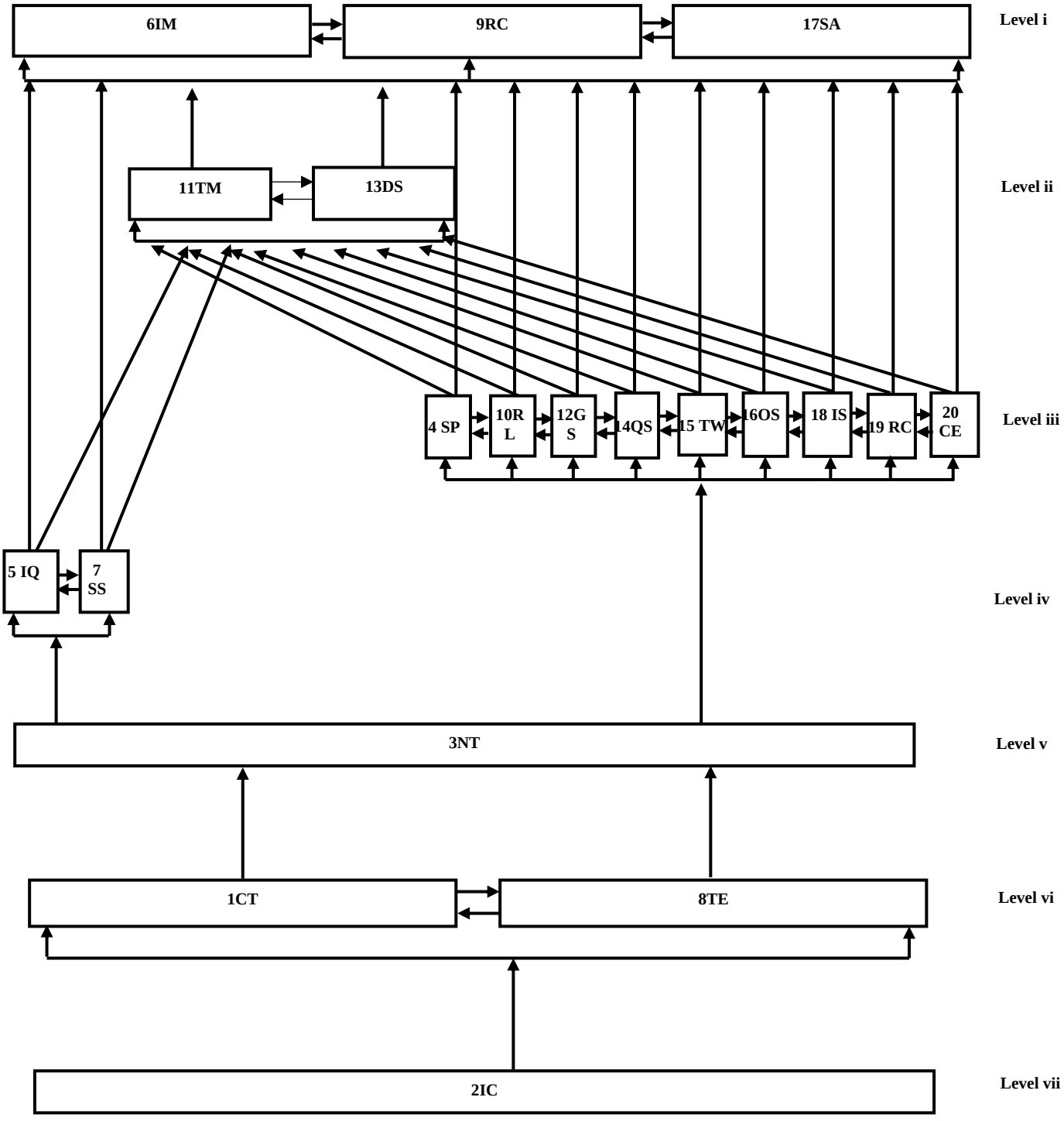

Fig 4. Diagraph of selected KSFs

RESULTS AND DISCUSSION

For an effective healthcare supply chain, focusing KSFs is unavoidable. Identify their importance in minimizing or overcoming their impact on the healthcare supply chain in the Pakistani context. This research's main objective is to identify key success factors in the healthcare supply chain for the successful implementation of supply chain operations during the shipment of healthcare products, further investigating the contextual relationship among selected KSFs. This study suggested applying ISM and MICMAC's hybrid methodology to evaluate the KSFs in the healthcare supply chain. However, successful supply chain operations in the healthcare sector are challenging without screening the severity of selected KSFs in the healthcare supply chain. This is the initial study that evaluates the KSFs in the Pakistani context's healthcare supply chain according to the literature. In the beginning, KSFs were obtained from the literature, and the final selection of KSFs was made on behalf of professionals' opinions. Then the selected KSFs were examined, and the ISM-based contextual relationship model was formulated according to the study findings.

Furthermore, the ISM based model and MICMAC results have been discussed in three sections. Firstly, the study's hierarchical structure, secondly, the top five KSFs of the study were compared with initially published studies; and thirdly, the four main quadrants of the MICMIC analysis were discussed.

Hierarchal structure

ISM methodology results derived seven levels of hierarchal structure of selected KSFs in the Pakistani context's healthcare supply chain. According to the ISM-based model, the first level extracted one KSF 'lack of initial capital (2CE)', which is identified as the most critical KSF. It means that the financial crisis is the main impediment to successfully implementing supply chain operations in the healthcare sector. Thus, the current situation can be improved by collaborating intensely with the government and different financial institutions. However, most of the authors raised the same issue in developing economies (M. Waqas, Q.-l. Dong, N. Ahmad, Y. Zhu, & M. J. S. Nadeem, 2018). First level KSFs 2CE leads 2nd level KSFs, including top management commitment (1CT) and lack of training & experience (8TE). These results were matched with an earlier study (Tumpa et al., 2019) and (Khan, Zkik, Belhadi, & Kamble, 2021), which revealed that lack of top management commitment is the most critical barrier to the adoption of GSCM in the Bangladesh textile industry. Jayant and Azhar (2014) indicated a lack of training courses as 2nd level impediment to implementing the supply chain in the Indian manufacturing industry.

New technology and information systems (3NT) were discovered at 3rd level KSFs, led by 2nd level KSFs. Appropriate technology and effective information systems play an essential role in on-time product delivery in any sector, especially in healthcare. 3NT KSF can be overcome by importing new technology and creative collaboration with developed countries. It would improve technical skills through the transformation of technical knowledge. Information quality (5IQ) and strategic partnership with the supplier (7SS) were extracted at the 4th level and were triggered by 3rd level KSFs. According to Prajapati, Kant, and Shankar (2019), information systems' inefficiency and lack of collaboration with suppliers are critical KSFs in a complex supply chain. The complexity of an information system's supply chain and inefficiencies can be removed through expertise and knowledge. The 4th level KSFs led 5th level KSFs, including nine KSFs, skilled professionals in SCM (4SP), reverse logistics infrastructure (10RL), green supply chain management (12GS), quality and safety compliance (14QS), teamwork (15TW), organizational support (16OS), insufficient strategic planning (18IS), resistance to change (19RC) and conflict among employees (20CE). These nine KSFs were identified at the 5th iteration leading 6th level KSFs, including transport management (11TM) and distribution system (13DS). Finally, two KSFs, 11 TM and 13DS, were identified at the 6th level, leading three KSFs at the 7th level, including inventory management (6IM), relationship with customers (9RC), and sales and production planning (17SA).

POLICY RECOMMENDATION AND RESEARCH IMPLICATIONS

Policy recommendations to facilitate selected KSFs in the healthcare supply chain in the Pakistani context and study implications are discussed in this segment.

Policy recommendation to facilitate KSFs in healthcare supply

Selected KSFs were divided into four categories: financial, managerial & experience, infrastructural & technological constraints, and policy factors. This segment presents the policies and implications to facilitate selected KSFs in the Pakistani healthcare supply chain.

1st level KSFs: Initial capital was identified as the most critical KSF related to financial factors and had a deep root cause for the failure of Pakistan's healthcare supply chain. However, according to the literature review, financial constraints are also faced by other developing countries such as China, India, and Bangladesh (Abdulrahman, Gunasekaran, & Subramanian, 2014; Tumpa et al., 2019). Thus, this critical KSF can be overcome by introducing short-term and long-term loans at easy terms and conditions by both government and financial institutions, e.g., the government of Pakistan has introduced the "Kamyab Jawan entrepreneurship loan scheme" for the youngster to promote small and medium businesses in the country.

2nd level KSFs: Top management commitment and training & experience related to managerial constraints were identified as the 2nd most critical KSFs to the healthcare supply chain in the Pakistani context. Less experience and lack of top management commitment may be more essential KSFs for supply chain and logistics companies, it can be overcome by logistics firms themselves by hiring skilled and professional employees, and a quarterly base training program might be introduced to enhance employee performance. Moreover, collaboration with other developing countries could improve technical skills by transforming technical knowledge.

Level KSFs: One KSFs was found at the 3rd level in the ISM model named "new technology and information system" related to infrastructural & technological constraints, hindering the operations of the healthcare supply chain. The results recommend that successful supply chain processes require new technology with a perfect information system and a skilled workforce. Thus, these actions will significantly affect the supply chain and logistics firm performance in Pakistan's healthcare sector.

4th level KSFs: Two KSFs were found at this level named “information quality and strategic partnership with supplies.” Poor information quality is another crucial KSF in supply chain and logistics because the proper product delivery at the right time depends on the information quality. Therefore, an experienced workforce is considered the basic fundamental for controlling and conveying the correct information at the right time in supply chain and logistics firms. Lack of strategic partnership with suppliers because of the complex supply chain is also considered a crucial KSF; however, previous studies opposed this idea. In the Pakistani context, supply chain and logistics departments are failed to improve performance, especially in the healthcare sector. The main reason behind this is the lack of coordination with their partners. It also leads to falling in sustainable long-run relationships with their suppliers, and suppliers are hesitant about coordinating with them.

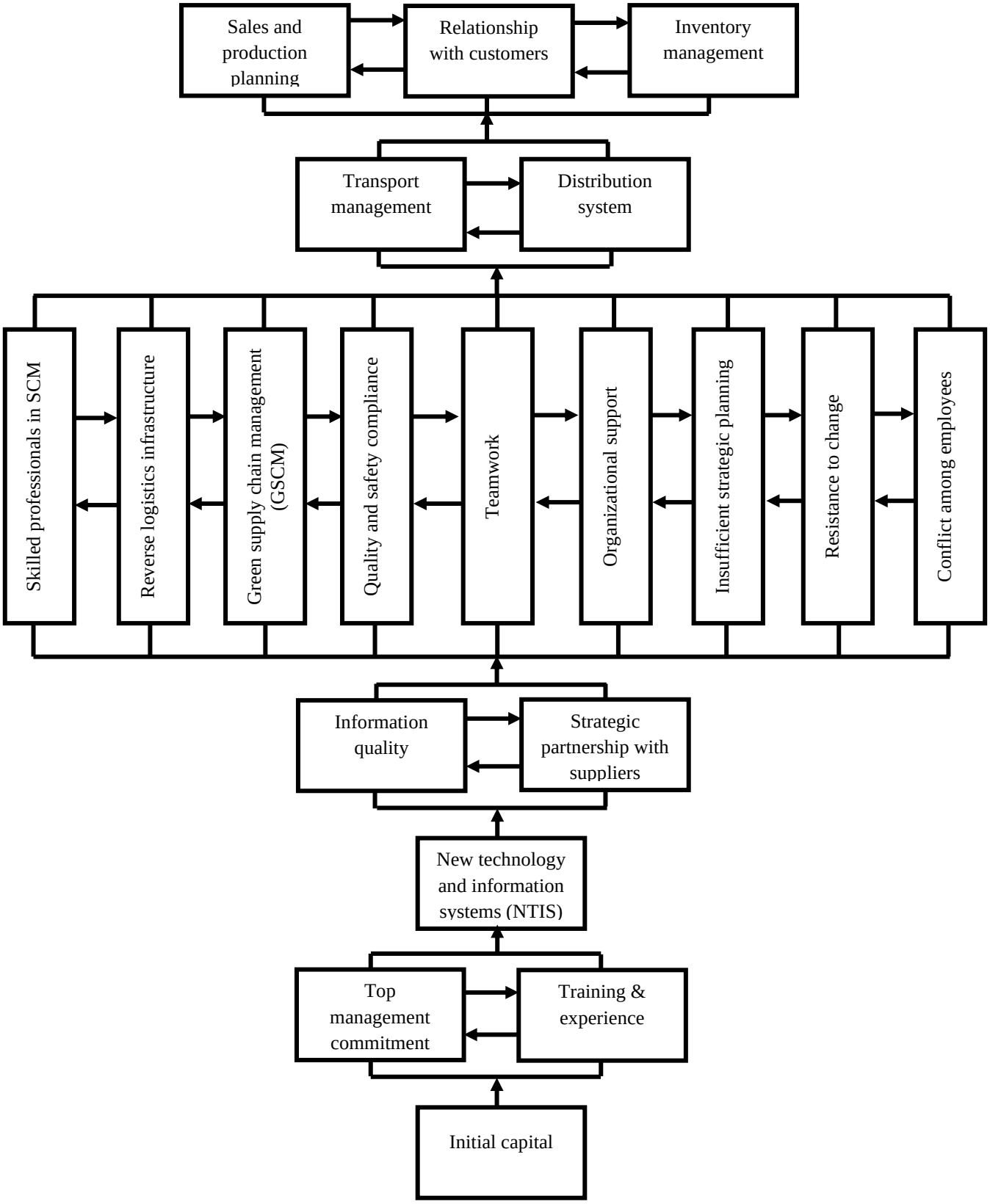

Fig 5. ISM based model for selected KSFs in healthcare supply chain of Pakistan

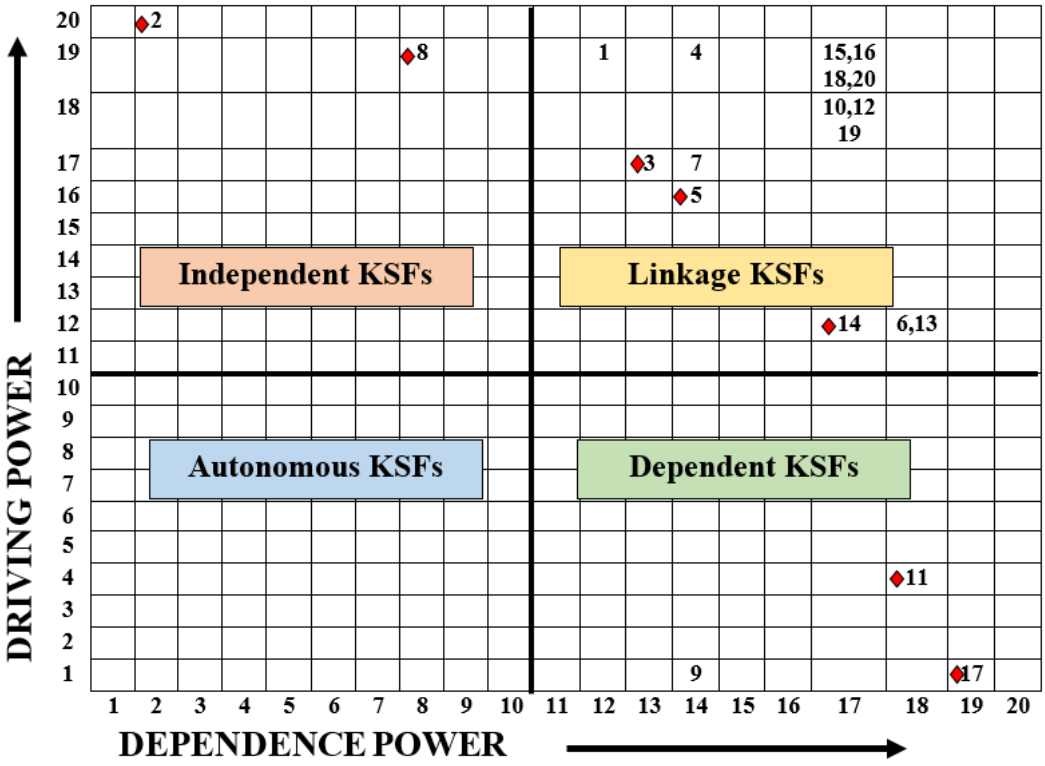

Fig 6. MICMAC analysis-based model for selected KSFs in the healthcare supply chain of Pakistan

5th level KSFs: Most of the selected KSFs were found at the 5th level named: skilled professionals in SCM, reverse logistics infrastructure, green supply chain management, quality and safety compliance, teamwork, organizational support, insufficient strategic planning, resistance to change, and conflict among employees. Skilled professionals assist firms in gaining a good position, but on the other hand, a less experienced workforce is a significant hindrance to adopting new technology in any sector. The study finding suggests that supply chain and logistics firms require skilled professionals to successfully implement the operations supply chain. Moreover, reverse logistics infrastructure is also needed to make supply chain operations cleaner and greener. Arranging and managing training sessions and workshops might be more helpful to the productive use of new technology (Rehman Khan et al., 2021). Moreover, introducing a reward system and a supportive work environment might motivate the workforce to reduce their resistance to change during new policies and technologies (Khan, Godil, Quddoos et al., 2021).

6th level KSFs: Two KSFs were identified at this level named: transportation management and distribution system. Both KSFs are related to infrastructural & technological constraints. Our study results suggest that infrastructural & technological constraints need to overcome transportation as the leading and most important pillar in the logistics and supply chain sectors. The modernized transport system needs the Pakistani supply chain industry to manage organizational operations effectively.

7th level KSFs: Finally, three KSFs were found at this level, including sales and production planning, relationships with customers, and inventory management that belong to managerial and policy constraints. Above mentioned, three KSFs are identified as 7th level constraining factors in the healthcare supply chain of Pakistan. These can be eradicated by comparing the available budget with the company's current forecast plan and aligning the information system among production, planning, sales, supply chain, and logistics departments to obtain the set production and sales target standards. Generally, company forecasting helps avoid extra production,

decreases the burden of unsold products, and increases the chances of on-time product delivery to end-users. Sustaining a solid relationship with end-users is a forward step toward producing products according to end-user expectations, which might help avoid this KSF. Inventory and data management software and a skilled operating workforce using this software might help reduce the intensity of identified KSFs at the current level.

Study implications

Considering all experts' opinions, the current study results disclose that the first three levels of KSFs are identified as critical to the health care supply chain. It shows that healthcare firms in different developing countries face diverse KSFs because of economic, social, and political changes. Therefore, this also reveals that the same strategies dealing with KSFs of logistics and supply chain firms may not deliver the required results for the up-gradation of the whole industry. Solutions on promote KSFs to the healthcare supply chain might be different from firm to firm as well as country to country. However, the identified KSFs in the Pakistani context of the healthcare supply chain is limited in the literature review.

Most of the literature studies have evaluated different KSFs impeding supply chain and logistics services in the healthcare sector in developed countries; however, very few research papers are found on the identification of KSFs in developing countries' contexts. Moreover, very little research in literature identifies the contextual relationship among different supply chain KSFs, but no study is found in the Pakistani context. Application of ISM and MICMAC analysis is common in very renowned fields such as construction, manufacturing, management, and marketing. However, its application in the healthcare supply chain, especially in Pakistan is limited. However, this research adds to the literature theoretically by applying the combination of a new methodology of ISM and MICMAC in the healthcare supply chain in the Pakistani context. Considering the results, this study reveals different managerial and practical implications.

An ISM-based model guides how these selected KSFs can be correlated, and the ISM model also unveils their contextual relationship. Lack of initial capital has been identified as the most critical barrier and has deepened the root for other selected KSFs in an ISM model. Government agencies and financial institutions can overcome financial constraints in the healthcare supply chain. Furthermore, China aims to invest 46 billion dollars in different projects under the China Pakistan Economic Corridor (CPEC) umbrella. The Pakistani supply chain and logistics sector and the government should highlight this sector's potential to attract Chinese private and state-owned supply chain and logistics companies to invest in this sector. Lack of initial capital leads to a lack of top management commitment and training & experience that are identified as 2nd level KSFs. The untrained workforce issues can be resolved by learning from China's expertise because China has one of the world's advanced supply chain and logistics infrastructures and an experienced workforce. This research will be confidently helpful in resolving the most critical KSFs of the healthcare supply chain efficiently and effectively in the Pakistani context. The results of this research might also be beneficial for other developing countries such as India, Bangladesh, and Iran. Furthermore, this study's findings might also help simplify the adoption of green supply chain management processes in the Pakistani manufacturing industry to accomplish sustainable development goals (SDG) related to healthcare (Khan, Mathew, Dominic, & Umar, 2021).

CONCLUDING REMARKS

The healthcare products manufacturing industry is one of the high-pressure industries to manufacture and deliver those products that give patients relief in their critical situations. The Drug Regulatory Authority of Pakistan (DRAP) ensures that the drug manufacturing companies are producing their products under current medical laws. The fear of fake medicines, product quality concerns, security and traceability, and authorized healthcare products in this sector. Manufacturers are now requested to deliver documented proof that the returned product has been manufactured under quality

standards; in the case of negligence, all delivered products can be recalled from the markets, thus demanding supply chain and logistics efficiency. Considering the current situation, this research aimed to identify KSFs to the healthcare supply chain in the Pakistani context and formulate a contextual relationship-based model that uncovers hidden interactions among selected KSFs.

Twenty main KSFs were selected from the literature and experts' opinions on the healthcare supply chain and logistics in the Pakistani context. Sales and production planning, relationships with customers and inventory management are identified as top-level KSFs in the ISM model driven by its next-level KSFs. Transportation management and distribution systems were situated at the 2nd level of the ISM model. The 3rd level includes skilled professionals in SCM, reverse logistics infrastructure, green supply chain management, quality and safety, compliance, teamwork, organizational support, insufficient strategic planning, resistance to change, and conflict among employees. Information quality and strategic partnerships with suppliers were identified as the 4th level. New technology and information systems were located at the 5th level. The 6th level contains a top management commitment and training and experience.

Lack of initial capital is identified as the most critical KSFs to the healthcare supply chain in Pakistan. It presents intense driving but weak dependence power and is located at the base of the ISM model. It is concluded that the lack of initial capital is the primary failure of supply chain and logistics firms in Pakistan's healthcare sector. In fact, according to the current situation, a shortage of financial resources exists in every industry in Pakistan, so this study makes the point valid. An ISM and MICMAC analysis revealed the hierarchical structure of selected KSFs in the Pakistani context to overcome or reduce their intensity in the logistics and supply chain. This study's findings can help concerned authorities better understand critical KSFs on a priority basis, and more severe KSFs can be dealt with according to their severity. This research has some limitations. In the current study, ISM Model was formulated with twenty KSFs in the healthcare supply chain, selected through extensive literature and finalized with experts' opinions according to the Pakistani context. According to their country context, future research may focus on other critical KSFs in the supply chain. However, this study's results might benefit developing countries with similar economic conditions. The current study's findings can be verified and analyzed using the Structural Equation Modeling (SEM) methodology. Furthermore, the significance of selected KSFs can also be evaluated by a structural model in the healthcare supply chain. The current study's findings can be further examined in the near future by applying research techniques such as the analytic hierarchy process (AHP), analytic network process (ANP), DEMATEL, and fuzzy methods.

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Muhammad Waqas
Department of Business Administration,
Ghazi University, Dera Ghazi Khan, **Pakistan**
e-mail: mwaqas@gudgk.edu.pk

Zhang Yu
1) School of Economics and Management,
Chang'an University, Xi'an, **China**
2) Department of Business Administration,
ILMA University, Karachi, **Pakistan**
e-mail: Hong_zhang@ilmauniversity.edu.pk

Syed Abdul Rehman Khan
School of Management and Engineering,
Xuzhou University of Technology, Xuzhou, **China**
e-mail: khan_sar@xzit.edu.cn

Muhammad Tanveer
Department of Business Administration,
Imam Mohammad Ibn Saud Islamic University, Riyadh, **Saudi Arabia**
e-mail: cans_tanveer@hotmail.com

Abdul-Rahim Ahmad
Computer Information Systems,
King Faisal University, Hofuf, **Saudi Arabia**
e-mail: adahmed@kfu.edu.sa