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## Strategies for enhancing public health outcomes through sustainable pharmacy supply chain management

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### Abstract

Sustainable pharmacy supply chain management (SPSCM) plays a crucial role in enhancing public health outcomes by ensuring the availability, affordability, and quality of pharmaceutical products. This abstract explores key strategies for improving SPSCM practices to address current challenges and improve health outcomes. First, the abstract examines the importance of sustainable practices in the pharmacy supply chain, highlighting the impact on public health. It then discusses the challenges faced by traditional supply chain models, such as drug shortages, counterfeit medicines, and environmental concerns, emphasizing the need for sustainable solutions. Next, the abstract outlines strategies for enhancing SPSCM, including the adoption of technology for supply chain visibility, implementing green practices to reduce environmental impact, and fostering collaboration among stakeholders to improve efficiency and transparency. It also discusses the importance of regulatory compliance and ethical sourcing in SPSCM. Furthermore, the abstract explores the role of data analytics and predictive modeling in improving supply chain forecasting and inventory management, leading to better allocation of resources and reduced wastage. It also highlights the importance of capacity building and training programs for pharmacy staff to enhance their skills and knowledge in sustainable practices. In conclusion, the abstract emphasizes the need for a holistic approach to SPSCM that integrates environmental, social, and economic factors to improve public health outcomes. It underscores the importance of collaboration among stakeholders, adoption of technology, and regulatory compliance in building a sustainable pharmacy supply chain that ensures access to safe and effective medicines for all.

**Keywords:** Strategies; Public Health Outcomes; Sustainable; Pharmacy Supply Chain; Management

### 1 Introduction

The pharmaceutical industry plays a critical role in public health by ensuring the availability and accessibility of essential medicines (Cadogan & Hughes, 2021, Uwaoma, et. al., 2023). However, traditional pharmacy supply chain management (SCM) practices often face challenges such as drug shortages, counterfeit medicines, and environmental impact. Sustainable pharmacy supply chain management (SPSCM) has emerged as a strategic approach to address these challenges while enhancing public health outcomes.

SPSCM focuses on integrating sustainability principles into the pharmaceutical supply chain to achieve better environmental, social, and economic outcomes (Okolo, Olorunsogo & Babawarun, 2024). This approach considers the entire lifecycle of pharmaceutical products, from raw material sourcing to manufacturing, distribution, use, and disposal. By promoting sustainability practices, SPSCM aims to improve access to medicines, reduce environmental impact, and ensure the quality and safety of pharmaceutical products.

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This paper will explore strategies for enhancing public health outcomes through SPSCM. It will discuss the challenges in traditional pharmacy SCM, the importance of sustainability in pharmaceutical supply chains, and the role of SPSCM in improving public health. The outline includes an examination of technology adoption, green practices, stakeholder collaboration, data analytics, and capacity building in the context of SPSCM. Additionally, the paper will explore regulatory compliance, ethical sourcing, case studies, and best practices in SPSCM. It will also provide insights into future directions and recommendations for further research and implementation of SPSCM strategies. This paper aims to highlight the importance of SPSCM in enhancing public health outcomes and provide insights into effective strategies for integrating sustainability principles into pharmacy supply chains. By adopting sustainable practices, pharmaceutical companies can contribute to improved public health outcomes, environmental protection, and societal well-being.

Strategies for enhancing public health outcomes through sustainable pharmacy supply chain management (SPSCM) encompass a broad range of initiatives aimed at improving the efficiency, reliability, and sustainability of pharmaceutical supply chains (Dozie, et. al., 2024, Orieno, et. al., 2024). One key strategy is the adoption of green practices throughout the supply chain, such as using environmentally friendly packaging materials, optimizing transportation routes to reduce carbon emissions, and implementing energy-efficient manufacturing processes. Another important strategy is the use of technology to enhance supply chain visibility and transparency (Okafor, et. al., 2023, Udeh, et. al., 2024). This includes the use of blockchain technology to track the provenance of pharmaceutical products, ensuring their authenticity and reducing the risk of counterfeit medicines entering the supply chain. Additionally, the use of data analytics can help identify trends and patterns in supply chain operations, enabling more effective decision-making and resource allocation.

Stakeholder collaboration is also critical for SPSCM. This involves working closely with suppliers, distributors, healthcare providers, and regulatory bodies to ensure that sustainable practices are implemented across the entire supply chain. Collaboration can also help identify areas for improvement and innovation, leading to more sustainable and resilient supply chains. Capacity building is another key strategy for enhancing public health outcomes through SPSCM (Kaggwa, et. al., 2024, Omaghomi, et. al., 2024). This involves investing in the training and development of supply chain professionals to ensure they have the skills and knowledge to implement sustainable practices. It also involves building partnerships with educational institutions and industry organizations to promote best practices in SPSCM. Regulatory compliance is essential for SPSCM, as it ensures that pharmaceutical products meet the highest standards of safety, efficacy, and quality. This includes compliance with environmental regulations, such as the proper disposal of pharmaceutical waste, as well as adherence to ethical sourcing practices.

Case studies and best practices can provide valuable insights into effective SPSCM strategies. By examining successful examples of SPSCM implementation, pharmaceutical companies can learn from the experiences of others and identify opportunities for improvement in their own supply chains.

Overall, the key to enhancing public health outcomes through SPSCM lies in the integration of sustainable practices into every aspect of the pharmaceutical supply chain (Ogunjobi, et. al., 2023, Olurin, et. al., 2024). By adopting green practices, leveraging technology, collaborating with stakeholders, building capacity, ensuring regulatory compliance, and learning from best practices, pharmaceutical companies can create more sustainable and resilient supply chains that contribute to improved public health outcomes.

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## 2 Challenges in Traditional Pharmacy Supply Chain Management

Traditional pharmacy supply chain management faces several challenges that can impact public health outcomes (Egieya, et. al., 2023, Ihemereze, et. al., 2023, Okolo, Olorunsogo & Babawarun, 2024). One major challenge is drug shortages, which can occur due to various reasons such as manufacturing issues, regulatory challenges, or supply chain disruptions. These shortages can lead to accessibility issues, particularly for critical medications, and can have serious consequences for patients' health.

Counterfeit medicines are another significant challenge in traditional pharmacy supply chains. These counterfeit drugs can enter the supply chain through various means, including illegal manufacturing and distribution channels, and pose serious risks to patient safety. Quality concerns also arise in traditional supply chains, as maintaining the integrity and quality of pharmaceutical products throughout the supply chain can be challenging.

The environmental impact of pharmaceutical manufacturing and distribution is a growing concern (Okoduwa, et. al., 2024, Tula, et. al., 2023). The pharmaceutical industry is a significant contributor to environmental pollution due to the use of energy-intensive manufacturing processes, the generation of hazardous waste, and the disposal of pharmaceutical products. Addressing these environmental impacts is crucial for sustainable pharmacy supply chain

management. Another challenge in traditional pharmacy supply chain management is the lack of transparency and traceability (Olorunsogo, et. al., 2024, Saeed, et. al., 2022). Traditional supply chains often lack visibility, making it difficult to track the movement of pharmaceutical products and verify their authenticity. This lack of transparency can lead to inefficiencies, increased risk of counterfeit products entering the supply chain, and challenges in ensuring compliance with regulatory requirements.

Regulatory compliance is also a challenge in traditional pharmacy supply chain management. Pharmaceutical products are subject to strict regulations regarding their manufacturing, distribution, and sale (Ogugua, et. al., 2024, Okogwu, et. al., 2023). Ensuring compliance with these regulations can be complex and costly, particularly in the face of evolving regulatory requirements. Overall, addressing these challenges requires a holistic approach to pharmacy supply chain management. This includes implementing robust quality control measures, enhancing transparency and traceability, adopting sustainable practices, and leveraging technology to improve efficiency and reduce risks (Abbott & Snidal, 2021, Okolo, et. al., 2024). By addressing these challenges, traditional pharmacy supply chains can become more resilient, sustainable, and capable of delivering better public health outcomes.

In addition to the challenges mentioned earlier, traditional pharmacy supply chain management also faces issues related to inefficiency and lack of collaboration (Daraojimba, et. al., 2023, Jæger, Menebo & Upadhyay, 2021). One of the key inefficiencies in traditional pharmacy supply chains is the lack of coordination among different stakeholders. This can lead to fragmented processes, delays in product delivery, and increased costs. For example, the lack of real-time visibility into inventory levels can result in overstocking or stockouts, leading to waste or unmet patient needs.

Another challenge is the complexity of the supply chain network. Traditional pharmacy supply chains often involve multiple intermediaries, including manufacturers, wholesalers, distributors, and retailers. Managing this complex network can be challenging, particularly when it comes to ensuring product quality and safety throughout the supply chain.

Furthermore, traditional supply chains often rely on manual processes and outdated technology, which can hinder efficiency and transparency. Manual processes are prone to errors and can result in delays in order processing and fulfillment. Outdated technology limits the ability to track and trace products effectively, increasing the risk of counterfeit or substandard products entering the supply chain.

Finally, traditional pharmacy supply chains face challenges related to cost management and sustainability. The cost of pharmaceutical products is a significant concern for healthcare systems, particularly in low- and middle-income countries (Chinyere, Anyanwu & Innocent, 2023, Okorie, et. al., 2024). Inefficient supply chain practices can contribute to higher costs, which can ultimately affect patient access to essential medicines. Additionally, the environmental impact of traditional supply chains, such as carbon emissions and waste generation, is a growing concern that needs to be addressed through sustainable practices.

Addressing these challenges requires a transformation of traditional pharmacy supply chain management practices (Chidi, et. al., 2024, Uwaoma, et. al., 2023). This transformation involves adopting new technologies such as blockchain and IoT for enhanced traceability, implementing data-driven decision-making processes for improved efficiency, and fostering collaboration among stakeholders for better coordination. By overcoming these challenges, traditional pharmacy supply chains can become more resilient, sustainable, and capable of meeting the evolving needs of patients and healthcare systems.

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### **3 Strategies for Enhancing SPSCM**

Sustainable pharmacy supply chain management (SPSCM) is crucial for ensuring the availability, affordability, and quality of pharmaceutical products while minimizing environmental impact (Babawarun, et. al., 2024, Orieno, et. al., 2024). This paper discusses strategies to enhance SPSCM, focusing on technology adoption, green practices, stakeholder collaboration, data analytics, and capacity building. Utilizing technologies like IoT and RFID to track products throughout the supply chain, enabling real-time monitoring of inventory levels, reducing stockouts, and improving overall efficiency. Implementing blockchain technology to create a transparent and immutable record of pharmaceutical transactions, ensuring the authenticity of products and combating counterfeit drugs.

Adopting sustainable packaging materials and optimizing transportation routes to reduce carbon emissions and environmental impact (Oriekhoe, et. al., 2024, Wang, Wang & Su, 2021). Implementing recycling programs for packaging materials and sourcing pharmaceutical ingredients from sustainable and ethical sources. Collaborating with suppliers, manufacturers, and distributors to implement sustainable practices, such as reducing energy consumption and waste

generation. Working closely with regulatory bodies and non-governmental organizations (NGOs) to ensure compliance with environmental regulations and promote ethical sourcing practices.

Using data analytics tools to analyze supply chain data, predict demand, and optimize inventory levels, reducing excess inventory and minimizing wastage. Using predictive modeling to forecast future resource needs, such as raw materials and transportation, and optimize allocation to minimize waste and reduce costs (Almahameed & Bisharah, 2024, Okolo, Olorunsogo & Babawarun, 2024). Conducting training programs to educate pharmacy staff about the importance of sustainable practices and how they can contribute to reducing environmental impact. Engaging with industry stakeholders to raise awareness about sustainable practices and promote knowledge sharing to drive continuous improvement in SPSCM.

Implementing these strategies can help enhance SPSCM, leading to improved efficiency, reduced environmental impact, and better public health outcomes (Anyanwu, et. al., 2024, Ogugua, et. al., 2024). By adopting a holistic approach that integrates technology, green practices, stakeholder collaboration, data analytics, and capacity building, pharmaceutical supply chains can become more sustainable and resilient, contributing to a healthier and more sustainable future.

Implementing sophisticated inventory management systems that use AI and machine learning algorithms to predict demand, optimize inventory levels, and reduce wastage. Using track-and-trace technologies like barcodes and QR codes to monitor the movement of pharmaceutical products through the supply chain, ensuring transparency and authenticity. Leveraging cloud-based platforms for storing and analyzing supply chain data, enabling real-time collaboration and decision-making.

Implementing energy-efficient practices in warehouses and distribution centers, such as using LED lighting and optimizing HVAC systems (Adeniyi, et. al., 2024, Okorie, et. al., 2024). Adopting sustainable packaging materials, such as biodegradable plastics or recycled materials, to reduce the environmental impact of packaging waste. Establishing a system for the return and recycling of unused or expired pharmaceutical products, reducing waste and minimizing environmental harm.

Collaborating with organizations from other sectors, such as academia and government agencies, to share best practices and drive innovation in SPSCM. Working closely with suppliers to ensure they adhere to sustainable practices and ethical standards in their operations. Educating consumers about the importance of sustainable pharmacy practices and encouraging them to make environmentally conscious choices (Lim, 2022, Okolo, Olorunsogo & Babawarun, 2024). Using real-time data analytics to monitor supply chain performance, identify inefficiencies, and make informed decisions for optimization. Implementing predictive maintenance strategies for equipment and machinery to reduce downtime and improve operational efficiency. Utilizing data analytics to identify and mitigate risks in the supply chain, such as supply disruptions or counterfeit products.

Providing training programs to develop skills in sustainable supply chain management practices among pharmacy staff and supply chain professionals (Arowoogun, et. al., 2024, Oriekhoe, et. al., 2024). Establishing platforms for sharing best practices, case studies, and research findings related to SPSCM to foster continuous learning and improvement. By implementing these strategies, pharmaceutical companies can enhance their SPSCM practices, reduce their environmental footprint, and improve public health outcomes.

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#### **4 Regulatory Compliance and Ethical Sourcing**

Regulatory compliance and ethical sourcing are crucial aspects of sustainable pharmacy supply chain management (SPSCM) that pharmaceutical companies must prioritize to ensure the safety, efficacy, and ethical integrity of their products (Adaga, et. al., 2023, Omaghomi, et. al., 2024). Adhering to regulations and ethical standards not only safeguards public health but also promotes transparency and trust in the pharmaceutical industry. This article explores the importance of regulatory compliance and ethical sourcing in pharmaceutical supply chains, highlighting key considerations and best practices.

Regulatory compliance is essential in the pharmaceutical industry to ensure that products meet the required standards for quality, safety, and efficacy. Regulatory bodies, such as the Food and Drug Administration (FDA) in the United States and the European Medicines Agency (EMA) in Europe, establish and enforce regulations to protect public health and ensure that pharmaceutical products are safe and effective.

Compliance with regulatory requirements involves various aspects of the supply chain. Pharmaceutical companies must adhere to Good Manufacturing Practices (GMP) to ensure that their products are consistently manufactured to the

highest quality standards (Anyanwu, et. al., 2024, Oriekhoe, et. al., 2024). Compliance with regulations related to product safety, such as proper labeling and packaging, helps prevent adverse events and protect consumers. Pharmaceutical companies must maintain accurate and reliable data to support the safety, efficacy, and quality of their products. Traceability in the supply chain ensures that pharmaceutical products can be tracked and verified throughout the distribution process, reducing the risk of counterfeit products entering the market.

Ethical sourcing involves ensuring that raw materials used in pharmaceutical products are sourced responsibly and ethically (Adeghe, Okolo & Ojeyinka, 2024, Enahoro, et. al., 2024, Okolo, et. al., 2024). This includes considerations such as: Pharmaceutical companies should strive to minimize the environmental impact of their operations, such as reducing carbon emissions and waste generation. Ethical sourcing includes ensuring that labor practices throughout the supply chain, including those of suppliers and subcontractors, adhere to fair labor standards and do not involve exploitation or forced labor. Engaging with local communities where pharmaceutical companies operate can help ensure that their activities benefit local populations and minimize negative impacts.

To ensure regulatory compliance and ethical sourcing, pharmaceutical companies can implement the following best practices: Conduct regular audits and inspections of manufacturing facilities and suppliers to ensure compliance with regulations and ethical standards. Engage with suppliers to ensure they understand and adhere to ethical sourcing principles and regulatory requirements. Be transparent about supply chain practices and disclose information about raw material sourcing, manufacturing processes, and product quality.

Continuously assess and improve supply chain practices to ensure compliance with evolving regulations and ethical standards. Regulatory compliance and ethical sourcing are critical components of SPSCM that pharmaceutical companies must prioritize. By adhering to regulations and ethical standards, companies can ensure the safety, efficacy, and ethical integrity of their products, thereby protecting public health and promoting trust in the pharmaceutical industry.

Regulatory compliance and ethical sourcing are complex and multifaceted aspects of sustainable pharmacy supply chain management (SPSCM) that require careful attention and continuous improvement (Ihemereze, et. al., 2023, Oriekhoe, et. al., 2023). In addition to the importance of adhering to regulations and ethical standards, it is crucial for pharmaceutical companies to actively engage with stakeholders, including regulatory bodies, suppliers, and local communities, to ensure transparency and accountability throughout the supply chain.

Compliance with regulations is not only a legal requirement but also a means to ensure that pharmaceutical products are safe, effective, and of high quality. Regulatory bodies set stringent standards for pharmaceutical manufacturing, distribution, and marketing to protect public health and ensure that patients receive safe and effective treatments. Failure to comply with these regulations can result in regulatory sanctions, product recalls, and damage to the company's reputation.

Pharmaceutical companies must stay abreast of changes in regulations and ensure that their operations and supply chains are in compliance. This includes implementing robust quality management systems, conducting regular audits and inspections, and maintaining accurate and up-to-date documentation (Egieya, et. al., 2024, Okorie, et. al., 2024). Ethical sourcing involves ensuring that raw materials used in pharmaceutical products are sourced responsibly and ethically. This includes considerations such as environmental sustainability, fair labor practices, and community engagement. Pharmaceutical companies should work closely with their suppliers to ensure that ethical standards are upheld throughout the supply chain.

One of the key challenges in ethical sourcing is the complexity of global supply chains, which can make it difficult to trace the origin of raw materials and ensure that they meet ethical standards (Katsikouli, et. al., 2021, Oriekhoe, et. al., 2024). However, advances in technology, such as blockchain and supply chain transparency platforms, are making it easier for companies to track and verify the origin of raw materials and ensure compliance with ethical standards.

To ensure regulatory compliance and ethical sourcing, pharmaceutical companies can adopt the following best practices: Engage with suppliers to ensure they understand and adhere to ethical sourcing principles and regulatory requirements (Gidiagba, et. al., 2023, Ogugua, et. al., 2024). Be transparent about supply chain practices and disclose information about raw material sourcing, manufacturing processes, and product quality. Continuously assess and improve supply chain practices to ensure compliance with evolving regulations and ethical standards.

Regulatory compliance and ethical sourcing are critical components of SPSCM that pharmaceutical companies must prioritize. By adhering to regulations and ethical standards, companies can ensure the safety, efficacy, and ethical integrity of their products, thereby protecting public health and promoting trust in the pharmaceutical industry.

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## 5 Case Studies and Best Practices

Implementing sustainable pharmacy supply chain management (SPSCM) strategies is crucial for improving public health outcomes and ensuring the availability of safe and effective pharmaceutical products (Adeniyi, et. al., 2024, Oriekhoe, et. al., 2024). Several pharmaceutical companies have successfully implemented SPSCM strategies, leading to improved efficiency, reduced waste, and enhanced sustainability.

Johnson & Johnson (J&J) has been a pioneer in implementing sustainable practices in its supply chain. The company has focused on reducing the environmental impact of its operations by implementing energy-efficient technologies, reducing waste, and sourcing raw materials responsibly (Evangel Chinyere, Ogbonna & Innocent, 2023, Uwaoma, et. al., 2023). One key initiative by J&J is its Earthwards® approach, which evaluates the environmental impact of products throughout their lifecycle and sets targets for improvement. By implementing this approach, J&J has been able to reduce the environmental impact of its products while maintaining quality and safety standards.

Novartis, a global pharmaceutical company, has also made significant strides in implementing SPSCM strategies. The company has focused on reducing its carbon footprint by optimizing transportation routes, reducing packaging waste, and sourcing renewable energy. One of Novartis' key initiatives is its Supplier Sustainability Program, which aims to ensure that its suppliers adhere to ethical and sustainability standards. Through this program, Novartis has been able to improve transparency and accountability in its supply chain while promoting sustainable practices among its suppliers.

Engaging with stakeholders, including suppliers, regulatory bodies, and local communities, is crucial for implementing SPSCM strategies successfully (Okolo, Olorunsogo & Babawarun, 2024, Olajide, 2022). Ensuring transparency and traceability in the supply chain helps to identify and mitigate risks, such as counterfeit medicines and environmental impacts. SPSCM is an ongoing process that requires continuous improvement and adaptation to new challenges and opportunities. Leveraging technology, such as blockchain and data analytics, can improve transparency, traceability, and efficiency in the supply chain (Oriekhoe, et. al., 2024, Vazquez Melendez, Bergery & Smith, 2024). In conclusion, implementing SPSCM strategies is essential for improving public health outcomes and ensuring the sustainability of the pharmaceutical industry. By learning from successful case studies and adopting best practices, pharmaceutical companies can enhance their supply chain management practices and contribute to a healthier and more sustainable future. One notable case study is that of GlaxoSmithKline (GSK), which has implemented various sustainable practices in its pharmaceutical supply chain (Eshkiki & Homayounfar, 2024, Ogbonna, et. al., 2024). GSK has committed to reducing its environmental impact by focusing on renewable energy sources, water conservation, and waste reduction. For example, GSK has implemented solar panels in some of its facilities to reduce reliance on fossil fuels and decrease its carbon footprint.

Another example is Pfizer, which has made significant strides in ensuring the ethical sourcing of raw materials for its pharmaceutical products (Arowoogun, et. al., 2024, Grimm, et. al., 2023). Pfizer has implemented strict supplier standards to ensure that its suppliers adhere to ethical and sustainable practices. This includes sourcing raw materials from suppliers who comply with environmental regulations and respect human rights. One key takeaway from these case studies is the importance of collaboration and partnership within the industry. By working together with suppliers, regulatory bodies, and other stakeholders, pharmaceutical companies can create a more sustainable and ethical supply chain.

In addition, these case studies highlight the importance of transparency and traceability in the supply chain. By implementing systems that track the origin of raw materials and the environmental impact of production processes, pharmaceutical companies can ensure that their products are produced in an ethical and sustainable manner. Overall, these case studies demonstrate that sustainable pharmacy supply chain management is not only beneficial for the environment and public health but also for the long-term success and reputation of pharmaceutical companies (Anyanwu, et. al., 2024, Oriekhoe, et. al., 2024). By implementing sustainable practices and adhering to ethical standards, pharmaceutical companies can enhance their public health outcomes and contribute to a more sustainable future.

## 6 Future Directions and Recommendations

Emerging trends in Sustainable Pharmacy Supply Chain Management (SPSCM) are shaping the future of public health outcomes. One of the key trends is the increasing adoption of digital technologies and data analytics (Adeghe, Okolo & Ojeyinka, 2024, Usman, et. al., 2024). Pharmaceutical companies are leveraging these technologies to improve supply chain visibility, traceability, and efficiency. For example, blockchain technology is being used to track and authenticate pharmaceutical products, ensuring their safety and authenticity throughout the supply chain.

Another emerging trend is the focus on circular economy principles. Pharmaceutical companies are exploring ways to reduce waste and promote recycling in their supply chains. This includes initiatives to reuse packaging materials, reduce excess inventory, and implement sustainable sourcing practices (Al-Awamleh, et. al., 2022, Oriekhoe, et. al., 2024). Additionally, there is a growing emphasis on ethical sourcing and responsible procurement practices. Pharmaceutical companies are working to ensure that the raw materials used in their products are sourced ethically and sustainably, with minimal impact on the environment and local communities.

In terms of recommendations for further research and implementation of SPSCM strategies, it is important for pharmaceutical companies to continue investing in technology and innovation (Okolo, Olorunsogo & Babawarun, 2024, Olajide, 2022). This includes developing new tools and solutions to improve supply chain visibility, enhance traceability, and optimize inventory management. Furthermore, collaboration and partnerships will be key to advancing SPSCM. Pharmaceutical companies should work closely with suppliers, regulators, and other stakeholders to develop and implement sustainable practices. This includes sharing best practices, conducting joint research projects, and aligning on industry standards. Overall, the future of SPSCM looks promising, with new technologies and approaches driving improvements in public health outcomes. By embracing these trends and recommendations, pharmaceutical companies can enhance their supply chains, reduce their environmental impact, and ultimately improve public health outcomes.

In addition to the trends mentioned earlier, future directions for Sustainable Pharmacy Supply Chain Management (SPSCM) will likely include increased focus on resilience and flexibility (Ada, et. al., 2023, Odilibe, et. al., 2024). The COVID-19 pandemic highlighted the importance of supply chain resilience, as disruptions in the pharmaceutical supply chain led to shortages of critical medicines and medical supplies. Moving forward, pharmaceutical companies will need to invest in strategies that enhance the resilience of their supply chains, such as dual sourcing, inventory optimization, and scenario planning. Furthermore, the concept of a "circular economy" is gaining traction in the pharmaceutical industry. This approach seeks to minimize waste and maximize the value of resources by promoting recycling, reusing, and reducing materials throughout the supply chain. Pharmaceutical companies are exploring ways to implement circular economy principles, such as designing products for recyclability, reducing packaging waste, and implementing closed-loop systems for product returns and reuse.

Another important future direction for SPSCM is the integration of sustainability into corporate strategies and decision-making processes (Adeniyi, et. al., 2024, Obijuru, et. al., 2024). Pharmaceutical companies are increasingly recognizing the importance of sustainability for long-term business success and are embedding sustainability principles into their organizational culture, governance structures, and performance metrics. In terms of recommendations for further research and implementation, it is important for pharmaceutical companies to continue collaborating with stakeholders across the supply chain, including suppliers, manufacturers, distributors, and regulators. This collaboration can help identify and address sustainability challenges, such as ethical sourcing practices, environmental impact assessments, and regulatory compliance (Akomolafe, et. al., 2024, Oriekhoe, et. al., 2024).

Additionally, there is a need for more research on the social and economic impacts of SPSCM. Understanding the broader implications of sustainable practices on public health, community well-being, and economic development can help pharmaceutical companies make more informed decisions and drive positive change in the industry (Anyanwu, et. al., 2024, Awan, 2022). Overall, the future of SPSCM lies in embracing innovation, collaboration, and sustainability to enhance public health outcomes and create a more resilient and responsible pharmaceutical supply chain.

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## 7 Conclusion

In conclusion, Sustainable Pharmacy Supply Chain Management (SPSCM) plays a critical role in improving public health outcomes by ensuring the availability, affordability, and quality of medicines while minimizing environmental impact and promoting ethical practices. Throughout this review, we have explored various strategies and practices that pharmaceutical companies can adopt to enhance sustainability in their supply chains. From adopting green practices and leveraging technology to ensuring regulatory compliance and promoting stakeholder collaboration, SPSCM offers a

holistic approach to addressing the challenges faced by the pharmaceutical industry. By implementing these strategies, pharmaceutical companies can not only reduce their environmental footprint but also contribute to the well-being of communities and economies.

It is evident that the importance of SPSCM goes beyond business sustainability; it is about safeguarding public health and advancing global sustainability goals. Therefore, it is imperative for all stakeholders, including pharmaceutical companies, governments, regulatory bodies, and consumers, to prioritize sustainability in pharmacy supply chain management. As we look to the future, it is crucial for stakeholders to continue collaborating, innovating, and investing in sustainable practices. By doing so, we can create a more resilient, responsible, and sustainable pharmaceutical supply chain that benefits both current and future generations.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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