

# **Integrating Artificial Intelligence and Blockchain for Resilient Pharmaceutical Supply Chains: A Systematic Literature Review**

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## **Abstract**

This paper presents a systematic literature review investigating the key applications of Artificial Intelligence (AI) and Blockchain technologies for enhancing the resilience of pharmaceutical supply chains (PSCs). Using the PRISMA methodology, a total of 139 relevant articles published between 2000 and 2025 were identified from Web of Science, ScienceDirect, and IEEE databases. The analysis reveals that AI is primarily applied in PSCs for demand forecasting, inventory optimization, anomaly detection, logistics planning, and drug development, enabling improved decision-making and operational efficiency. Blockchain applications, on the other hand, focus on cold chain monitoring, data sharing and transparency, smart contracts, and traceability, supporting secure, tamper-proof, and real-time information flow across the supply chain. By synthesizing these applications, this study highlights how the integration of AI and Blockchain can address key resilience challenges in PSCs, such as supply disruptions, counterfeit drugs, and inventory imbalances. The findings provide researchers and practitioners with a comprehensive overview of current

technological applications, serving as a foundation for future development of resilient and technology-enabled pharmaceutical supply chains.

## **Keywords**

Pharmaceutical Supply Chain, Resilience, Artificial Intelligence, Blockchain, Systematic Literature Review.

## **1. Introduction**

The COVID-19 pandemic exposed significant vulnerabilities in pharmaceutical supply chains (PSCs), highlighting their lack of resilience in the face of sudden global disruptions. These supply chains, responsible for the flow of critical medicines and vaccines from manufacturers to patients, faced challenges such as material shortages, transportation delays, and regulatory bottlenecks (Paul, 2025). Such disruptions highlighted the urgent need for more robust and adaptive systems that can withstand shocks while maintaining the availability and accessibility of essential pharmaceutical products.

In response, digital technologies have emerged as key enablers of supply chain resilience. For example, during the pandemic, pharmaceutical companies adopted digital control towers to monitor operations in real-time, enhancing coordination among suppliers, manufacturers, and healthcare providers, and improving responsiveness to fluctuating demand (Hong et al., 2025). Broader digitalization initiatives, including the use of Digital Twins, Internet of Things (IoT), Artificial Intelligence (AI), and Blockchain, have shown promise in improving supply chain visibility, predictive capabilities, and secure data sharing (Xames & Topcu, 2024; Jamil, 2025).

AI applications in PSCs can enhance decision-making through accurate demand forecasting, inventory optimization, anomaly detection, and logistics planning, thereby reducing the risks of stockouts or overstocking. Similarly, Blockchain technology can strengthen PSC resilience by ensuring data transparency, enabling secure information sharing, and improving traceability to combat counterfeit drugs (Khan et al., 2025). The integration of these technologies creates opportunities for proactive disruption management and greater PSCs agility.

Despite growing research interest in AI and Blockchain applications, a comprehensive integration of both technologies is still limited within PSCs. Therefore, the objective of this study is to systematically review and map the key applications of AI and Blockchain technologies in PSCs to enhance their resilience, thereby informing both academic research and industrial practice.

Section 2 presents the review methodology, Section 3 discusses the results, and Section 4 concludes the study.

## **2. Review Methodology**

This study aims to use a structured approach to perform the systematic literature review in the field of PSCs. For identifying the best structured approach. Table 1 highlights some of the articles, methodology, and databases used. The most used and reliable approach is PRISMA. Hence, this study will use PRISMA as the review methodology. This methodology incorporates the following steps: Identification, Screening, Inclusion (Page et al. 2021). The widely used databases in the covered literatures include ScienceDirect, Web of Science, and IEEE–The records discussed in this article will be gathered using the same databases.

Table 1. Overview of Systematic Literature Review in the domain of PSC

Title	Review Methodology			Used Databases				Citation
	PRISMA	SLR	Others	Scopus	Web of Science	Science Direct	Others	
Do changes to supply chains and procurement processes yield cost savings and improve	✓						✓	(Seidman and Atun 2017)

availability of pharmaceuticals, vaccines or health products? A systematic review of evidence from low-income and middle-income countries								
Blockchain applications in supply chain management: a systematic review of reviews	✓			✓	✓			(Khan et al. 2025)
Green pharma supply chain: a review of existing practices and future directions	✓			✓		✓		(Belal et al. 2025)
Pharmaceutical supply chain risks: a systematic review		✓		✓	✓			(Jaberidoost et al. 2013)
Artificial Intelligence in pharmaceutical supply chain management: A systemic review			✓				✓	(Roy et al. 2025)

## 2.1 Identification

The first stage of this systematic literature review involved identifying the appropriate keywords and constructing effective search strings to retrieve relevant articles on AI and Blockchain applications in PSCs resilience. This process required iterative refinement to ensure that the selected terms accurately captured the scope of PSC resilience, Blockchain, and their integration.

Based on the coverage and relevance reported in the literature, this study selected three major scholarly databases; Web of Science, ScienceDirect, and IEEE Xplore as the primary sources for retrieving articles. Although Scopus is also widely used, Mongeon and Paul-Hus (2016) reported that Web of Science and Scopus have an estimated 84% overlap in content, making the inclusion of both potentially redundant. Therefore, this study focused on databases that collectively offer strong interdisciplinary coverage in supply chain, engineering, and digital technologies.

Table 2 outlines the inclusion criteria, time frame, and keywords used to construct the search strings. The keywords were grouped into five main components.

Table 2. Search Parameters and Inclusion Criteria

Parameter	Value
Keywords	Resilience, Pharmaceutical, Distribution, AI, Blockchain
Time Period	2000–2025
Language	English
Document Types	Journal Articles, Review Articles, Conference Proceedings

Figure 1 presents a conceptual Venn diagram illustrating the intersection of search categories. Sets A through D represent Resilience, AI and Blockchain, Pharmaceutical Supply Chain, and Logistics, respectively. The overlapping region marked in red represents the core intersection of interest for this review.

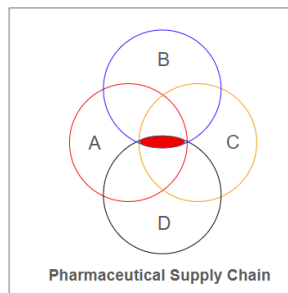


Figure 1. Conceptual Venn Diagram of Search Categories (Resilience  $\cap$  AI & Blockchain  $\cap$  PSC  $\cap$  Logistics)

Using the final combination of search terms, an initial pool of 537 records was retrieved from which 175 from Web of Science, 157 from ScienceDirect, and 205 from IEEE Xplore. After removing 12 duplicates, a total of 525 unique records remained for the next phase: title and abstract screening.

## 2.2 Screening

The screening phase followed the initial retrieval of 537 records from the selected databases. In this stage, each article’s title and abstract were reviewed to assess its relevance to the research objective specifically, the application of Artificial Intelligence and Blockchain technologies to enhance PSC resilience. Articles that did not align with the topic, such as those focused solely on general digitalization, non-PSCs, or unrelated healthcare technologies, were excluded.

After applying the inclusion criteria and removing out-of-scope studies, a total of 149 articles were retained for full-text review and analysis. Table 3 summarizes the number of included articles by database.

Table 3. Number of Articles Included by Database

Database	No of Articles
Web of Science	61
ScienceDirect	39
IEEE	49
Total Number of Papers	149

## 2.3 Inclusion

Following the screening phase, 149 articles were identified as relevant and proceeded to the full-text retrieval stage. Of these, 139 full-text articles were successfully retrieved and met all inclusion criteria, including relevance to PSCs and explicit discussion of AI and/or Blockchain applications. These 139 articles were ultimately included in the final synthesis.

The complete screening and inclusion process is illustrated in the PRISMA flow diagram presented in Figure 2.

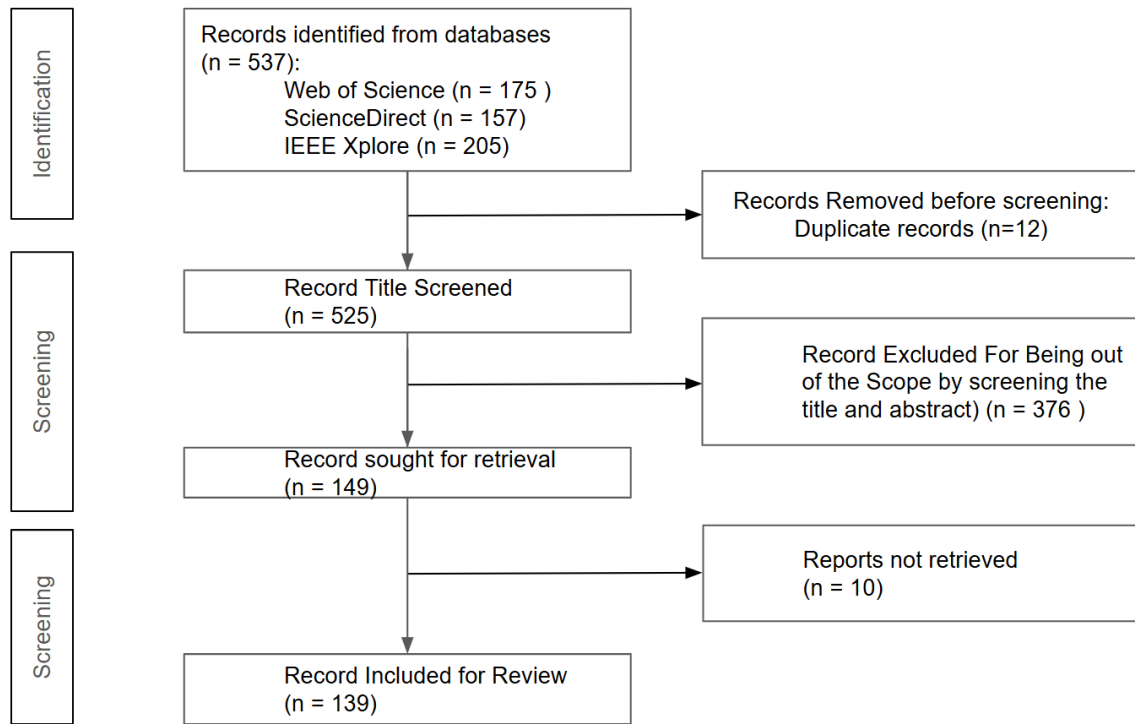


Figure 2. PRISMA Flow Diagram of the Article Selection Process

### 3. Results and Discussion

#### 3.1 Numerical Results

In this section of this study, the numerical results of the descriptive analysis will be presented. The two primary characteristics of the analysis include: the conferences and the journals publishing PSC research and the trend of the research interest over the period.

Among 139 retrieved journal articles, 59 of the articles were from conference proceedings. The highest number of papers in this topic was covered in the International Conference on Industrial Engineering and Operations Management; the count is 8. The second prominent conference in this area is the IEEE international Conference on Blockchain (IEE IBC). Table 4 illustrates the top conferences in this field.

Table 4. Search Strings, Exclusion, and Inclusion criteria's

Conference Name	Full Form	Number of Papers
IEOM Conference	International Conference on Industrial Engineering and Operations Management	8
IEEE ICBC	IEEE International Conference on Blockchain	7
ISPEC	International Conference on Information Security Practice and Experience	7
ICSTE	International Conference on Software Technology and Engineering	6
ICACCS	International Conference on Advanced Computing and Communication Systems	6

This article points out the top journals publishing quality articles in the field of Pharmaceutical Supply Chain. Table 2 highlights the details: name of the journals and number of articles published in the study horizon.

Table 5. Prominent Journals publishing PSC research throughout the period of this study

Journal/Conference	Number of Papers
Computers & Industrial Engineering	9
Ieee Access	8
Socio-Economic Planning Sciences	3
Journal Of Cleaner Production	3
Expert Systems With Applications	2
Research In Transportation Economics	2
Ieee Transactions On Computational Social Systems	2
Scientific Reports	2
International Journal Of Production Research	2
Heliyon	2
International Journal Of Pharmaceutics	2
Supply Chain Analytics	2
Procedia Computer Science	2
Technological Forecasting And Social Change	2
International Journal Of Logistics-Research And Applications	2
International Journal Of Production Economics	2

As per Table 5, the prominent journal in the field of Pharmaceutical Supply Chain is Journal of Computers & Industrial Engineering. And followed by, IEEE access journal ranks second since the number of papers published in this journal is 8. This table will allow other researchers to find the top journals for aiming their next papers publication in blockchain and AI in PSC. Therefore, this chart is the board of all the best journals in this field.

### 3.2 Graphical Results

This section of this study aims to highlight the percentage of articles covered in this study based on the type of publications (Figure 3).

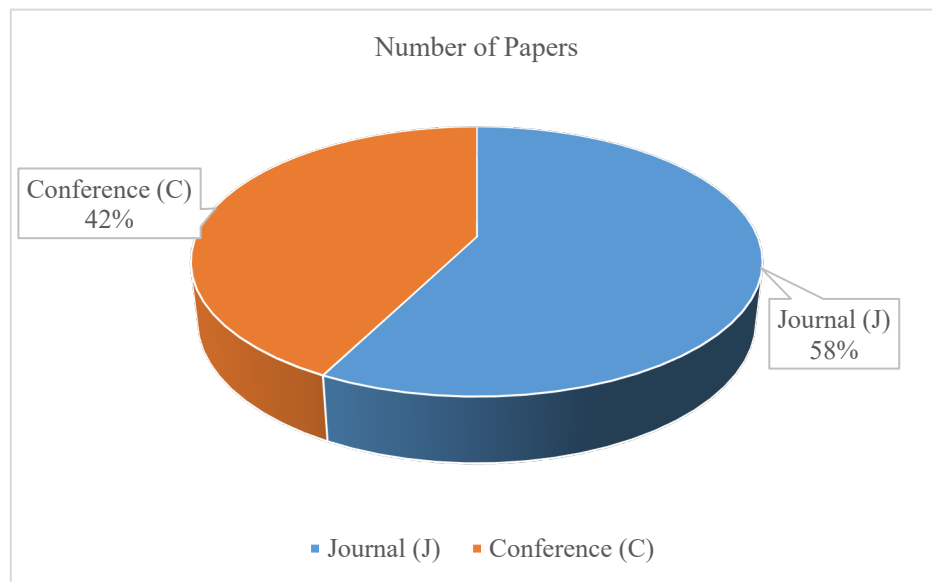


Figure 3. Percentage of articles covered in this study

Among 139 articles, 58% of the articles are Journal articles and 42% of the articles from Conference proceedings. Conferences are no focusing on such topic, pharmaceutical supply chain resilience. The concern for improving the resilience after covid pandemic is positive.

Among all 139 papers, the proportions of papers that discuss the AI applications and BC applications in PSC are shown in Figure 4.

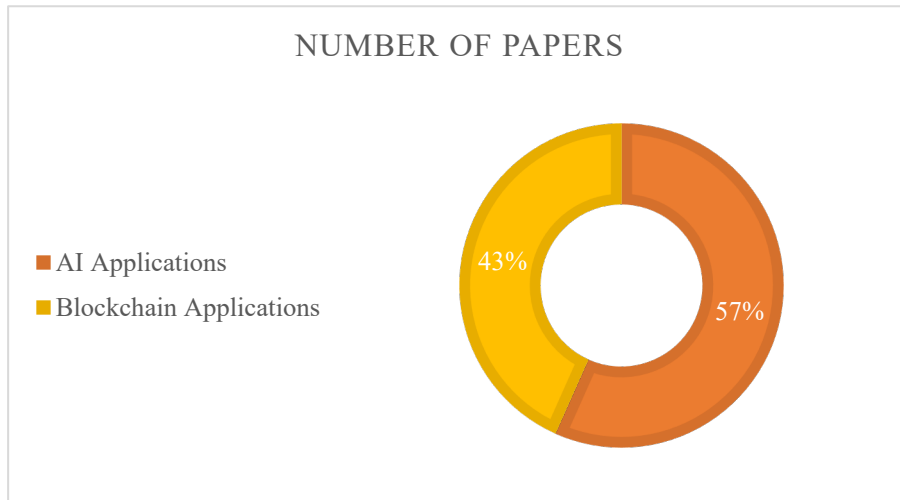


Figure 4. Percentage of articles covered in this study

### 3.3 Key Applications of AI in PSC

The key application areas of AI in PSC include Demand forecasting, Inventory Optimization, Anomaly Detection, logistics, and Drug development. Figure 5 shows the number of papers that discussed these applications areas.

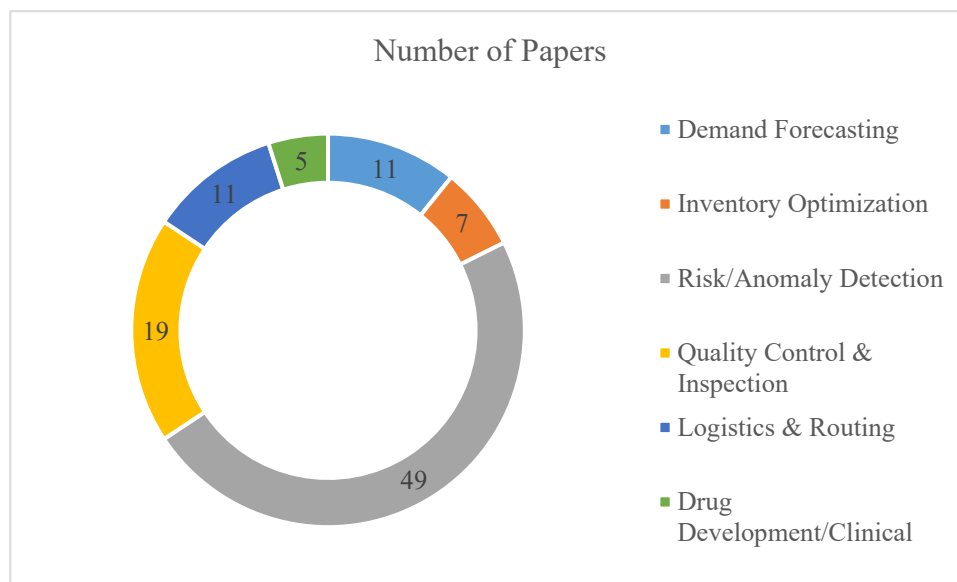


Figure 5. Application Areas of AI in PSC and the corresponding no of papers

AI has been groundbreaking in any other areas of industrial engineering. AI will increase the resiliency of the supply chain, safety of the network and the transparency of the communication throughout the Pharmaceutical Supply Chain. In general, the application of AI in PSC is to identify the anomalies by detecting the patterns in data. It can easily identify issue like demand fluctuations and supply disruptions by following the trend (Hosseini Bamakan et al. 2021; Saxena et al. 2023). AI is also being used to make the supply chain efficient and productive using demand forecasting and optimization(S. P and K. Venkatesh 2023; Samonte et al. 2023). Demand forecasting can significantly reduce the waste of materials or stockouts because AI enables almost accurate results.

### **3.3 Key Applications of Blockchain in PSC**

The major applications of blockchain technology in PSC include Cold Chain Monitoring, Data sharing and Transparency, Smart Contracts, and Traceability (Figure 6).

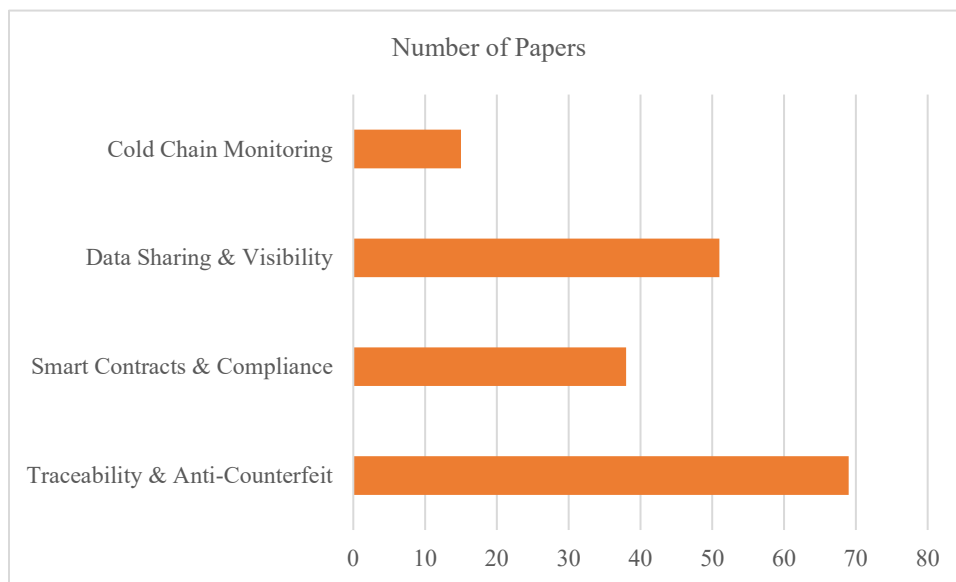


Figure 6. Applications of Blockchain in PSC

On the other hand, blockchain is to ensure transparency and traceability. According to a study, Blockchain combats counterfeit medicines by keeping every transactions on a safe log sheet (Grest et al. 2019; Lau et al. 2021). Among partners, blockchain ensures secured data sharing; in addition, it enables smart contracts to use automatic compliance check(Dolgui et al. 2021).

Therefore, together both technologies will make the supply chain more resilient and efficient.

### **3.5 Validation**

This study followed the PRISMA guidelines and made sure each step has been performed and acknowledged. Since a standard and widely used protocol has been used to perform the overall literature review, the results and discussion of this study are not biased or subjective to anyone.

## **4. Conclusion**

This study presented a systematic literature review to identify and synthesize the key applications of AI and Blockchain technologies in enhancing the resilience of PSCs. The PRISMA methodology was employed to ensure transparency and rigor in the review process, minimizing bias and improving replicability.

To achieve this objective, the literature search was conducted using three well-established databases: Web of Science, ScienceDirect, and IEEE Xplore. A total of 537 articles were initially retrieved, from which 12 duplicates were removed. After screening titles and abstracts for relevance, 149 articles were selected for full-text review, of which 139 met the inclusion criteria and were included in the final analysis.

The findings of the review reveal several prominent journals and conferences actively publishing in this area, including Computers & Industrial Engineering, IEEE Access, Socio-Economic Planning Sciences, and the Journal of Cleaner Production. Key conference venues include the International Conference on Industrial Engineering and Operations Management (IEOM), IEEE ICBC, ISPEC, and ICSTE.

With respect to technological applications, AI is primarily used in PSCs for demand forecasting, inventory optimization, anomaly detection, logistics planning, and drug development. Blockchain, on the other hand, is applied in areas such as cold chain monitoring, secure data sharing and transparency, smart contract execution, and traceability. These applications demonstrate the potential of digital technologies to address persistent challenges in PSC operations, such as supply disruptions, counterfeit drugs, and data silos.

This review contributes to the academic literature by offering a consolidated view of how AI and Blockchain technologies are currently being used to build more resilient PSCs. It serves as a foundation for researchers and practitioners aiming to adopt or study these technologies in future supply chain designs.

Limitations of this study include its qualitative focus and reliance on published literature in English. Future work should consider a more in-depth thematic analysis or bibliometric mapping to uncover deeper insights and interconnections across research domains. Additionally, emerging technologies such as digital twins and generative AI could be explored in subsequent reviews to assess their complementary role in enhancing PSC resilience.

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## **Biographies**

**Abu Saleh Md Nakib Uddin** is a student of MASc in Industrial Systems Engineering at the University of Regina. He has been awarded fully funded MASc Position by the Faculty of Engineering and Applied Science due to his research excellence in undergraduate studies. During the first semester (Winter 2025) of his master’s studies, he was awarded “SGI Graduate Student Traffic Safety Research Scholarship” by the Faculty of Graduate Studies and Research as a part of the Winter 2025 Main Scholarship Competition at the University of Regina. Before stating his master’s studies in Canada, he received his bachelor’s degree in industrial and production engineering from the Military Institute of Science and Technology, Bangladesh. During his junior year of his bachelor’s degree, he delved into developing an Ecofriendly Gutter Cleaner where he got exposure of research. From that point on, he has been passionate about research, and he aims to start his career in academia. Before he defended his undergraduate thesis, he was able to write some journal papers because of his passion. He published his co-author papers in reputed journals. And he attended International Conferences virtually and physically. He is a student member of CORS and was an IEOM Student Member.

**Dr. Dua Weraikat, Ph.D., Eng.**, is currently an Assistant Professor and MEIE Program Coordinator at the Rochester Institute of Technology, Dubai Campus. She brings a strong academic and research background in industrial engineering, with expertise in operations research, supply chain management, and sustainable reverse logistics. Prior to joining RIT Dubai in 2017, she held research and teaching positions at Concordia University, Canada, where she completed her Ph.D., and later served as a postdoctoral researcher at Université Laval, focusing on value chain coordination in the forest industry. With over 15 years of experience across academia and industry, Dr. Weraikat has contributed to several impactful publications, including journal articles and book chapters, in areas such as green supply chains and pharmaceutical logistics. She has also taught various courses including production planning, operations research, and project management. Her leadership is reflected in her current role on the Operations Research Division Board of the Institute of Industrial and Systems Engineers (IISE) for the 2025–2027 term. Fluent in English, Arabic, and French, Dr. Weraikat is passionate about integrating smart and sustainable solutions into engineering education and research, mentoring students, and fostering collaboration across academic and industrial platforms

**Dr. Shireen Al Hourani, Ph.D., PMP**, is an Associate Professor at University Canada West, Vancouver, with over 20 years of combined experience in academia and industry. She previously served as Assistant Professor at King Abdulaziz University and German Jordanian University, where she taught courses in industrial and mechatronics engineering, including project management, production planning, and engineering design. Her academic leadership included overseeing senior capstone projects, accreditation processes, and contributing to student development through training and evaluation initiatives. Before entering academia, Dr. Al Hourani held several leadership roles in the pharmaceutical industry at Hikma Pharmaceuticals, including Engineering Director and Senior Supply Planning Manager for the MENA region. Her work focused on excellence in engineering, lean manufacturing, preventive maintenance systems, and SAP PM implementation. She has authored multiple research papers in pharmaceutical engineering, automation, and supply chain optimization. Dr. Al Hourani’s interdisciplinary expertise spans mechanical and mechatronics engineering, operations excellence, and business leadership. She holds a Ph.D. in Mechanical Engineering from the University of Jordan and professional certifications in project management and leadership.

**Sharfuddin Ahmed Khan** is currently an Associate Professor and Associate Program Chair of Industrial Systems Engineering at the University of Regina, Saskatchewan, Canada. Prior to this role, he served as a Lecturer (September 2009 – August 2019) and later as an Assistant Professor (September 2019 – December 2021) at the University of Sharjah, United Arab Emirates. He then joined the University of Regina as an Assistant Professor (January 2022 – June 2025) before being promoted to his current position. Dr. Khan has contributed extensively to top-tier academic journals and Scopus-indexed conferences in areas such as supply chain management, sustainability, and engineering management. His research has been published in renowned journals, including *Business Strategy* and the *Environment, Supply Chain Management: An International Journal*, *IEEE Transactions on Engineering Management*,

Production Planning and Control, International Journal of Production Research, and Operations Management Research, among others. He has also authored book chapters and published books with leading academic publishers such as Taylor & Francis and Emerald Publishing. Dr. Khan has successfully secured significant research funding and has supervised and co-supervised numerous graduate students at master's and doctoral levels. His research continues to make a strong academic impact. A detailed overview of his scholarly work is available on his Sharfuddin Ahmed Khan - Google Scholar