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INTERNATIONAL JOURNAL OF AGEING, SAFETY, HEALTHCARE & SCIENCE INNOVATION (IJASHSI)

(Int Peer Reviewed Journal)

Vol. 01, Issue 3, March 2025, pp: 40-47

Impact Factor: 3.001

AI-Driven Continuous Improvement Frameworks for Reducing Medication Waste in Geriatric Care

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Abstract

Medication waste in geriatric care is a critical challenge that impacts healthcare costs, patient safety, and environmental sustainability. The complexities of medication management in aging populations, including overprescription, improper disposal, and medication non-adherence, contribute significantly to this issue. AI-driven continuous improvement frameworks offer a promising solution by optimizing medication management processes, reducing errors, and enhancing resource utilization. By leveraging predictive analytics, automation, and machine learning, AI can improve prescription accuracy, monitor real-time medication use, and personalize treatment plans. Additionally, AI-powered systems enable proactive interventions, reducing medication wastage and improving patient outcomes. This paper explores various AI-driven strategies for minimizing medication waste, examining real-world applications and case studies that demonstrate their effectiveness. Furthermore, the challenges associated with implementing AI in geriatric care, such as data privacy, ethical concerns, and adoption barriers, are discussed. The findings suggest that AI-driven frameworks have the potential to revolutionize medication management in geriatric care, paving the way for a more sustainable and efficient healthcare system.

Introduction

The increasing aging population presents significant healthcare challenges, particularly in medication management. As elderly individuals often require multiple medications to manage chronic conditions, polypharmacy increases the risk of medication waste due to factors such as overprescription, non-adherence, improper storage, and a lack of real-time monitoring. Unused or expired medications not only contribute to financial losses but also pose significant risks to patient

safety and environmental health. Effective medication management is essential to mitigate these issues and improve health outcomes for older adults.

Artificial intelligence (AI) has emerged as a transformative tool in healthcare, offering innovative solutions to streamline medication management. AI-driven systems can enhance medication tracking, optimize prescription patterns, and personalize treatment plans tailored to individual patient needs (Juba et al., 2024a). By leveraging data analytics, machine learning, and automation, AI can help predict medication adherence patterns, identify potential risks of waste, and suggest timely interventions. Furthermore, AI-driven frameworks support continuous improvement methodologies such as Lean and Six Sigma, ensuring sustained enhancements in geriatric medication management practices.

The integration of AI in geriatric care is not without challenges. Issues such as data privacy, regulatory compliance, and resistance to adopting new technologies remain critical barriers. Additionally, the effectiveness of AI-driven solutions depends on the availability of high-quality data, interoperability of healthcare systems, and the willingness of caregivers and healthcare providers to embrace technological advancements. This paper explores the role of AI in reducing medication waste in geriatric care by examining AI-driven continuous improvement frameworks and their applications. Through case studies and empirical evidence, we highlight successful implementations, discuss challenges, and propose strategies for optimizing medication management in aging populations.

AI-Driven Continuous Improvement Frameworks

Continuous improvement methodologies such as Lean and Six Sigma have been widely used in healthcare to enhance efficiency and reduce waste (Olajide, 2024). Integrating AI with these frameworks can further improve medication management in geriatric care facilities.

1. **Predictive Analytics for Medication Optimization**

   AI-powered predictive models can analyze patient data to forecast medication needs, reducing overstocking and expiration-related waste (Juba et al., 2022). These models consider factors such as patient history, adherence patterns, and disease progression to optimize prescription refills.

2. **Automation and Smart Dispensing Systems**

   AI-integrated automated dispensing machines ensure accurate dosage administration and track medication usage in real-time. This reduces human errors in dispensing and helps prevent medication waste (Juba et al., 2024b).

3. **Personalized Medication Plans**

   AI algorithms can tailor medication plans based on individual patient needs, reducing the risk of non-adherence and improving treatment outcomes. Studies have shown that personalized care strategies enhance geriatric patient compliance (Juba et al., 2023).

4. **Real-Time Monitoring and Compliance Tracking**

   Wearable AI devices and smart pill dispensers monitor medication intake, sending alerts to caregivers and healthcare providers in case of missed doses. This technology enhances medication adherence, thereby minimizing waste (Olajide & Oluwafunmise, 2024).

Case Studies and Empirical Evidence

Several healthcare facilities have successfully implemented AI-driven frameworks to improve medication management. For instance, a study by Juba et al. (2024) demonstrated a 25% reduction in medication waste in geriatric care centers using AI-enhanced monitoring systems. Similarly,

Phiri et al. (2024) emphasized the importance of technology-driven quality standards in reducing medication errors and waste.

Challenges and Considerations

Despite its advantages, AI integration in geriatric care faces several challenges:

1. **Data Privacy and Security Concerns**

   AI-driven medication management systems rely on large volumes of patient data. Ensuring compliance with data protection regulations such as HIPAA and GDPR is essential to maintaining patient confidentiality and security. Cybersecurity threats, including data breaches and unauthorized access, pose risks to sensitive patient information.

2. **Resistance to Technology Adoption**

   Healthcare providers, caregivers, and elderly patients may be hesitant to adopt AI-driven systems due to a lack of technological literacy, fear of job displacement, or concerns about system reliability. Training programs and awareness campaigns are necessary to facilitate smooth integration and acceptance.

3. **High Implementation Costs**

   The cost of acquiring, installing, and maintaining AI-driven systems can be a significant barrier, particularly for small healthcare facilities. Financial constraints may limit the widespread adoption of AI solutions, requiring government support or funding initiatives to bridge the gap.

4. **Interoperability and Data Integration Challenges**

   AI systems must seamlessly integrate with existing electronic health records (EHR) and pharmacy management software. Variability in data formats and lack of standardization across healthcare systems hinder effective AI implementation.

5. **Ethical Considerations and Bias in AI Models**

   AI algorithms may inadvertently introduce biases due to training data limitations. Ensuring that AI-driven medication management systems provide fair, unbiased, and equitable healthcare solutions is a crucial challenge that must be addressed through rigorous testing and validation.

6. **Regulatory and Compliance Barriers**

   AI in healthcare is subject to strict regulatory frameworks. Meeting compliance standards and obtaining necessary approvals from governing bodies can be time-consuming and complex, delaying implementation.

Addressing these challenges requires a collaborative approach involving policymakers, healthcare providers, AI developers, and researchers to create a sustainable AI-driven medication management ecosystem.

Conclusion

AI-driven continuous improvement frameworks present a viable solution to reducing medication waste in geriatric care. By leveraging predictive analytics, automation, personalized medication plans, and real-time monitoring, healthcare facilities can enhance efficiency and patient safety. The successful integration of AI into medication management has the potential to revolutionize geriatric healthcare, leading to improved patient adherence, optimized prescription practices, and significant cost savings.

Future research should focus on refining AI models, addressing ethical concerns, and improving data integration to ensure seamless adoption. Additionally, collaboration among healthcare stakeholders, policymakers, and technology developers is crucial to overcoming implementation barriers and maximizing AI's impact on geriatric healthcare.

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