A Critical Evaluation of the Impact of Artificial Intelligence in Enhancing Transparency, Efficiency, and Traceability in the Pharmaceutical Supply Chain.

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ABSTRACT

The research was designed to analyse the role of artificial intelligence (AI) in enhancing traceability, transparency and efficiency in the pharmaceutical supply chain network. Achieving this required the review of relevant industry and academic literature to retrieve secondary quantitative and qualitative data by adopting parallel methodology. During the research, it was observed that there is limited information to evaluate the sustained impact of integrating AI in the pharmaceutical supply chain to justify its high cost. Additionally, there is a need to have a standard metric for measuring the positive impact of utilising AI in manufacturing, purchasing, transportation, storage, and delivery in the pharmaceutical supply chain.

The triple bottom line concept was used to access the impact of AI on sustainability, and it was identified that organizations which use AI can utilize the analysed data to make key decisions on supplier selection, authenticate the source of raw materials, configure, and design their supply chain networks in a sustainable manner. In doing this, there will be a positive impact on the environment, through ethical sourcing, the people, because counterfeit drugs will be eliminated, original drugs will be available when needed, and profitability for organisations through reduced cost and enhanced productivity. Furthermore, it was identified that using AI ensures there is a continuous flow of essential medicines using the continuous flow model, in an agile and lean way while eliminating supply chain variability. Finally, it was established that integrating AI in the pharmaceutical supply chain is essential because it will revolutionize and optimize the entire system. Therefore, organizations should invest in AI and human capital development so people with the requisite skills can manage the pharmaceutical supply chain systems.

INTRODUCTION

The application of artificial intelligence (AI) is rapidly permeating every industrial process, and its importance in improving operations can no longer be ignored. Despite being an emerging technology, it provides opportunities for diverse businesses in every sector to enhance their operations. Recent studies indicate that AI will cause significant changes globally sooner than later especially in supply chain management (Sharma et al., 2022). This assertion by the authors implies that although AI is a modern technology, it possesses the potential to significantly optimize operations in every industry worldwide with the adoption rate now quicker than initially anticipated by experts. One of the industries which will be greatly impacted by AI is the pharmaceutical sector which plays a pivotal role in sustaining global healthcare and has begun using this technology across their supply chain (Wu, 2023), with drug discovery and manufacturing, and other parts of the pharmaceutical supply chain experiencing a significant boost through the reduction of production time as stated by (Gupta et al., 2021).

1.1 What is Artificial Intelligence?

Artificial intelligence (AI) is defined as the application of computing power with datasets to learn, understand patterns, reason, and identify attributes through retaining, obtaining, experiencing, and advancing knowledge to address critical challenges associated with decision-making processes where certain outcomes are required (Min, 2010). This technology utilises computing capabilities and reliable data to train models and equip them with the ability to gain insight about systems, memorise the information, analyse, and provide outcomes when a request

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is placed at a quicker pace than humans (Min, 2010). Additionally, AI empowers machines to undertake cognitive actions usually performed by humans through continuous training to learn independently and gain self-awareness as expressed by (Min, 2010). Specifically, this author has discovered that the integration of AI enables a system to carry out tasks usually performed by humans once trained, because there will have the ability to likely outperform and complete the processes faster than humans would. This, therefore, signifies that AI can automate any system it is has been integrated into and optimise every process within the supply chain network. This assertion aligns with the opinion of (Dolgui and Inanov, 2021), who has identified that AI is vital in digitalizing and automating the supply chain to optimize overall productivity.

1.2 Concept of Supply Chain Management

A definition of Supply Chain Management by (Stock and Boyer, 2009), states that it is "a network of activities within a company and between interconnected corporations and business sections comprising of raw material suppliers, manufacturing facilities, purchasing, logistics, finance, marketing, and other associated systems that enable the onward and backward movement of services, materials, information and finances from a manufacturer to the end consumer by adding value, and increasing profit by enhancing operations to gain customer satisfaction" Figure 1.

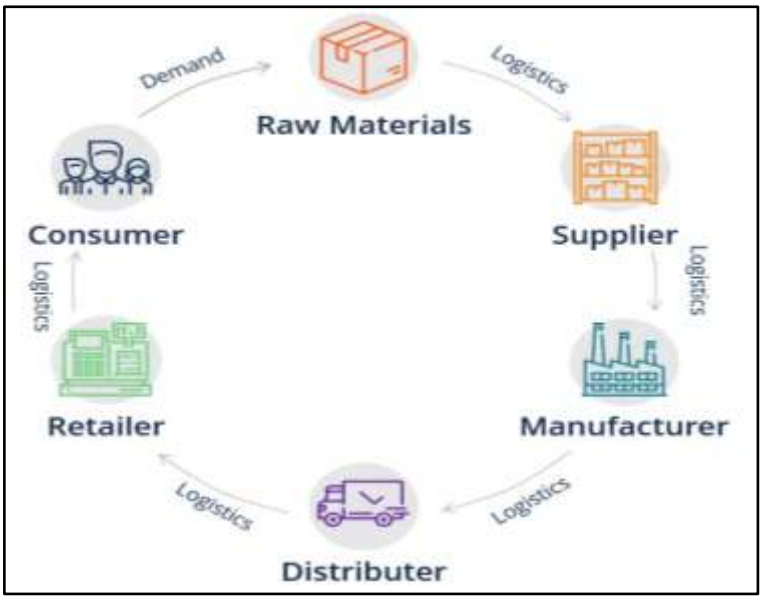

Figure 1. This shows a comprehensive overview of supply chain processes from the manufacturer to the consumer. Modified after (Stock and Boyer, 2009).

This definition by the authors indicates that supply chain management comprises of diverse activities and processes within the organization from sourcing of raw materials, through manufacturing and processing until the product is delivered to the customer who will now provide feedback assessing whether the service offered was satisfactory or not. The outcome of this feedback usually enables the organization to make informed decisions associated with process improvement where necessary to meet and enhance customer satisfaction. Furthermore, this entails that these diverse processes occur between separate industries including pharmaceutical companies which are interdependent on each other for manufacturing, processing, storage, transportation, delivery, etc., until it is delivered to the final consumer.

1.3 Supply Chain in the Pharmaceutical Industry

The aim of the research is to ascertain how the integration of artificial intelligence (AI) in the pharmaceutical supply chain Figure 2, can make it more efficient. This is vital because the supply chain depends on diverse technologies to enhance, optimise, and make the network more traceable, transparent, and efficient to meet customer needs. Consequently, AI has been identified by researchers and industry experts (Wu, 2023) as a core technology with the capacity to revolutionize supply chain processes across industries, especially the pharmaceutical industry.

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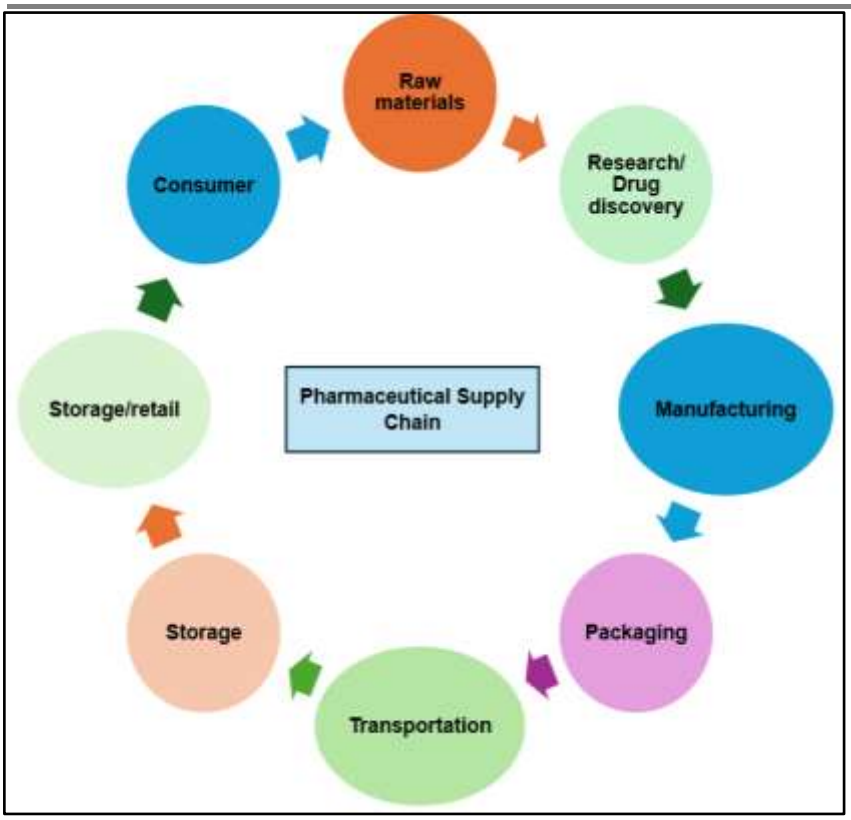

Figure 2. This shows an illustration of the pharmaceutical supply chain processes. Modified after (Stock and Boyer, 2009).

1.4 Research Significance

The pharmaceutical industry is critical to the wellbeing of humans globally which makes it a highly regulated sector because of the complex and diverse products required by consumers (Wu, 2023). Furthermore, the industry oversees conducting research, manufacturing, development, and administration of medicines needed by patients globally for healthy living as stated by (Matej, 2024). A recent assessment indicates that the pharmaceutical industry has grown steadily and is worth over 1.6 trillion U.S. dollars as shown in Figure 3 (Matej, 2024). As acknowledged by the authors, the industry plays a crucial role globally, therefore, it is essential for the pharmaceutical industry to constantly innovate and streamline all its operations through consistent research and development to meet global demands. Additionally, companies must adopt and integrate an emerging technology like AI which has the potential to optimise all operations in the pharmaceutical supply chain, increase profitability, and meet global demands.

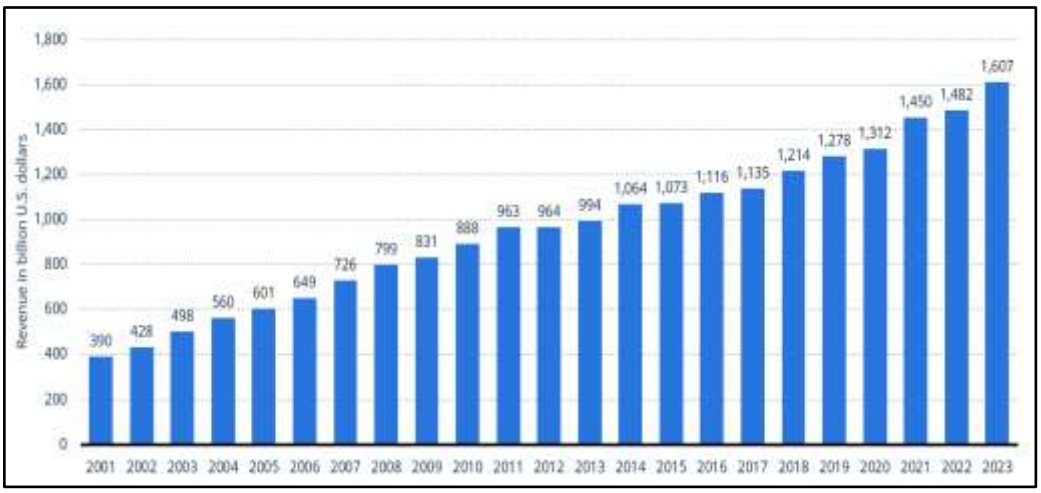

Figure 3. This shows the global revenue of pharmaceutical companies from 2001 – 2023 in billions of US dollars. Adapted from (Matej, 2024).

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1.4.1 Research Aim

The goal of this research is to use the available academic and industry resources to critically evaluate how the use of AI in the pharmaceutical supply chain can enhance transparency, efficiency, and traceability across the network.

1.4.2 Research Objectives

1. To understand the contribution of AI in establishing an efficient, transparent, and traceable pharmaceutical supply chain network.

2. To critically analyse how integrating AI will enhance manufacturing, inventory management, demand forecasting, and logistics, in the pharmaceutical supply chain.

3. To offer recommendations that will optimise supply chain operations in the pharmaceutical industry.

1.5 Research Methodology

A mixed method was adopted in this research because of the use of quantitative and qualitative secondary data sourced from academic journals, industry publications, and technical reports. The secondary data was used to establish the research patterns, identify differences and attributes available as asserted in the study by (Atwi and Hamza, 2015). The reason for using secondary data in this study is because of the inability to obtain primary data from pharmaceutical companies.

1.6 Research Gap

There is limited information to estimate the long-term impact of using AI in the pharmaceutical supply chain and justification for the high investment cost. This is important because it will enable companies to make strategic investment decisions. Additionally, there is need to establish mechanisms for smaller companies to incorporate and benefit from using AI in their supply chain. Another gap identified is the metrics to ascertain the positive impact of using AI across manufacturing, purchasing, transportation, storage and delivery. This would be necessary because understanding the impact across the supply chain network will provide more understanding of the right strategy to adopt.

DISCUSSION AND SUMMATION OF RESEARCH FINDINGS

2.1 Research Literature Review

The completion of this research relied on reviewing existing literature to extract qualitative and quantitative secondary data which was subsequently analysed to obtain the results and findings, including conclusions and recommendations. A review of the literature indicates that the influence of AI in pharmaceutical supply chain is increasing despite being at its infancy. This is evident in a study by (Gupta et al., 2021), which forecasted that AI is set to revolutionize the global supply chain sector and make it more sustainable than it currently is because of its ability to integrate big data and machine learning. The importance of AI as stated by this author will alter supply chain operations in a bid to optimise every activity using large datasets, and this impact will also be beneficial to the pharmaceutical supply chain which is part of the global industry. Furthermore, AI is predicted to aid companies tackle challenges that plague their supply chain with higher precision at a faster rate by leveraging on the large amount of data generated (Gupta et al., 2021). Since data is critical to AI efficiency, the pharmaceutical sector which has access to huge amounts of data can utilise that to their advantage and streamline the operations from drug discovery, manufacturing to final delivery to the consumer.

2.1.1 Integrating AI in the Pharmaceutical Supply Chain

Studies have shown that the pharmaceutical supply chain is not immune to challenges that plague the global supply chain network. As observed in the study by (Vora et al., 2023), activities within the supply chain like research, drug discovery, manufacturing, storage, transportation, distribution, etc., were negatively impacted

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during the global COVID-19 pandemic which crippled industries globally by about 14%. The severe impact of this spurred industry leaders to seek technologies capable of reducing the risk and optimising the operations effectively. Although the outcome of the pandemic was negative, it stirred up the need to innovate by integrating AI into the pharma supply chain. This is so because of the huge potential AI possesses to revolutionize the entire pharmaceutical supply chain. Some of the areas in the pharma supply chain that AI has positive impact on were identified as follows:

1. **Transparency**: The review identified that the use of AI will make data for invoices, product or service tracking, shipment, and demand forecasting visible across the entire supply chain, thereby preventing fraudulent activities. As observed by (Gulen, 2023), the application of AI enhances transparency in the supply chain because if offers "real-time visibility" of its processes.
2. **Procurement strategy**: Further review showed that AI can analyse contracts, manage suppliers, and monitor cost analysis using available data to make unbiased decisions, whereas that may not be the case most times assuming this process is completed by humans specifically in areas where lack of transparency abounds. This aligns with the study by (Min, 2015), on supplier assessment and selection before procuring raw materials.
3. **Personalised solutions**: This reveals another aspect of AI redefining the pharma supply chain by targeting specific customers through the knowledge of different consumer behaviour and market demands for different pharmaceutical products. Organizations with the capability control demand variations can cut cost, stock accurate inventories, and meet specific customer needs as noted by (Sharma et al., 2022).
4. **Last mile delivery**: This technology has also been used to monitor last mile delivery through predictive analysis, monitor the workforce and digitalize all the operations. This is possible through algorithms and artificial neural network designed to aid pharmaceutical companies monitor natural disasters and reduce shipping due to unforeseen circumstances (Sabegh et al., 2017).
5. **Minimise impact of disruption**: AI has been used in collaboration with warehouse management systems to automate processes and make the supply chain flexible through adequate operations planning. As stated by (Abedinnia et al., 2017), the integration of AI in the supply chain aids system recovery, detection, and prediction of challenges that may affect operations.
6. **Sustainability**: The use of AI can significantly enhance sustainability in the pharmaceutical supply chain by using data to make critical decisions on supplier selection, configuration, and design of the supply chain as suggested by (Pournader et al., 2021). This implies that people who purchase drugs will be getting quality products from sustainable sources with minimal impact on the environment, while organizations also benefit by reducing cost and maximizing profit. Therefore, people, organizations, and the planet will all benefit positively when AI is deployed in the pharmaceutical supply chain Figure 4.

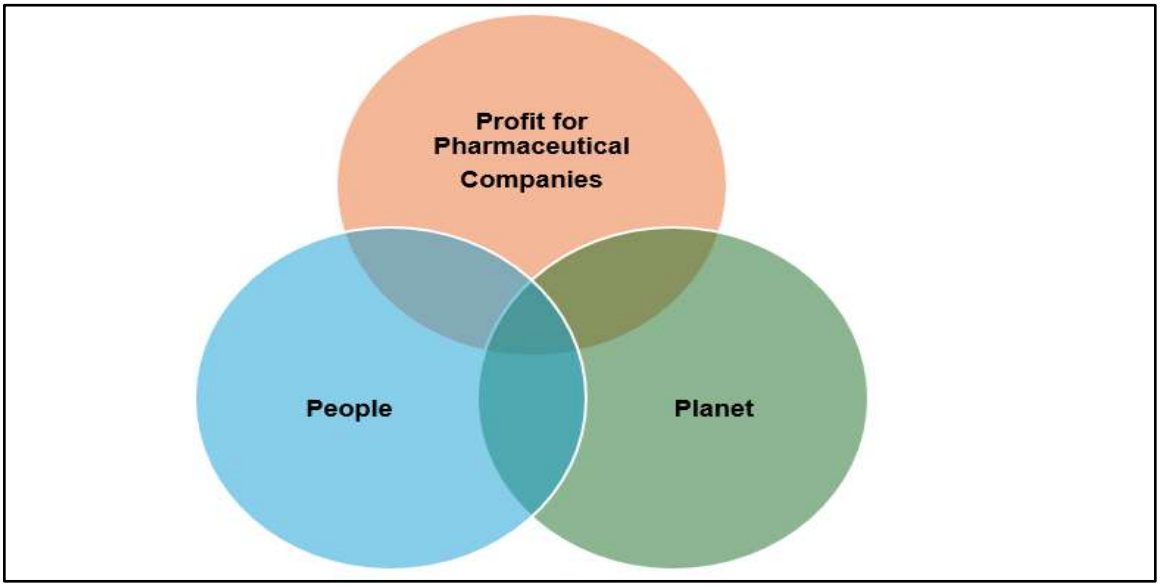

Figure 4. This shows how the use of AI can enhance sustainability in the pharmaceutical supply chain as indicated using the triple bottom line concept. Modified after (Gimenez et al., 2012).

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2.1.2 Evidence of Pharma Companies using AI in Supply Chain Management

The review of published articles by (Deloitte, 2020) showed that RxAII is currently combining AI and big data to authenticate drugs with a tool "RxScanner II" to combat counterfeit drugs in the supply chain at a verification speed of 20 seconds and 99.9% accuracy. The algorithm used to achieve this was specifically designed to precisely distinguish genuine from fake drugs within the pharmaceutical supply chain and it has so far proved efficient especially in West Africa. Customers are now more confident when purchasing their medication because this AI tool has improved supply chain integrity by making it transparent.

Another company Merck has also deployed Aera Technology which is specifically designed to use market intelligence, shipping history, sales record, weather, disease outbreaks, etc., to enhance demand forecasting with 90% precision (Deloitte, 2020). The ability to capture and analyse data from other sources to recognise patterns and differences aids accurate demand forecasting and equips pharmaceutical companies with the knowledge needed to manage inventory levels. Other areas like drug production management and transportation (logistics) have benefited immensely by leveraging on the predictive analytics capability of this AI-powered tool.

Furthermore, Pfizer has designed a smart platform integrated with AI and data analytics to enhance the movement of products and services in the whole supply chain (Wu, 2023). The system can correctly identify disruptions in the supply chain, forecast demand, improve inventory level, and prompt delivery of products and services, and reduce logistics charges. Refer to literature in appendix A for more information.

2.2 Potential Challenges of adopting AI in the Pharmaceutical Supply Chain.

The complexity of the pharmaceutical industry because of bureaucracies and tight regulations affects every operation in the supply chain, thereby making it difficult to effectively manage the supply chain network. A set of present issues affecting the pharmaceutical industry which the use AI has the capacity to fix are highlighted below:

2.2.1 Inaccurate Demand Forecasting

Accurate demand forecasting is essential for an effective pharmaceutical supply chain because it makes medicine accessible to users at the correct time, right place, and in the right amount. Despite the obvious benefits, it can be extremely difficult to correctly predict customer demand for new medical products if there is no past data to analyse and use to train the AI model. The study by (Wan and Evers, 2011), which indicated that incorrect demand forecasting resulting from lengthy lead times, variation of information, and rapid demands can cause a "bullwhip effect" in the supply chain.

2.2.2 Substandard Drugs and Equipment

The availability of fake medication and substandard medical equipment undermines the integrity of the pharmaceutical supply chain and puts the wellbeing of service users at risk. This challenge as observed from the study is prevalent in developing countries but should not be ruled out in advanced countries. Consequently, the counterfeit drugs which are quite difficult to separate from genuine products pose a significant challenge to pharmaceutical companies who aim to satisfy their global clients. As stated by (Hassija, 2020), the inability to identify and remove counterfeit products is bound to occur if there is limited or no access to the data required to build the algorithm needed to authenticate the products.

2.2.3 Low Drug Inventory

A further analysis showed that drug shortages are a key challenge experienced by the global pharmaceutical industry and this has had negative consequences on patient recovery and can cause death in severe cases where critical medicines were lacking. Some causative factors identified are manufacturing setbacks, surge in demand, accidents or theft during transportation, quality issues, and regulatory compliance. As stated by (Buckley et al., 2013), these challenges are detrimental to the entire supply chain.

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2.2.4 Dependence on Global Supply Chain Networks

The use of third-party logistics companies globally by pharmaceutical companies to minimize cost was also identified as a key challenge in the pharmaceutical supply chain. By relying on this method of transportation, it was observed that companies experienced longer lead time, delayed delivery, and price instability, because of the challenges emanating from natural disasters and political crisis in some regions. Unfortunately, the complexity of the pharmaceutical industry makes outsourcing of logistics services inevitable so they can focus on their core competences (El Mokrini et al., 2016).

2.2.5 Low Investment in AI Technology by Pharmaceutical Companies

The challenge of funding the development of these AI technologies required to revolutionize the pharmaceutical supply chain and make it more agile is a major concern (Geissbauer et al., 2022) Figure 5. For instance, end-to-end visibility requires the use of supply chain control towers to give comprehensive information about all processes within the network. These towers are designed to act as cluster hubs which gather information from different systems that audit, monitor, and provide results. For these hubs to be useful in supply chain management, pharmaceutical companies integrate AI abilities like machine learning to assist with organizing the operations and automate the supply chain. An example of this is "Sterling Supply Chain Insights" developed by IBM (IBM, 2020). This tool is an AI-enabled control hub which permits an extensive live visibility of the supply chain through the incorporation and interpretation of data.

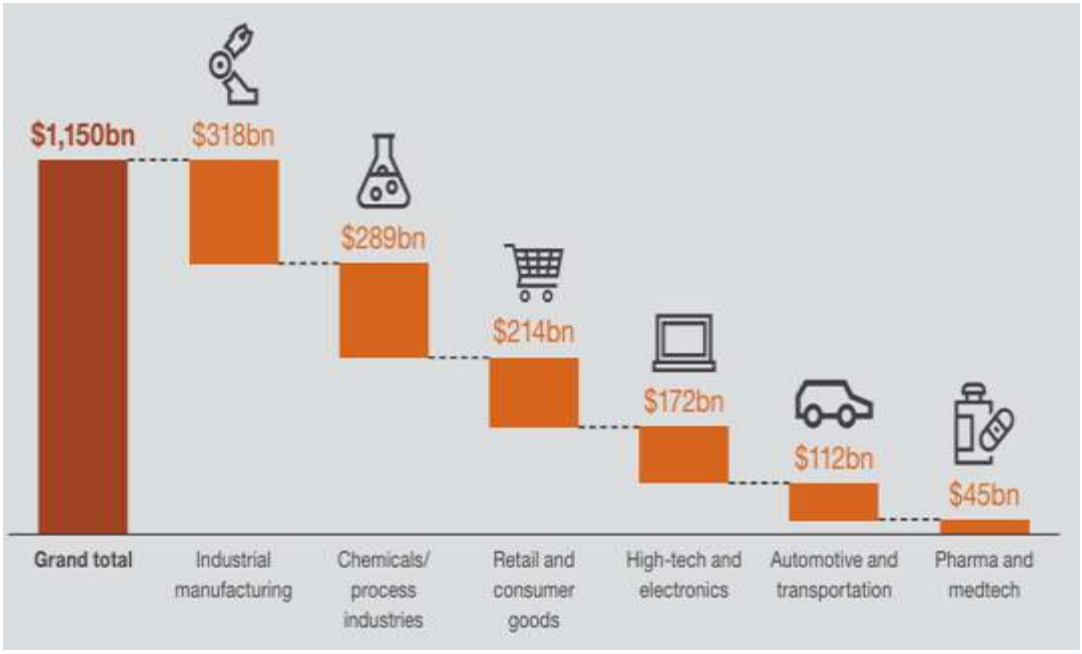

Figure 5. This shows investment in AI by different industries. Adapted from (Geissbauer et al., 2022).

2.3 Effect of AI on Pharmaceutical Supply Chain Productivity.

This section will focus on understanding the effect AI has on the pharmaceutical supply chain.

2.3.1 Application of AI in Demand Forecasting

Understanding the performance metrics is critical to comprehending how the use of AI is assisting pharmaceutical companies to meet the needs of their customers so they can modify their methods in areas with low performance indices. The quantitative and qualitative analysis of the available data indicates that pharmaceutical companies now have a more accurate inventory management system in place to avoid over stocking or shortages of important medicines required by patients.

As shown in Figure 6, drug shortage incidences have occurred yearly for different reasons like over demand which accounted for approximately 45% of the low supply Figure 7 (FDA, 2023). However, an AI model is now

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able to prevent this from happening using demography, order sequence, weather, and regional activities to predict demand accurately and this information is fed back into the system so the required drugs will be shipped to the right location at the right time, in the right amount (Ben-Daya et al., 2019). It can be inferred that using this AI model has increased efficiency in the supply chain by effectively monitoring demand and triggering the system whenever it senses under supply and this information is automatically sent to the manufacturing plant for production "just in time" to respond to the demand.

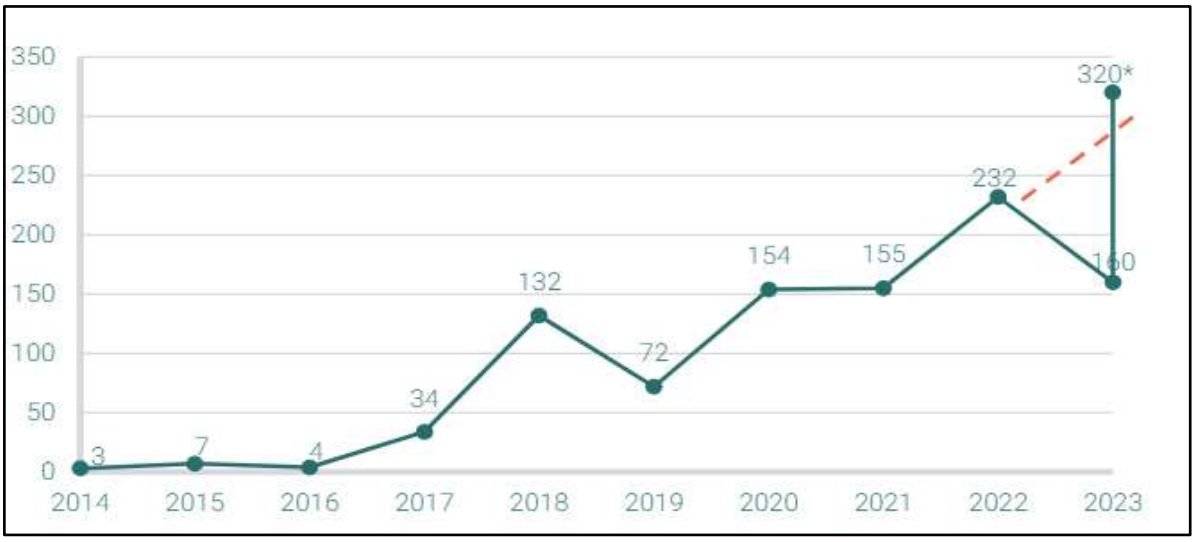

Figure 6. This represents cases of drug shortages from 2014 - 2023. Modified from (FDA, 2023).

Beyond tackling manufacturing and shortage issue, it also addresses other challenges like discontinuation, ingredient shortages, and other supply chain issues identified in Figure 7. The improvement of demand forecasting as highlighted is possible because AI-powered tools can manage, analyse and interpret huge datasets, and further provide real-time results to aid decision-making related to demand and supply as stated by (Ben-Daya et al., 2019).

The efficacy of this method depends on the use of accurate data retrieved across the supply chain and using software filters to mine and analyse the data as described in the case of Merck KGaA, a pharmaceutical company currently using this technique. Results obtained show that demand forecast accuracy through this software increased to 90% thereby increasing efficiency within their supply chain.

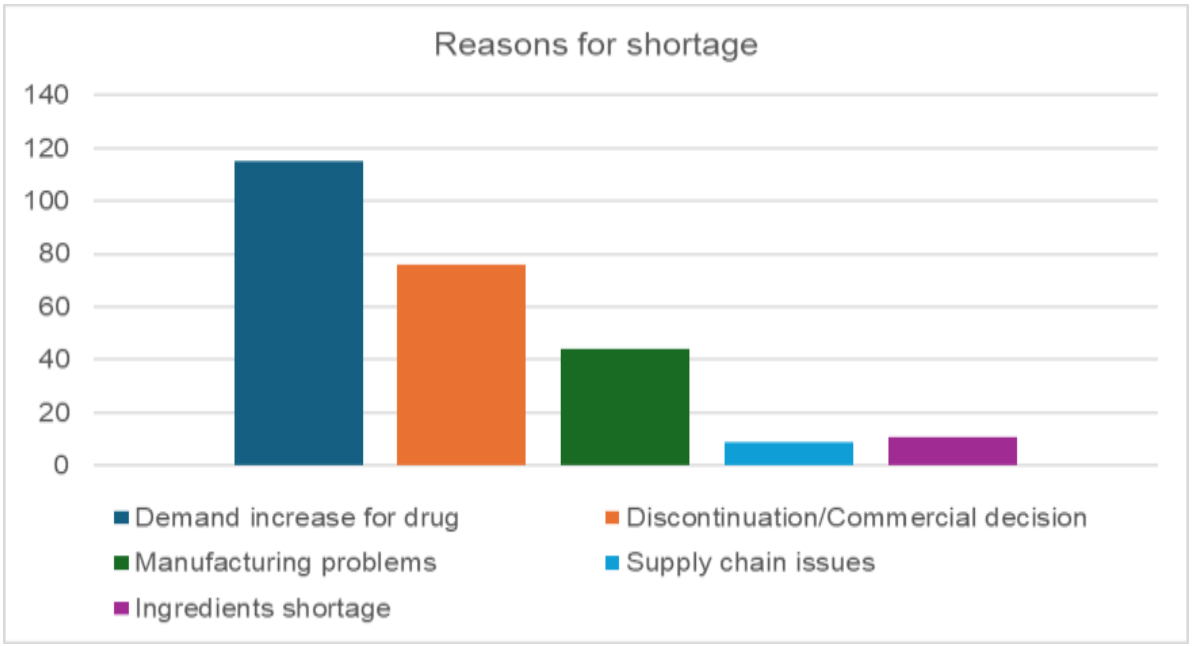

Figure 7. This depicts factors accountable for medicine shortages. Modified from (FDA, 2023).

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2.3.2 Application of AI in Inventory Management.

AI has also had a positive impact in managing inventory in the pharmaceutical supply chain as experienced by Roche, a pharmaceutical company that has deployed the power of AI to enhance operations in its warehouses (Deloitte, 2020). This technology uses a machine learning system which observes, and analyses live data available through the installed sensors in each warehouse to enhance inventory management. This method was deemed to be effective, eliminated waste, and increased efficiency in their warehouses. Additionally, using AI to manage inventory has improved manufacturing cost, operational efficiency, and storage space. In certain cases, as shown in Table 1.

Table 1. This indicates the impact of AI and other technologies in the pharmaceutical supply chain. Adapted from (Nazari et al., 2023).

S/N	Service Type	Output rate (%)
1	Production Cost	30
2	Storage Space	25
3	Operational Cost	30

The production cost was cut by 30%, with storage area occupied by excess inventory was reduced by 25%, and

operational cost was successfully reduced by 30% using AI as shown in Figure 8, as shown in the study by (Nazari et al., 2023). By using this technology, a pharmaceutical company can accurately monitor its inventory to ensure that drugs required by patients are available when needed. Furthermore, integrating predictive analytics helps monitor product conditions in the supply chain effectively.

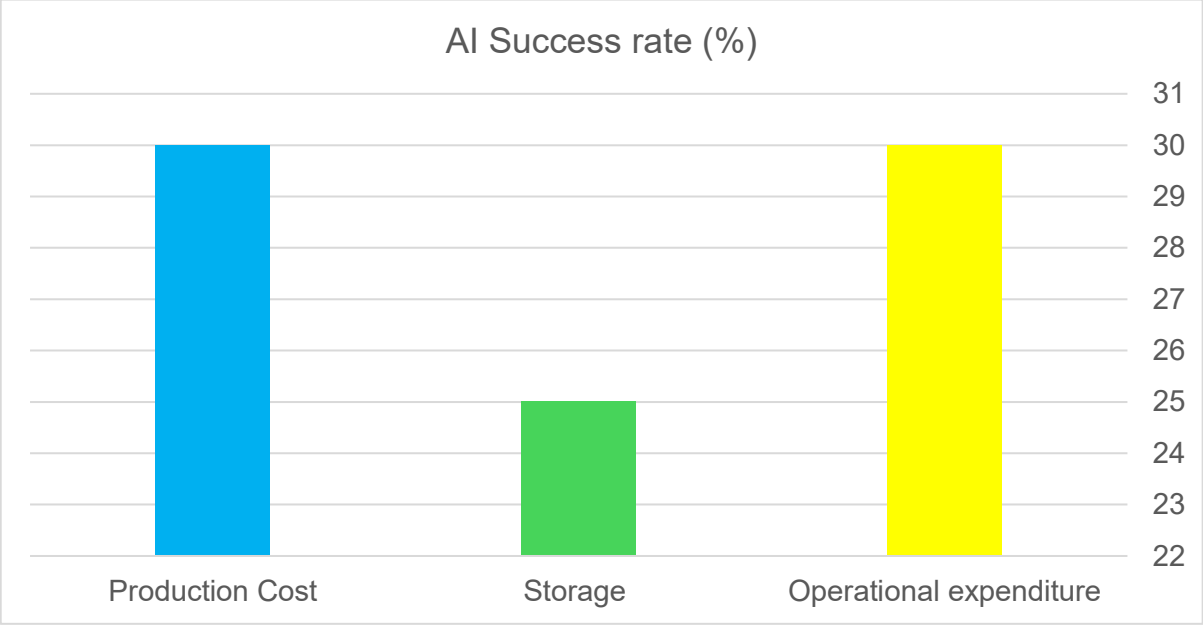

Figure 8. This shows how AI successfully minimised production cost, storage, and operational cost. Modified after (Nazri et al., 2023).

2.3.3 Use of AI to identify and remove fake drugs in pharmaceutical Supply Chain

The application of AI to detect and eliminate counterfeit drugs in the pharmaceutical supply chain has proved effective in protecting consumers from health risk associated with ingesting fake drugs. These counterfeit pharmaceutical products account for over 50% of the products circulating in the pharmaceutical supply chain especially in developing countries. Ordinarily, the consumers do not possess the skills to identify these products without the use of technology (Julianna, 2019). However, the design and integration of AI and blockchain

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technology by RxAll's flagship scanner has solved this problem. The scanner can scan and provide reports within 30 seconds which makes it extremely efficient and has 96.7% accuracy so far. Since the scanned results are timestamped, geo-positioned, irreversible, users can see counterfeit drugs within the supply chain. The Pharma Ledger project is also leveraging on blockchain and AI to remove fake drugs from the polluting the pharmaceutical supply chain, promote transparency, traceability and enhance product integrity. The solution to eliminate counterfeit drugs using AI is backed by the research of (Ma et al., 2020), who established that the incorporation of AI in drug defect recognition improved product quality, efficacy, and safety.

2.3.4 Enhancing end-to-end Visibility in the Pharmaceutical Supply Chain with AI.

The companies currently using AI in their supply chain can now observe what is happening in their supply chain because of access to live data for all transactions as there occur. By using the data generated, pharmaceutical companies can identify low supplies, monitor all products, track all goods, and activate production automatically when required to meet customer demands globally.

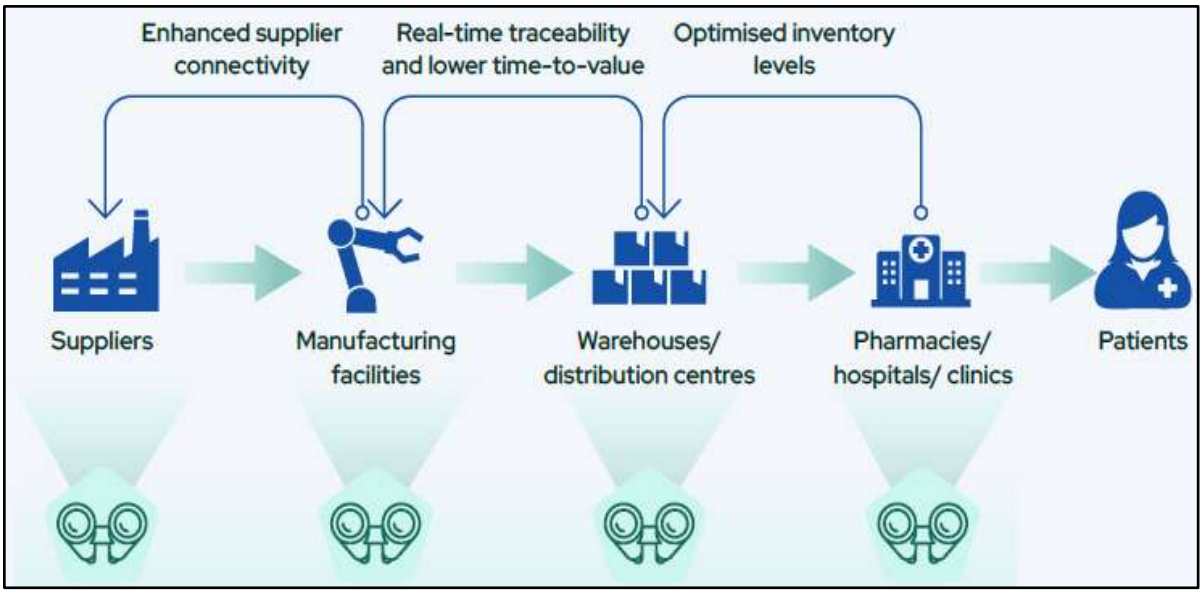

Figure 9. This represents how AI enhances end-to-end visibility in a pharmaceutical supply chain. Adapted from (Xenonstack, 2024).

As highlighted in Figure 9, the components of the supply chain are interconnected, with visibility on each section resulting in enhanced supplier connectivity, optimised inventory levels, and live traceability of products. By doing this, the data extracted and analysed by AI tools generates practical information that enables quick decision-making so companies can minimize supply chain disruptions and become more responsive, agile, and efficient. A key example of how AI is making the pharmaceutical supply chain is the use "Sterling Supply Chain Insights" designed by IBM. The system relies on control towers that utilise AI to link data centres in the system. These tool matches data from within and outside the system, and aids the analyses of 80% raw data, in addition to weather and digital media reports. The insight derived from these gives organisations proper knowledge to evaluate how the data affects the whole supply chain, and this assertion is in line with the study by (Deloitte, 2020) and (Xenostack, 2024).

2.3.5 Application of AI in Predictive Maintenance.

Prior to the introduction of AI in manufacturing, the pharmaceutical production plants have functioned by "run-to-failure" preventive maintenance to mitigate total equipment overhaul and avoid delayed production of essential medical supplies (Deloitte,2020). These traditional methods made supply chain operations ineffective because the equipment got damaged completely causing downtime in the production line, and this can lead to severe financial loses. However, the use of AI as identified in the analysis in appendix A, can harness the production data from factories to gain knowledge on equipment and operations performance using the sequence discovered to forecast faults and machine failure before there happen. The use of this technology will also give

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information about future equipment failures through ML predictive models which will then be addressed before there occur to prevent unexpected downtime. Through predictive maintenance powered by AI, the pharmaceutical supply chain becomes more efficient and perform optimally. A similar assertion was made by (Abedinnia et al., 2017) in their study on machine disruptions during production.

2.4 Potential Limitations of Adopting AI in the Pharmaceutical Supply Chain

The use of AI in managing the pharmaceutical supply chain is predicted to have huge potential, however, there are certain issues that must be tackled for smooth integration and maximization of the immense benefits inherent in this technology. So far, bigger companies like Pfizer have invested heavily to use AI technology, whereas smaller companies are struggling to match this as reported by (Kulkov, 2021). This indicates the challenges and benefits will still be prevalent if small firms from adopting AI because of it cost. Furthermore, the AI models need large amount of accurate data to build models. Unfortunately, the distorted data, errors, and gaps prevent the correct use of AI. Solving this challenge requires the use of data processing tools which are critical to enhancing quality, accurate data, and trustworthy information (Tai et al., 2019).

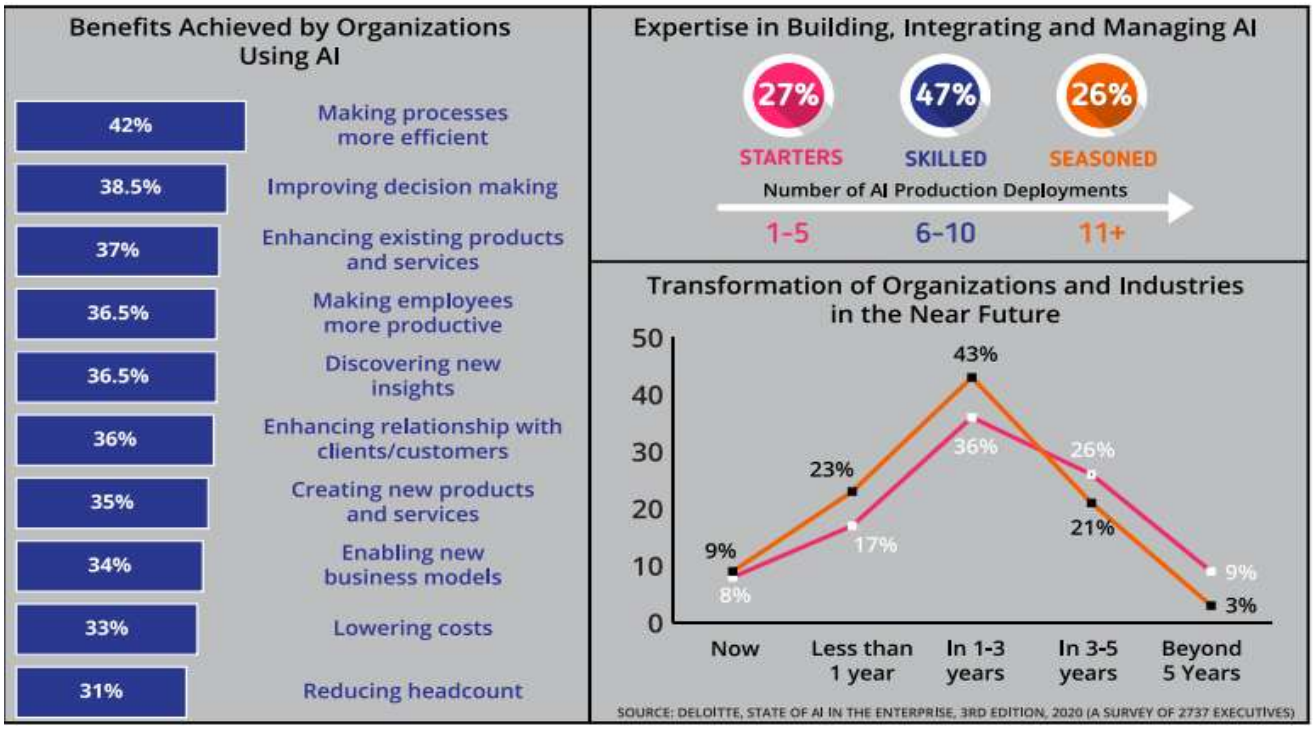

Figure 10. This shows the benefits gained by corporations that are currently using AI to optimise their supply chain processes. Adapted from (Ammanath et al., 2020).

CONCLUSION

Conclusively, the research has established the importance of integrating AI in optimising the pharmaceutical supply chain, with the outcome translating to safer drug delivery by identifying and removing counterfeit products in the pharmaceutical supply chain which are detrimental to users. Furthermore, an AI enabled supply chain will expedite product delivery, prevent product shortages through accurate inventory management, avoid under and over production, prolong the equipment lifespan through predictive maintenance and expedite drug discovery as asserted by (Ammanath et al., 2020), Figure *10*. Additionally, pharmaceutical supply chain management will be more agile and lean because it will become flexible and responsive with AI integration. Overall, AI possesses enormous potential to make every pharmaceutical supply chain process more transparent, efficient, and traceable which would eventually increase profitability.

RECOMMENDATIONS

The following recommendations should be considered based on this study.

1. Companies should invest in human capacity development so their own staff will have the technical abilities to conduct research and development to build customised models to fit their operations. The reason for this as stated by (Wu, 2023), is because organizations are bound to resort to using humans with requisite skills to manage AI-driven supply management, with emphasis on training their staff.
2. A portion of the yearly profits should be kept for investment in AI research and development because funding is crucial to integrating AI-powered systems in any organization. If this is not done, it will not be possible to invest in AI because of the high cost as noted by (Geissbauer et al., 2022).
3. Regulatory frameworks should be specifically designed to instruct organisations using AI to comply with global regulatory bodies. This is necessary because it mandates pharmaceutical companies to constantly adhere to standards by ensuring product effectiveness, safety and quality as observed by (Wu, 2023).
4. The government should provide incentives for smaller companies to fund their AI programs so they can optimise their operations. This will enable them mine and store the huge datasets needed to train the AI models and other investments required to build the system.

Confidentiality Statement

The research is the original work of the author and has been conducted using secondary qualitative and quantitative data sourced from public academic and industry sources. All the resources adopted have been adequately referenced with due credit given to the owners of the copyrights including the images.

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