

The utilization of AI in advancing green supply chain management focusing healthcare sector in Saudi Arabia

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Abstract

Artificial Intelligence (AI) is a notable developing technology and its applications have extended the benefits to almost all disciplines. The aim of this current research is to investigate the impact of Artificial Intelligence on Green Supply Chain Management (GSCM). This research explains the applications of AI in GSCM and illustrate, how the application of AI has opened new directions in future for GSCM and what are the challenges need to be addressed for its effective working. AI facilitates in reducing cost, automating, and increase in productivity and eventually achieving economies of scale in SCM. This research provides a development of an outline for the use of an AI based GSM for industries especially in the Healthcare sector (HST). For the purpose of the study we have applied Qualitative analysis and methods of data collection were workshop and interview with HST professionals and stakeholders in KSA. The results show that HST professional have good experience and gave 90 percent positive feedback for applying AI for GSCM in HST but Stakeholders for some situations have shown apprehension due to short term increment of cost in handing the GSCM and applications of sensors to automate the process but their responses were also 70 percent positive.

Subject Classification: 94-02.

Keywords: Artificial intelligence, Green supply chain management, Healthcare sector interview, Qualitative analysis.

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1. Introduction

“Green smart business” has flourished as a frontline in the realm of sustainable development, exemplifying a multidimensional approach to enhancing business effectiveness. This model strives for a seamless fusion between production, service spaces, and customer interaction, thereby heralding a new era of progressive enterprise [1]. In the contemporary milieu steeped in data reliance, novel practices have surfaced, fostering both challenges and opportunities [2]. The advent of innovative data sources has paved the way for pioneering applications that harmonize business functions with the demands of modern life [2].

Supply Chain Description

The supply chain stands as a tapestry interweaving myriad elements encompassing organizations, resources, activities, and information networks. Its purpose lies in the transformation of raw materials into consummate products delivered unto the discerning end customer [2-3]. A paradigm shift has been engendered in traditional supply chains owing to pivotal factors such as hyper-segmentation, localized sourcing and production, amplified customer expectations, and comprehensive visibility throughout the operational spectrum [3]. These capabilities enabled leading technology organizations to collaborate effectively, revolutionizing the entire supply chain process through enhanced automation in hybrid design. [4]. Business organizations are applying AI at many the domains and experience positive outcomes as well as increment in revenue [5]. HST is an essential part of commercial profession which plays an important role in economic growth. HST experts and professional have understood that health sectors cannot achieve its target and work with the applications of emerging technologies such as AI [5].

Concept of Artificial Intelligence (AI)

AI systems epitomize the epitome of computational prowess, mimicking human cognitive abilities in decision-making and task execution. At present, AI thrives on advanced analytics, employing machine learning, optimization, and profound learning methodologies. This fusion augments the sophistication of products and devices, thereby externalizing their cognitive faculties [6]. AI ushers in unparalleled opportunities for augmented learning experiences and personalized interactions, fostering seamless collaboration between AI systems [6]. This

distinct advantage of AI has been harnessed by HST to optimize the seamless production of medical supplies (refer to Figure 1).

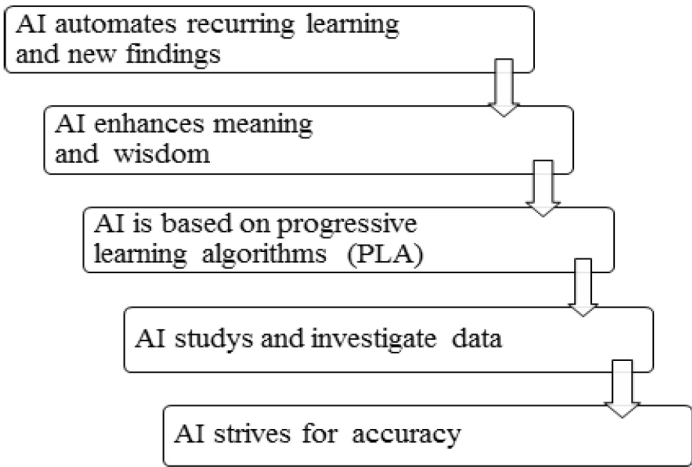


Figure 1
Reasons for the Application of AI [6]

AI contributes in different domains and particularly in HST for various benefits (see Table 1).

Table 1
Application of AI in HST [7]
Precautionary Maintenance
Management and optimum application of for the best use of time, machine and money
Low costs of energy
Management of working infrastructure

Applications of AI

AI aids the HST sectors to cut costs and motivate in repair the medical machines. The manifold applications of AI within business operations, particularly within the healthcare sector (HST), have proven instrumental in decision-making, cost-effectiveness, and environmental conservation [7]. Its strategic implementation enables the discernment of machinery requisites, curbing hardware consumption, and optimizing existing equipment functionality [8]. AI’s efficacy lies in identifying maintenance needs, optimizing machinery performance, and averting substantial investments through selective part replacement instead of complete

overhauls [9]. Figure 2 shows the advantages in SCM through the applications of AI [9].

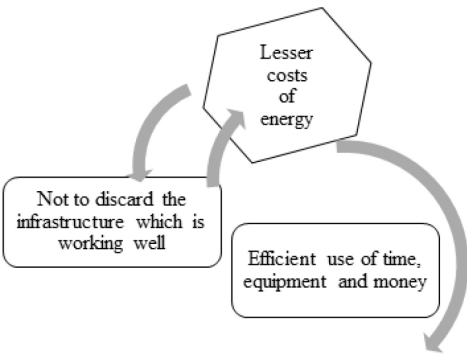


Figure 2
AI in the general benefits in SCM [9]

Working of SCM

Supply Chain Management (SCM) involves overseeing the entire product journey, from raw manufacturing to consumer consumption. Effectively managing this process necessitates establishing a network of suppliers to facilitate the seamless progression of the product through each stage. [9]. SCM embodies the meticulous orchestration of goods and services, commencing from raw material genesis to end-user consumption.

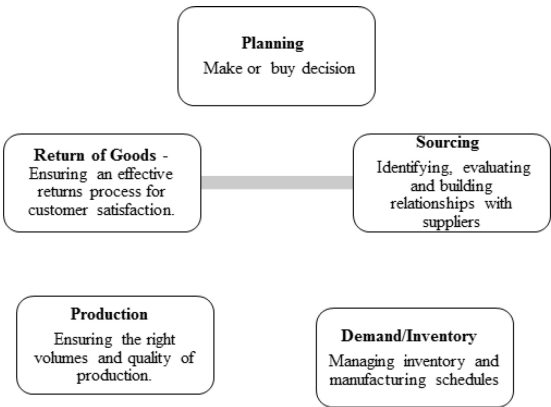


Figure 3
Elements of SCM in BPM [13]

A well-honed SCM framework not only fortifies an organization’s financial stature but also aligns value delivery with overarching corporate strategies [10]. It constitutes a linchpin in ensuring customer satisfaction, while concurrently curbing operational costs throughout the supply chain continuum [11]. The financial success of major corporations is intricately linked to the efficient governance of their supply chain [12]. Figure 3 delineates the six crucial components of Supply Chain Management (SCM) within the framework of Business Process Management (BPM).

In 2007, Srivastava outlined the scope of Green Supply Chain Management (GSCM) and explained its future for any firm. He also explained the benefits of reducing, reworking, reclaiming and recycling in the GSCM [14]. The future of SCM has three attributes as shown in Figure 4.

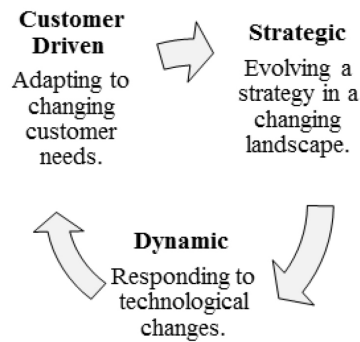


Figure 4

Future of SCM for specific firm

This comprehensive perspective of GSCM is motivate all sectors of societies, BPM, national and international committee to work for environment preservation [16].

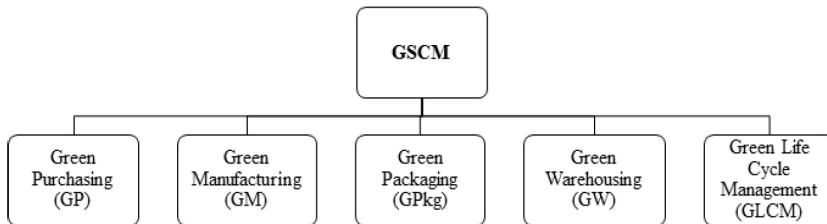
Applications in Green supply chain (GSCM)

The endeavours of GSCM seeks to curtail carbon emissions, minimize waste, and optimize profitability. The purview of GSCM extends across the entire supply chain gamut, enshrining green improvements in the manufacture, procurement, distribution, and handling of medical supplies [17]. Some instances of GSCM applications in HST to improve environmental quality and cut costs is shown in Table 2.

Table 2**Applications GSCM in the cost control for Environmental Sustainability [18]**

Rethinking materials:	Using recycled materials during the manufacturing process can save money
Optimizing transport:	Streamlining the transportation logistics provide many ways to save money and reduce the carbon footprint.
Reusing waste or by-products	Reusing the wastes or discard or even unlock new revenue streams from recyclable materials.
Redesigning processes	Considering new ways and technology to streamline the manufacturing processes in order to reduce the cost and carbon emission and enhance the efficiency.
Reducing business risk	Reduce the unsustainable practices
Cutting back on packaging:	Switching to streamlined packaging uses fewer materials and can lead to lower costs.

GSCM uses some methods for environmental sustainability for reducing pollution in air and water as shown in Figure 5 [19].

**Figure 5****Environmental conservation in GSCM [20]**

GSCM is characterized by a specific objective in enhancing environmental health within the supply chain. Conversely, sustainable supply chains adopt a more comprehensive approach, aiming to diminish their impact across various facets of life to safeguard the continuous operation of industries in the future. Naturally, environmental considerations are integral to sustainability [20]. Additionally, organizations navigating these domains must navigate economic considerations, particularly in terms of orchestrating ecological advancements (see Table 3).

Table 3
GSCM best practices at the management level [21]

Leadership	Managers and executives have to develop a unified approach to creating a green supply chain strategy.
Commitment	A variety of software applications and advanced technology support green supply chain management at various steps of the process.
Technology	When going green has positive implications for firm's brand and culture supports these changes, introducing new green practices throughout firm's supply chain tends to go efficiently.
Brand Image and Firm	
Cost	Depending on the business and industry, developing a green supply chain may initially seem cost prohibitive.
Knowledge	Participants' expertise stands to have a big impact on supply chain performance at every stage.

The AI has impact on GSCM to optimize the BPM and increase the efficiency as shown in Figure 6.

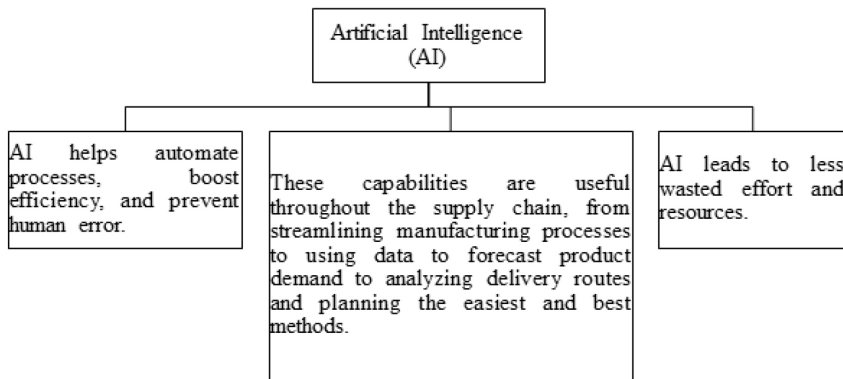


Figure 6
Impact of AI in GSCM [22]

The adoption and adept implementation of AI hold the potential to enhance collaboration among supply chain stakeholders by facilitating swift and accurate information transfer through information systems. This, in turn, augments the overall efficiency of the HST [23]. Recognizing the intricacies inherent in healthcare supply chains, the exploration of new technologies emerges as a crucial factor for optimizing performance. Integrated information devices stand out as particularly pertinent in HST management. The accurate and instantaneous coverage of relevant information within the medical domain not only streamlines processes but also promotes transparency, thereby facilitating smoother progress. Figure 7 shows the AI in the GSCM in HST.

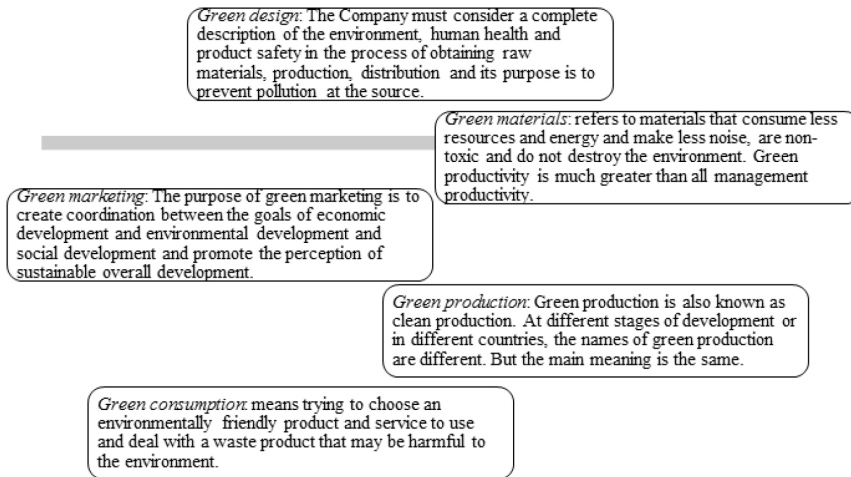


Figure 7
AI in GSCM in HST [24]

AI emerges as a potent and effective tool in these scenarios, catalyzing significant transformations in the realm of Healthcare Supply Chain (HST) at a pace unparalleled in the last decade [25].

The two objectives of the current study to find the applications of AI in HST for GSCM.

RQ1: To measure the effectiveness of AI in HST for GSCM

RQ2: To illustrate the benefits and problems in the applications of AI in HST for GSCM.

2. Literature Review

In 1996, the applications of Green Supply Chain Management (GSCM) was explained in the industrial research center of Michigan State University. GSCM, when viewed through the lens of Green Life Cycle Management (GLCM), encompasses every phase of the medical product lifecycle within the healthcare system, including raw goods, their design, operations, sales, transportation and recycling [26]. To optimize resource and energy utilization, the Healthcare Supply Chain (HST) can proactively address adverse consequences, apply technologies which are good for environment and conduct efficient GSCM practices [27].

GSCM represents a comprehensive approach systematically addressing environmental considerations throughout the entire supply chain, integrating environmental requirements at each stage, such as product design and supply chain selection. While sustainable supply chain management and GSCM are distinct concepts, they are often used interchangeably in supply chain literature. Sustainable supply chain management encompasses economic, social, and environmental sustainability dimensions, making it a broader concept compared to GSCM, which is a subset of sustainable SCM [28].

Traditionally, the Product Life Cycle (PLC) focused on practices from the design phase to consumption. However, with environmental management methodology, the PLC now encompasses raw material preparation, design, creation, usage, recycling, and reuse, forming a closed-loop material flow that reduces resource consumption and environmental harm [29].

Recognizing the nexus between environmental issues and the economy, nations are pursuing environmental protection strategies that enhance production, with Green Supply Chain Management (GSCM) emerging as a recent and impactful strategy [30]. GSCM aims to eliminate or reduce waste, representing a significant innovation for organizations striving to achieve common economic and market goals while mitigating environmental risks and improving competence [31]. Compliance with environmental laws and regulations serves as a key motivator for adopting green supply chains.

Artificial Intelligence (AI), a foundational element of big data creation, plays a pivotal role in leveraging the competitive gain of the Healthcare Supply Chain (HST) [32]. By aligning with environmental standards and laws, enhancing patient awareness, and minimizing the challenges in environmental preservation, HST enhances its competitive edge. The supply chain, serving as the core unit of HST, encompasses a broad spectrum of procedures from medical supplier relationships to manufacturing practices, and from production to making products accessible to HST [33].

While previous research [34] discussed the challenges and future directions of the GSCM without specifying the applied technology, and Ali et al. (2020) explored the integration of GSCM practices, the specific application of AI in GSCM remains underexplored. This research uniquely focuses on AI technologies in HST for GSCM, providing valuable insights into the significance of AI in enhancing the efficiency and sustainability of medical supplies and healthcare services.

3. Methodology

We have applied descriptive methods and interviewed HST professionals. Also arranged workshops for them followed by query sessions.

Proposed Work

AI stands as a groundbreaking technology applicable across diverse industries, showcasing its considerable possible processes, including the SCM. The integration of AI technologies into management, forecasting, and monitoring applications has proven instrumental in enhancing the operational efficiency of healthcare systems. By leveraging AI in the distribution process, healthcare management not only improves decision-making transparency but also ensures a more streamlined and effective operational framework. Top of Form

Figure 8. Shows the research process of the current study.

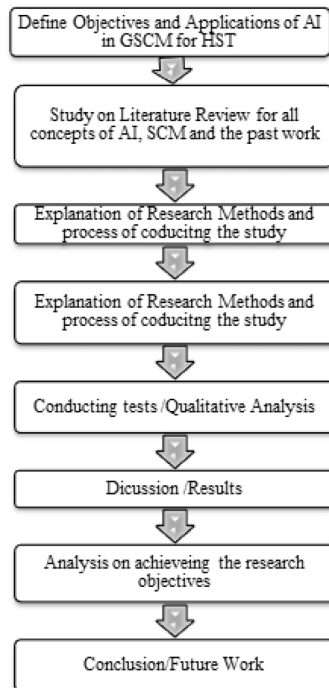


Figure 8
Methodology of current research in GSCM of HST

4. Results and Discussion

The integration of AI into GSCM within the healthcare sector has engendered real-time monitoring of medical supply shipments, astute tracking of storage conditions, predictive analysis of supply movements, optimized planning, and infusion of green practices. Interviews and workshops with healthcare professionals and stakeholders have elicited resoundingly positive responses, affirming AI's pivotal role in environmental stewardship and GSCM refinement.

Artificial Intelligence (AI) delivers a seamless flow of real-time data to the Healthcare Supply Chain (HST) workforce, encompassing doctors, stakeholders, and other medical staff members. This data pertains to medical products like medications, accessories, and equipment, providing insights into their location and the environmental conditions during shipping (See Figure 9).

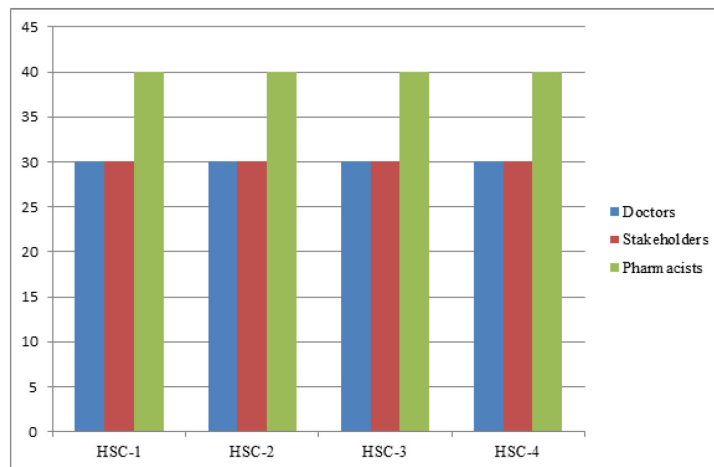


Figure 9

AI applications in GSCM for MS

Pharmacists, Stakeholders and Doctors have trust on AI applications in GSCM for MS and they feel positive for the growth and advancement of AI in HST in coming years.

RQ1: To measure the effectiveness of AI in HST for GSCM

Artificial Intelligence (AI) introduces environmental sensors utilized by medical professionals to monitor transportation conditions actively and respond promptly to ensure the optimal storage of medical supplies.

AI plays a pivotal role in automatically adjusting these conditions throughout the Supply Chain Management (SCM) process (See Figure 10).

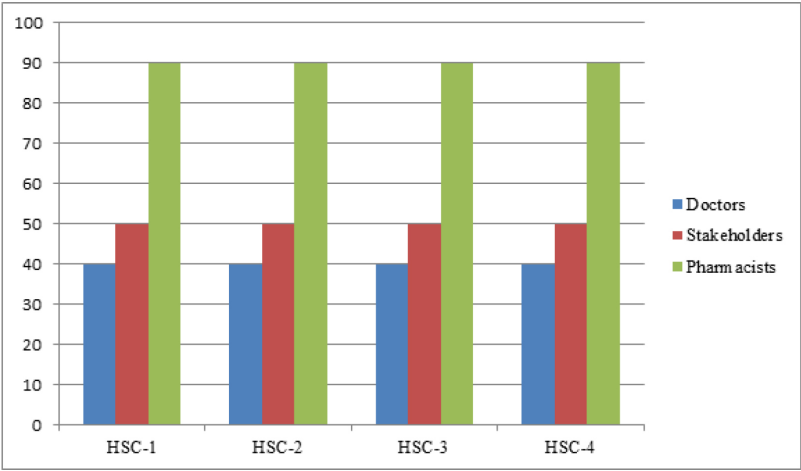


Figure 10
AI applications in MS for managing the Inventory

The results show that HST professional have good experience of AI in the process of managing SCM for MS. Doctors and HST owners gave good response but they are also worried of increase in cost and investment for GSCM.

RQ2: To illustrate the benefits and problems in the applications of AI in HST for GSCM.

HST Specialists leverage AI tools and information analysis systems to enhance decision-making and achieve precise delivery predictions for healthcare supplies. Real-time tracking applications enable HST to monitor medical supplies in predicting consignment delivery duration and times, uncertainties in the logistics and learning preservation of MS. Artificial Intelligence (AI) is crucial for identifying necessary conditions for warehouse management in MS.

The incorporation of GSCM systems based on artificial intelligence. emerges as a key technological trend in inventory management, ensuring environmentally friendly device usage. Advantages range from improving inventory processes efficiency to tailoring inventory management specifically for medical supplies. Additionally, AI contributes to the health and safety of employees in the supply chain management (SCM) sector,

especially when handling MS that require extra care and can be damaged if not handled properly.

AI facilitates an integrated workflow and performance that would be otherwise unattainable for medical supplies. By automating inventory control through artificial intelligence, it further streamlines processes and enhances overall efficiency in managing medical supplies (See Figure 11).

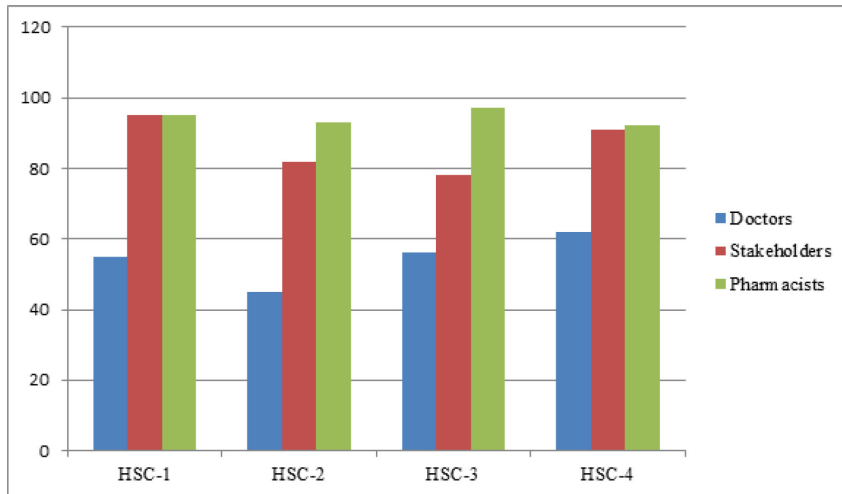


Figure 11

Monitoring by AI for the flow of MS goods from Inventory to the shipment

All the experts of HST agrees positively for the applications of AI in monitoring by the AI tools for the SCM of MS and applaud the benefits of AI in GSCM for HST.

Stakeholders of HST are found to be less motivated in using AI for GSCM due to increase in cost and investment however, Doctors and pharmacists are highly enthusiastic to foresee more applications of AI in maintaining GSCM in HST.

5. Analysis

The incorporation of AI into GSCM signifies an immense stride in healthcare logistics, energy conservation, and the propagation of eco-conscious practices. Despite initial concerns regarding costs, healthcare professionals evince robust enthusiasm for AI's transformative potential in fortifying SCM and fostering environmental sustainability.

6. Conclusion/ Future Work

In principle, the integration of AI into GSCM proclaims an era of sharp effectiveness in healthcare logistics, coupled with a resolute commitment to environmental preservation. Healthcare professionals advocate a steadfast belief in AI's capacity to optimize supply chains and help in eco-friendly operations.

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Received March, 2023