RESEARCH PAPER

Transforming African Healthcare Through Ai-Driven Drug Delivery Technologies And Data Governance Frameworks: A Systematic Review

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ABSTRACT

Background: African health care Systems are confronted by continuing infrastructure disparities or lack of capacity with regard to the workforce and unequal access to care. To address these challenges, artificial intelligence (AI) and data governance frameworks have become the change makers in the health sector, especially in the wake of the African Union Convention on Cyber Security and Personal Data Protection (2014) which was used to provide the foundation upon which digital innovators look to bring solutions to life in the healthcare sector.

Purpose: This paper explores the adoption of AI in the drug delivery technologies in African healthcare systems since 2014. It evaluates how AI can be used to optimize drug delivery, enhance the accuracy of treatment, and reduce healthcare access disparities as well as consider the implications of data governance systems to the ethical use of AI in drug management.

Methods: 41 peer-reviewed articles published between 2015 and 2023 were reviewed on the basis of systematic literature review. Sources such as PubMed, IEEE Xplore, and Google Scholar were used to search on such topics as AI in drug delivery, data governance, and Africa. To ensure the rigor of methods, grey literature was not included. The review targeted the empirical literature about the application of AI-based drug delivery technologies in African nations.

Findings: Publications on AI in drug delivery technologies have increased considerably due to increased interest and investment in the technology. AI has been demonstrated to enhance accuracy of drug delivery, operational efficiency and individualized treatment planning. Nevertheless, there are still huge challenges such as insufficient infrastructure, irregularity in the application of regulations and uncertainties around the ethical use of patient data.

Conclusion: The study proposes that African governments, health ministries, and digital health stakeholders adopt specific interventions to help AI-based technologies deliver drugs. This will involve the creation of effective data governance systems, ethical management systems, and improvement of digital infrastructure. The development of AI in the African healthcare systems should be supported by future study based on longitudinal studies and comparisons of policies across the regions to facilitate sustainable integration of AI in African healthcare..

Keywords: Artificial Intelligence, Drug Delivery Technologies, Data Governance, Healthcare Systems, Ethics, Health Policy, Africa Artificial Intelligence

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INTRODUCTION

Since the mid-1980s, AI was integrated into the broad healthcare context and initially termed medical AI [1]. This period was marked by the development of expert systems, which utilized predefined rules and logical principles to mimic human knowledge in specific medical domains. The systems used data inputs to generate diagnostic suggestions and developed into modern healthcare AI applications [2]. Medical practitioners focused on extracting knowledge from unstructured medical texts through the entire span from early 2000s until the 2010s. Natural language processing systems together with text-search methods enabled medical and research records as well as health papers to be extensively investigated to extract detailed information. The advancement made it possible for medical professionals to produce specific useful knowledge from large amounts of medical texts for better healthcare decisions [3].

AI methods underwent substantial developments in medical image interpretation following the year 2010. The technology of convolutional neural networks achieved top performance in photo processing functions which included picture element identification along with segmentation and classification projects. The recent technological progress enabled medical practitioners in Africa to receive enhanced comprehension of diagnostic images including X-rays and MRIs and CT scans. The improved capability to identify patients alongside enhanced anomaly detection was made possible by this aspect [4]. Currently, AI applications in the healthcare sector include disease prediction, in-depth understanding and the operation of robots that assist in surgical procedure [5]. These applications transformed AI into a potent force, which revolutionized modern healthcare practices. Notable examples of AI utilization in Africa highlight its impact on improving human life and fostering openness, safety and operational ease. The effectiveness of AI in healthcare is heavily reliant on access to suitable data sources, particularly big data, to execute tasks efficiently and expeditiously [6].

The use of artificial intelligence (AI) based form of technologies in the delivery of drugs is a prospective innovation in mitigating the chronic problems of healthcare in Africa. These technologies should be viewed as accelerators that can be used to increase the efficiency of drug delivery, improve the accuracy of dosing, and individual treatment strategy due to the personal patient data. In a large part of Africa where effective and timely treatment is still a problem, AI-based drug delivery systems can serve as a means to streamline healthcare delivery and provide better patient outcomes and eliminate drug-related errors. At the same time, data governance frameworks are being increasingly incorporated into the African healthcare system in order to underpin the responsible usage of patient data, defend privacy, and encourage ethical usage of AI[5]. In 2014, the groundwork of formulating the national data governance policies among the member states was established based on the African Union Convention on Cyber Security and Personal Data Protection (AUCCPDT), which forms the basis of the successful implementation of AI-enabled healthcare technologies. These models are intended to cover the most serious issues, such as data interoperability, regulatory control, and confidential health data.

AI and data governance frameworks are being introduced into African healthcare systems as a response to structural and systemic healthcare challenges is not prima facie evidence in favour of the technological determinist stereotype. Healthcare systems in the entire continent are not homogeneous in terms of infrastructure, human resources, institutional capacity and technological readiness. Rural and urban health care, clinical and nonclinical systems, and sub disciplines whose members provide health care such as pharmacy, nursing, radiology and clinical laboratory sciences are found to have pronounced disparities. There are its own classification system and coding structure for each sub discipline, examples Terminologia anatomica, SNOMED T axis, ICD-11, SNOMED D axis, Procedural codes (CPT, ICD-10 PCS, LOINC) and ATC, RxNorm and SNOMED C axis (pharmaceutical codes). The codes are a reminder of how the data exists across institutions and regions, which is some complexity. The lack of a harmonization and semantic interoperability may lead to a poor performance of AI systems or reinforcement of existing disparities.

Finally, African health systems have developed in peculiar socio political and legal contexts. For example, South Africa's health care system moderns itself in the wake of apartheid era institutional segregation by persistent bifurcated service delivery architectures that persistently defy

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disintegration. History dictates the structure, priorities and effectiveness of the healthcare systems' response to new technologies such as AI.

Based on typological frameworks, healthcare delivery models also are characterized in varying degrees of entrepreneurial (market driven) from welfare oriented and universal systems. Some systems are centralized, others decentralized; some publicly funded, others dominated by private actors. These differences impact how AI and data governance mechanisms are implemented, scaled, and regulated.

In order to successfully introduce AI-based drug delivery technologies, one must lay healthcare infrastructure in layered terms: (i). The business layer (workflows of care delivery). (ii). The data layer (patient records, test results). (iii). The application layer (clinical decision support systems). (iv). The technology layer (networks, cloud services). All these layers pose distinct challenges that should be treated both in the governance structure and the implementation of AI. An AI-based approach to African healthcare cannot be general. The interventions should be context-dependent and aware of layered healthcare architecture, sector-specific norms, historical inequities, and typological diversity[7].

The data security and privacy have become an issue due to the higher demand of data to train different health models. Consequently, the African Union (AU) added the AU Convention on Cyber Security and Personal Data Protection (AUCCPDT) in 2014. Some countries were involved in the formulation of national policies on data governance, and as of the start of 2023, laws have been enacted in at least 27 countries, and eight others are still pending [7,8]. The focus on digital health records and massive data repositories has increased post-2020 to forecast medical outcomes and offer individual treatment in Africa. The machine learning and data mining have allowed to analyze the large scales of data and, as a result, determine the course of disease development, estimate the risks and alter the course of treatment in accordance with the needs of respondents [9]. Table 1 presents the chronological Framework on AI and Healthcare in Africa.

Table 1: Chronological Framework of AI and Healthcare in Africa

Era	Period	Development
Expert Systems	1980s	Although medical AI has been used in other parts of the world, it was piloted in Kenya during the mid-1980s followed by Egypt and the Gambia for the detection of diseases that may not be obvious (Hunter et al., 1989), Owoyemi et al., 2020).
Advances in Medical Image Analysis: Diagnostics	Post-2010	Diagnostics in the 2012 clinical validation study, including patients with a diagnosis of diabetes in the Copperbelt province of Zambia (Bellemo et al., 2019).
Current Trends: AI in Disease Prediction and Robotics, Drug Discovery	Post-2020	Drug discovery (Turon et al., 2023), disease control (Aborode et al., 2022), drug repurposing (Anuradha, 2024) and disease management (Akingbola et al., 2024).
Recent Developments: AI and Data Governance	Since 2014, with a significant increase after 2020	Data governance: With the adoption of the African Union Convention on Cyber Security and Personal Data Protection in 2014, a significant reliance on AI was observed for the management and analysis of digital health records and extensive data repositories. This aspect ensures data security and enhances the accuracy of medical prediction. The convention gave rise to Data Protection Laws in 27 out of the 50 countries by early 2023 (Ndemo & Mkalama, 2024) across the continent.

1.1. Contextual Challenges of AI and Healthcare in Africa

AI adoption in Africa continues to expand but limited implementation occurs because the region lacks technological equipment along with inadequate healthcare systems combined with a lack of digital literacy skills. Throughout Africa there are inconsistent levels of technology access which create barriers to its utilisation. The necessary infrastructure needed to operate AI programmes does not exist in various rural and underserved regions [10,11]. These constraints directly affect the deployment of AI-driven drug delivery technologies, which rely on stable digital systems for dosage optimization, treatment monitoring, and supply chain coordinationThe implementation of software in healthcare facilities is problematic due to the inability to purchase and maintain proper hardware, high-speed connections, and reliable connections. Such restrictions prevent the successful implementation of AI systems in pharmaceutical services, such as electronic prescribing, smart drug dispensing, and AI-aided medication management. Moreover, the digital literacy of healthcare professionals is not at par with each other, thereby limiting the adoption and effective use of AI-based drug delivery tools. The AI-based drug delivery systems should be implemented successfully, which is possible only with the help of the continuous professional training programs provided to guarantee the ability of healthcare workers to get the best out of the technological pharmaceutical remedies.

The various levels of development of healthcare infrastructure in the African regions are major implementation challenges. Facilities with resource-constrained facilities do not have the financial and technical capability to install AI-based technology, such as intelligent pharmacy delivery systems and pharmacist-specific medicine dispensing systems [1]. Consequently, AI applications are the least available in areas where the most effective delivery of drugs is required. The solutions to these issues involve specific investment in digital facilities, special education of medical and pharmaceutical staff, and fair allocation of resources [12]. In addition, the effective integration of AI-based drug delivery technologies requires the coordinated work of the national governments, players in the private sector, and international organizations to establish the enabling environments and help to provide safe and effective pharmaceutical care. These systems are also effective in drug delivery, like any other healthcare application, and their performance relies on large and high-quality datasets, which allow rapid and precise work of these systems [6].

The growing use of digital health records in Africa has further heightened the pressure on AI that can be used to predict the results of treatment and help deliver personalized treatment. Machine learning and data mining algorithms are used to study large quantities of data, finding patterns of the diseases, calculating the risk of treatment, and designing drug regimens to fit the needs of the concrete patient [9]. Nevertheless, the effectiveness of AI-based models in drug delivery is extremely contingent on the quality of connections to the reliable and properly structured pharmaceutical and clinical data. The challenges that persist in most countries in Africa are associated with the incompleteness of records, individual data entry and the lack of coherence among drug information systems [13]. Poor data quality jeopardizes predictive models of drug delivery resulting in possible poor dosing choices, lower treatment success, and adverse patient outcomes.

Table 2: Summary of Existing Reviews on AI, Data Governance, and Drug Delivery–Relevant Applications in African Healthcare

Study	Type of Review	Scope	Identified Gaps
Owoyemi et al. (2020)	Narrative Review	General applications of AI in African healthcare	Lacks systematic methodology and does not address AI-enabled drug delivery or pharmaceutical data governance

Ciecierski-Holmes et al. (2022)	Systematic Scoping Review	AI in LMICs with African representation	Focuses on health systems strengthening**;** limited attention to AI-driven drug delivery and post-2014 data governance frameworks
Adebamowo et al. (2023)	Expert Commentary	Data science potential in African health research	Theoretical perspective; no structured evidence synthesis on AI applications in medication management or drug delivery
Alami et al. (2020)	Global Systematic Review	AI innovation in LMICs	Broad global scope; does not explore African-specific regulatory, governance, or pharmaceutical implementation challenges
Gwagwa et al. (2021)	Landscape Report	Responsible AI in Sub-Saharan Africa	Policy-oriented; lacks systematic methodology and does not examine healthcare or drug delivery use cases in detail

The review is based on the available literature; it conducts a systematic analysis of peer-reviewed articles published in 2015-2023 with a particular emphasis on AI-based drug delivery technologies and the related data governance models in African health care systems in the framework of the AUCCPDT (2014). Although prior studies have examined AI applications in healthcare and analyzed responsible AI from a policy perspective, no research has systematically synthesized this literature with a specific focus on pharmaceutical and drug delivery applications in Africa. It offers a comparative analysis of regulatory alignment and evaluates real-world implementation outcomes. In addition, the study provides context-specific insights into how governance mechanisms, data quality, and infrastructural constraints influence the adoption and sustainability of AI-enabled drug delivery technologies across African healthcare settings.

1.2. Objectives

a) The study assesses how AI-driven drug delivery technologies and data governance in Africa have evolved and affected the nation since 2014 and the role they have played in enhancing the efficiency of medication delivery, the accuracy of treatments, patient outcomes, and the responsible management of data in the pharmaceutical industry.

b) The proposed study will create an evidence map that examines the applications of AI in drug delivery systems and data governance approaches applied to the African healthcare interventions in terms of operational performance, ethical and regulation issues, implementation barriers and implications of scalable and sustainable implementation.

2. Methods

The paper examines the implementation of AI-based drug delivery technologies and healthcare data governance systems in African nations in a systematic manner. The methodological strategy analyzes the evidence based on the analysis of medicine delivery-related healthcare practices, regulatory measures, and technological development measures [14]. The overall overview of gaps in the current knowledge base allows policymakers, healthcare regulators, and practitioners to gain strategy insights on how to boost AI-enabled pharmaceutical systems and build a solid evidence base.

To facilitate the methodological rigor, transparency, and reproducibility of the review, the PRISMA 2020 protocol, a standardized methodology applied in systematic review, was guided. PRISMA lowers the selection bias, allows the replication, and increases the validity of the results regarding AI applications in drug delivery and other related data management systems. The methodology consisted of four steps, which included identification of literature, screening of articles, eligibility process and data extraction. A PRISMA flow diagram that shows the process of selecting the articles is provided in Figure 1 and summarized in Figure 2.

Upon the exclusion of duplicates, 41 peer-reviewed articles were initially taken into account to be assessed in full-text. These were found in the large academic information databases such as IEEE Xplore (15), Google Scholar (58), ACM Digital Library (12), PubMed (35) and other sources used (7). After the procedure of screening and eligibility verification, 41 empirical studies were selected to be analyzed depending on the relevance to the AI-driven drug delivery technologies, pharmaceutical data use, and healthcare data governance in Africa. To ensure that the literature is methodologically rigorous and consistent with the requirements of a systematic review. The PRISMA diagram was revised with minor typographical corrections (e.g. revised to say assesses rather than asses).

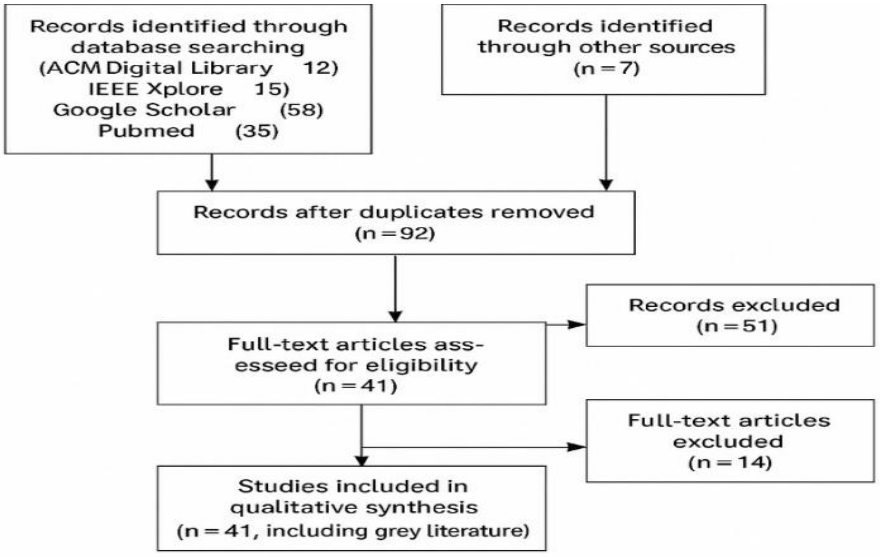

Figure 1: Figure 1 PRISMA Diagram

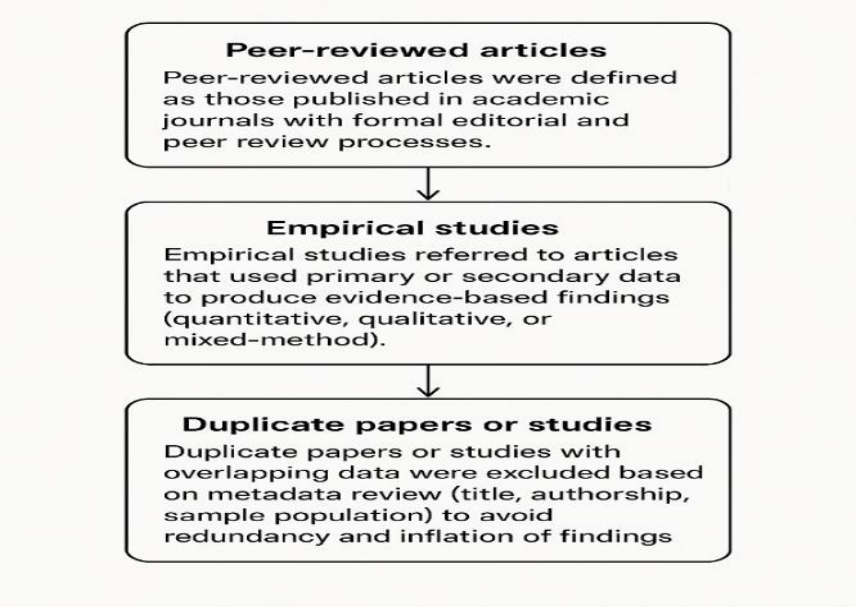

Figure 2: Selection Criteria and Definitions

The study has used a structured and well-organized search strategy to analyze the intersection of AI technologies, drug delivery systems, and data governance in African healthcare environments. To provide access to quality, peer-reviewed, and current literature, the selection of leading academic databases was chosen: IEEE Xplore, Google Scholar, ACM Digital Library, and PubMed. A research strategy has been formulated (see Table 2) and the selection criteria were based on relevance, empirical rigor, and interdisciplinary value. The targeted keywords were used to apply the use of Boolean operators (AND, OR, NOT): AI-driven drug delivery, artificial intelligence in pharmaceuticals, health data governance, and Africa. This strategy identified a wide but narrow literature on the optimization of medication delivery, pharmaceutical data management and governance issues. The search strategy was formulated in such a way that it attempted to locate the studies that reflected different opinions on the interplay between AI-enabled drug delivery technologies, regulatory frameworks, and healthcare system performance in Africa.

Table 3: Research Strategy

Database	Keywords	Inclusion Criteria	Exclusion Criteria
IEEE Xplore	"AI-driven drug delivery," "artificial intelligence in pharmaceuticals," "data governance," "Africa"	Peer-reviewed journal articles; empirical studies; English language; drug delivery or pharmaceutical AI focus; 2015–2023	Editorials, reviews, non-English texts, non–drug delivery AI studies
PubMed	"AI AND drug delivery AND Africa"	Peer-reviewed articles; empirical evidence; studies conducted in African healthcare or pharmaceutical contexts; English; 2015–2023	Studies without relevance to drug delivery, medication management, or pharmaceutical systems; conceptual papers only
Google Scholar	"Artificial intelligence in drug delivery in African healthcare"	Peer-reviewed; full-text available; empirical data; AI applications in medication delivery or pharmaceutical data use; 2015–2023	Non-peer-reviewed sources, blogs, dissertations, grey literature
ACM Digital Library	"Data governance in African pharmaceutical and health systems"	Peer-reviewed; empirical studies; African region focus; English; data governance relevant to drug delivery or healthcare AI; 2015–2023	Non-African focus; theoretical or policy-only articles without healthcare or pharmaceutical relevance
Other Sources	Hand searches, cited references	Peer-reviewed African-focused studies aligned with AI-driven drug delivery and data governance frameworks	Grey literature, conference posters

All sources shared the same core criteria for inclusion: empirical, peer-reviewed, African context, and English language. The decision to start from 2015 stems from the 2014 African Union Convention on Cyber Security and Personal Data Protection, which marked a significant policy shift in data governance on the continent—making 2015 a logical start point for post-convention impact assessment.

2.1. Data Extraction

An extraction form that summarized the main study features was created to identify key study features, such as author(s), publication year, country, study design, drug delivery or pharmaceutical application domain addressed by AI, data governance and data protection approach, health system layer addressed (business, data, application, or technology), reported results, and ethical or legal considerations. This strategy made sure there was uniformity in the extraction of information that is pertinent to AI-based drug delivery technologies and governance systems in African

health care systems. Each article that was included in the research was independently data mined by two reviewers to increase the level of accuracy and reliability, and the cases of disagreements were resolved by discussion and agreements.

The process of data extraction was based on the principles of ethics in the use of secondary data and was focused on the responsible management of possibly sensitive medical and pharmaceutical-related information, especially when the patient data or medication records were implicated [15]. Such an ethical orientation was particularly significant on the basis of the dependency of AI-based drug delivery systems on the quality of clinical and pharmaceutical datasets. The summary of the included studies by years according to table 4 will give an overview of the trends of publications in relation to AI-enabled drug delivery and data governance research in Africa.

Table 4:Number of Studies Used

Year	Number of Studies
2018	4
2019	5
2020	7
2021	5
2022	5
2023	6
2024	6
2025	3
Total	**41**

2.2. Screening and Analysis

Screening followed a two-stage approach:

Relevance screening Title and abstract screening: AI-driven drug delivery technologies, African-based healthcare systems, and data governance systems.

Full-text screening to determine the level of empirical insight, geographic applicability to the African healthcare environment and thematic correspondence to pharmaceutical uses of AI, medication delivery, and data governance systems.

A structured inclusion criteria matrix was used to assess each paper. The studies that included only secondary analysis, as well as those that focused on AI-assisted drug administration or healthcare data regulation, were excluded. In order to reduce the risk of selection bias, a research team at Warwick University reviewed 30% of its articles chosen independently, and disagreements were settled by agreement.

After selection of the studies, thematic analysis was performed to be able to synthesize the findings under three significant categories of analysis: (i). AI-Driven Drug Delivery Technologies. (ii). Data Governance in AI and Healthcare. (iii). Challenges in AI-Driven Data Governance and Drug Delivery Technologies. (iv). Ethical Considerations in AI and Healthcare.

The methodological framework by Sun et al. (2019) was used to perform an iterative coding process to find common themes, conceptual frameworks and gaps in the research that are important to AI-driven drug delivery technologies and data governance within African healthcare systems[16].

2.3. Conceptual Framework

Figure 3 shows a clearly defined conceptual framework that can be used as a roadmap to this study since it presents the dynamic interaction among AI-driven drug delivery technologies, data governance structures, and the African healthcare system. The framework highlights the interdependence and relationship between these parts and their overall impact on the process of medication delivery, regulatory supervision, ethical conduct, and technological progress of healthcare environments.

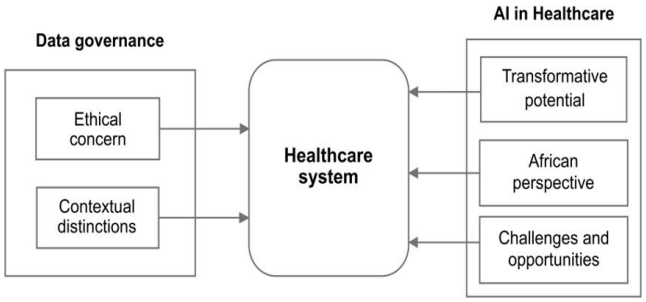

Figure 3: Conceptual Framework

The primary component of the system is the healthcare system, and it is directly affected by the contributions of AI-based drug delivery technology and data governance systems. Some of the data governance issues depicted in the framework include patient consent, data privacy and responsible usage of pharmaceutical data and contextual differences like regional differences in infrastructure, regulatory maturity, and resources availability among others. These factors determine how healthcare and pharmaceutical information is collected, processed, distributed and stored. Concerning the AI application aspect, the framework speculates on the transformational possibility of AI in pharmaceutical delivery e.g., in drugs optimization, personalised treatment and greater efficacy in the factor of pharmaceutical supply. The African lens deals with the local healthcare realities, including the unequal access of medicines, shortage of labor, and shortage of infrastructure, which dictate the implementation of AI. Moreover, the issues, along with opportunities, are two sides of the coin of AI implementation involving the absence of data quality and regulation implementation in addition to the possibilities to execute a scalable and technology-based option of drug delivery. The importance of the role that data governance has in enabling safe, ethical, and effective systems of administering AI-driven drugs is one of the main themes that emerge out of the framework. Effective data regulation fosters ethics, secure pharmaceutical and patient data, and enhances the degree of transparency in the decision-making process through AI-assistance. The model also recognizes the fact that the variations of cultural standards, financial means, and infrastructural capacity have a significant contribution to the introduction of AI technologies and data control measures into the African healthcare systems. The proposed conceptual framework indicates that the systematic review tends to be systematic in terms of which the overlap of AI-based drug delivery technologies, data governance models, and the performance of the healthcare system are analyzed. It clarifies the intricate associations that position the examination and support a contextual experience of ways in which pharmaceutical developments that are AI-enabled might be absorbed accountably into the African health systems.

3. Results

The number of studies to be incorporated into the final synthesis was 41 studies that were included based on the inclusion criteria. The chosen articles represented a wide range of applications in the areas of artificial intelligence (AI) and data governance in the African health sector, including diagnostic decision-support systems, predictive analytics, epidemiological surveillance, healthcare management and logistics, and ethical, regulatory, and governance implications of AI-based health technologies. The studies utilized in the article had varying designs, which included quantitative studies (n = 22), qualitative studies (n = 8), and mixed-methods studies (n = 11). The geographical setting of most of the studies was in the Sub-Saharan Africa though South Africa, Kenya and Nigeria recorded the greatest density of research outcomes.

Tables 5 and 6, respectively, give a detailed description of thematic categorization of the studies used and their distribution across the world. The subsections below further expound on the major thematic trends that were identified during the review.

Table 5:Thematic Categories of Included Studies

Thematic Category	No. of Studies	Description
AI-Driven Drug Delivery Technologies	15	Research involving the use of artificial intelligence in drug discovery, formulation design, targeted and controlled drug delivery systems, nanomedicine, predictive pharmacokinetics/pharmacodynamics and AI-enabled therapeutic optimization.
Data Governance in AI and Healthcare	10	Research on data governance, data protection, regulatory frameworks, interoperability, data quality management and policy provisions to the responsible use of health data in AI-based healthcare systems.

Challenges in AI-Driven Data Governance and Drug Delivery Technologies	9	Research involving technical, infrastructural, regulatory, socio-economic, and data-related issues, such as data bias, small datasets, barriers to integration with existing systems, resource limitations, and scalability in AI-powered healthcare and drug delivery.
Ethical Considerations in AI and Healthcare	7	Research on ethical considerations, like fairness, transparency, accountability, explainability, patient consent, privacy protection, algorithm bias, trust, and equity in the implementation of AI technologies in the healthcare environment.

Table 6: Geographic Distribution of Included Studies

Country / Region	No. of Studies	Focus
Sub-Saharan Africa (multi-country / regional)	12	Regional analyses of AI applications, data governance frameworks, ethical challenges, and health system strengthening across multiple African countries
South Africa	8	AI governance, ethics, digital health infrastructure, diagnostic AI systems, and policy-oriented healthcare AI studies
Nigeria	6	AI-driven diagnostics, healthcare access, digital health adoption, pharmacy practice, and health system applications
Kenya	5	AI-supported disease detection, public health surveillance, and digital health pilot implementations
Uganda	3	AI in pharmaceutical technology, drug delivery design, and community-level healthcare applications
Ghana	2	Data governance, public-sector digital health initiatives, and health data management
Ethiopia	2	AI-enabled health system strengthening and digital healthcare services
Rwanda	1	Government-led AI and eHealth initiatives
Other African countries (e.g., Tanzania, Morocco, Tunisia)	2	Emerging AI use cases in healthcare and early-stage governance discussions

3.1. AI-Driven Drug Delivery Technologies

The reviewed studies show that the application of AI-driven technologies in the support of drug delivery, clinical decision-making, and personalised routes of treatment is becoming more common, especially in resource-constrained and digitally evolving health systems. Some of the studies emphasize how artificial intelligence (AI) can be used to detect diseases early and optimise treatments, where machine learning models can be used to improve the quality of diagnoses and treatment targeting [17,20]. As an illustration, AI-based colorectal cancer screening technologies in sub-Saharan Africa have exhibited higher sensitivity in early detection than traditional methods, with preferential treatment interventions being better and timely [25].

AI-enabled real-time monitoring and intervention systems also became an important development. the use of AI-driven monitoring frameworks to manage body fluid imbalances in sickle cell disease was able to provide for predictive alerts and timely clinical responses in sub-Saharan African settings [48]. Additionally, artificial intelligence–driven clinical decision support systems for the management of chronic conditions such as diabetes have been shown to assist clinicians at the point of care by integrating patient-specific information with evidence-based recommendations, thereby enhancing the accuracy and effectiveness of treatment decisions [49].

The contribution made by AI to accuracy and customized medicine was mentioned in a number of studies. AI-based hybrid models for drug-target interaction optimization showed accelerated drug discovery and better therapeutic matching with the potential of decreasing timelines for drug development and helping to design targeted treatment strategies [51]. Broader frameworks of precision medicine that integrate AI with large-scale health data analytics were shown to allow for scalable, patient-specific treatment pathways across a wide range of clinical contexts [52,56]. Advanced AI concepts such as human digital twins further expanded these capabilities by enabling the predictive simulation of patient response to therapies, and supporting individualized therapy planning [53].

In the field of oncology and neurological care, AI usage for personalized medicine was reported to lead to better stratification of patients at the level of treatment and engagement. There were AI-enabled cancer treatment models that implemented cloud-based data infrastructures to support more adaptive and patient-specific drug treatments[54]. Patient-centered studies in Parkinson's disease emphasized the idea that while AI-driven personalized medicine provides great clinical promise for patient care, patient trust and informed consent on how data will be used remains at the forefront of successful implementation [50]. Additionally, AI-based healthcare financial and access models justification tensions between innovation, cost efficiencies and fair access to precision therapies and the need for strategies on ethically grounded deployment [57, 58]. Across low and middle income country contexts, AI-supported digital health infrastructures were found to enhance healthcare delivery by facilitating task-shifting, better access to treatment in rural contexts and supporting preventive and personalised care approaches [21,22,24]. Collectively, these finds suggest that AI driven drug delivery and precision medicine technologies are transforming the delivery of healthcare with demonstrated benefits in terms of diagnostic accuracy, personalization of treatments, and system efficiency while at the same time raising important issues in terms of ethics, governance and equity.

3.2. Data Governance in AI and Healthcare

Two critical issues arise when artificial intelligence systems are implemented in healthcare practise due to the need for rigorous standard for protection of patient private information when there is so much data. Moreover, data management effectiveness has a dual role in enabling secure information exchange, as well as detail protection in healthcare operations, and simplifies continuous data flows. Two main qualities that need to be in healthcare data systems, they need to be resilient and flexible and have the capacity to adapt to healthcare and technological changes. Another focus on data organisation is to ensure the safety as well as the fairness for AI health applications among all healthcare stakeholders[35]. However, serious attention must be given to healthcare requirements, existing technical capa bilities as well as local and worldwide data security rules. Healthcare regulations on data deal with health information and protection of personal details which should apply to all sectors because they protect personal information as well as secure health related facts according to the international standards [21].

It is worth mentioning that when it comes to AI integration in healthcare, healthcare providers are dealing with big complex data which makes fine tuning those guidelines more important [36]. Thus, these regulations are set to protect the health information, the security of the health information and ethical boundaries there by creating trust in healthcare systems and ensure effective performance of AI tools.

An organisation must conduct its regular policy evaluation to be aware of regular AI advancements and the latest security threats. Fast technological progress is supported by continued effectiveness for patient privacy and security measures, in terms of the ability to perturb healthcare systems [23]. Healthcare professionals need to be part of continuing training and learning activities to keep up to date with the new healthcare technologies [37]. It is necessary to continuously regulate medical data because it contributes to the work of correct implementation and compliance with

standards in healthcare at the stage of development of the current period of AI application [38].

Proper regulatory framework must then be achieved to support the new healthcare concepts as healthcare quality protection and patient rights defence including. It necessitated established guidelines and sharp continuous training to support the development of a new technology [18]. To use recently available tools that improve complex information management without sacrificing patient security and confidentiality, healthcare workers need an implementation of ethical data handling practises.

AI has the potential to support healthcare, who were also cautious about ungrounded enthusiasm about AI's applications [39,40]. They insisted that data privacy became necessary together with responsibly deploying AI and skilled management solutions to streamline data and codes. Alami et al. explore both positive and negative impacts of the use of AI to alleviate health disparities for people living in underdeveloped countries through examination [41]. It indicates various benefits such as enhancing the availability medical services and techniques of forecasting diseases. As reported by Gwagwa et al., a set of challenges is identified inclusive of these two primarily concerning the data bias issues and management complexities[42]. They both advocate for a cautious approach.

Successfully deployed digital health instruments in Africa with artificial intelligence are powerful forces behind health system evolution in developing countries[41]. Because of this need for dedicated support infrastructure in addition to regulatory standards with consistent funding commitments to sustain AI healthcare solutions, a thorough approach is mandatory that goes beyond simple technology implementation [43]. This research gives the reason for why data fairness issues need to be addressed firstly, while building high quality healthcare AI applications.

Big data and AI in health care can be affordable and useful, but not enough evidence is out there that AI products would bring considerable benefits to the health care [39]. The researchers say that the results are so exact they depend on exact results and make concrete differences for medical practise. Research was conducted on ethical issues emphasizing health care requirements for better rules and privacy security as well as responsible AI practises [44].

In addition to general health data governance, there are a few studies that point to governance challenges specific to AI-driven drug development, drug delivery, and pharmacy practice. AI systems in medicine management, clinical pharmacy and drug discovery use extremely sensitive patient, genomic and prescription information which raises risks about data misuse, prejudiced algorithms and accountability. Governance frameworks need to consider issues such as traceability of AI supported prescribing decisions, transparency in the drug-algorithmic interaction and responsibility for adverse drug outcomes when AI supported systems are involved [32,35,44]. Ethical issues surrounding AI in pharmacy practice has also led to a further need for clear data ownership, informed consent for secondary data use of medication data and protection against bias in automated treatment recommendations [55]. Studies are also emphasising that poor governance processes around pharmaceutical AI systems may increase inequities in the availability of advanced therapies, especially in low-resource settings and thus the need for advanced drug-specific governance principles to be included in national AI and health data policies [41,57].

National AI plans to analyse their impact on public sector improvement and business competition systems [40]. Data and computer programme management under the public sector plays a vital role as the study demonstrates the fundamental importance of governance in this field. National governments require substantial investments that target AI capability development most especially in building new capabilities. The researchивsted for tactical steps to improve AI exploitation capacity since AI represents a fundamental requirement for national advancements in the future [45,46].

Different studies have and presented opposing opinions established that AI deployment in health diagnosis, prognosis prediction and patient care management alongside hospital and community healthcare services leads to better medical system efficiency specifically in densely populated health facilities with insufficient resources at developing world locations [39,40].

3.3. Challenges in AI-Driven Data Governance and Drug Delivery Technologies

The analyzed literature confirms that the implementation of AI-based systems in healthcare and pharmaceutical delivery is limited by serious governance, technical, ethical, and infrastructural issues. One overriding worry is on the management of high, heterogeneous, and sensitive data needed to operate AI applications, especially in drug discovery, precision medicine, and practice in pharmacy. In the context of medication administration, clinical decision-making, and medication delivery systems based on AI, multiple research works note that the systems are premised on integrated clinical, genomic, and prescription data, potentially increasing the likelihood of privacy violations, data misuse, and the lack of clear accountability frameworks [27,35,36].

One problem that has been observed among researchers is the absence of strong, situation-specific data protection frameworks that can support AI-based risks in the entire lifecycle of pharmaceuticals. The current regulatory frameworks have been termed as being piecemeal or failing to be responsive to the fast-changing AI technologies especially in low- and middle-income contexts [30,34,41]. The existence of this regulatory gap makes it difficult to regulate the AI-based drug development pipelines, automated prescribing systems, and AI-assisted medication management tools, where the solving of mistakes or adverse effects due to errors is ill-defined [36,44]. Experts warn that the lack of governance models can erode trust and clinical accountability in AI-assisted technologies in drug delivery to patients [35].

The other significant challenge that impacts AI-based drug and healthcare applications is the concept of data quality and representativeness. A number of studies emphasize that AI models that are trained on unrepresentative or biased data may produce inaccurate or unfair results, especially in case with the under-represented groups [33,42]. As far as drug delivery and precision medicine are concerned, these biases can lead to inappropriate dosing advice, useless treatment, or a higher risk of adverse drug reactions [39,55]. Such interests are particularly strong in African and other poorly resourced settings, where pharmaceutical and clinical information that is localized to a particular setting is uncommon [30,34].

Limitations in technology and infrastructures also limit the successful implementation of AI-based drug delivery technologies. The studies have shown the problems related to the absence of digital infrastructure, interoperability of health information systems, and the absence of homogenous data architecture that holds back the protection of pharmaceutical data exchange and management [22,28]. The lack of technical capability also affects the implementation of more sophisticated AI models in clinical pharmacy and drug handling that results in their reduced size and long-term sustainability [38,46].

Governance limitations are mainly correlated with ethical issues. Several reports indicate that applications in AI and pharmacy result in ethical issues regarding informed consent, disclosure of algorithmic choices, and the risk to push out professional judgments [19,29,43]. Risks of over-reliance on automated systems, bias in AI-aided prescribing, and lack of patient awareness on the use of their medication data to train and optimize AI are some of the ethical issues in the pharmacy practice [55]. Such lapses in ethics are worsened whereby the governance structures do not provide a clear definition of the ownership of the data, the rights of the patients, as well as the redress mechanisms in the event of harm [27,44].

Lastly, the literature reviewed cites the lack of human and institutional capacity as a significant vulnerability to the adoption and implementation of AI governance of drug delivery and healthcare systems. A number of studies report a lack of skills in healthcare professionals, pharmacists, and regulators in understanding AI outputs and how to deal with AI-related risks [21,38]. In the absence of focused education, interdisciplinary cooperation, and ongoing investment in governance capacity, AI-based drug delivery technologies can become a source of further health disparities instead of better therapeutic outcomes [41,45].

3.4. Ethical Considerations in AI and Healthcare

Another researcher investigated the linking between AI and digital health utilising bibliometrics as their research method [47]. The research analysed how responsible AI works while investigating moral and ethical problems that exist in healthcare AI systems. By employing a systematic technique the authors found the changes together with challenges and positive outcomes of AI integration in healthcare within World Health Organisation ethical framework for AI [48]. This document delivered detailed instructions along with practical advice for medical practitioners who follow the main contemplation of ethics alongside regulation when using AI to transform healthcare. These studies (Appendix 1) demonstrated the need for fair medical service delivery which includes moral considerations with rule compliance alongside essential infrastructure creation. AI healthcare utilisation develops toward responsible behaviour and inclusion through cohesive element integration to secure benefits for numerous people. Ethical and operational concerns were also an integral part of AI-driven drug delivery and care models. Studies that focused on pharmacy practice raised ethical concerns about the role of algorithmic bias, transparency and

accountability when AI systems influence medications management and therapeutic decisions [55].

4. Discussion

The present systematic review incorporated 41 studies to examine the role of artificial intelligence (AI)-based drug delivery systems and data regulations in African and similar global healthcare settings, in accordance with the post-2014 regulatory background. The conclusions provides an integrated overview that AI is becoming more and more influential when it comes to diagnostic support, therapeutic optimisation, pharmaceutical innovation and the efficiency of health system. Nevertheless, the review also unveils some enduring governance, infrastructural and ethical impediments that restrict the effective and fair implementation of AI-based drug delivery systems, especially within low- and middle-income environments. In the studies covered, AI-api applications in clinical and pharmaceutical applications were most eminent in early intervention strategy, disease monitoring, and diagnostics. The research conducted on the world and Africa has shown evidence that AI has enhanced the diagnostic accuracy and clinical decision-making, specifically with cancer, diabetes, and chronic diseases that demand continuous monitoring and individualised treatment regimens [17,18,25,48,49]. An example of a predictive analytics application is the use of AI-based real-time monitoring systems, like the one used to handle sickle cell disease in sub-Saharan Africa, to support early intervention and minimize preventable complications in resource-constrained environments [48].

Likewise, AI-based clinical decision support systems to support diabetes care see the possibility of point-of-care algorithms to help clinicians by combining patient data with evidence-based treatment recommendations[49]. In addition to diagnostics, there is an increasing number of studies on the growing role of AI in drug discovery, formulation, and delivery design. Hybrid machine-learned models that can optimise drug-target interactions are potentially useful in speeding up pharmaceutical discovery and lowering the cost of research and development [51]. The research on precision medicine also implies that the AI-based data analytics can be used to assist in the development of personalized treatment plans by combining clinical, biological, and behavioural data [52,56]. Such innovations especially apply to the African health systems where the scarcity of specialised human resources and disparities in the access to medicines continue to be witnessed [22,24]. However, the review notes that the majority of applications of AI in pharmaceutical are still in the experimental or pilot phase and have not been translated into practice. The concept of data governance became a supporting factor of AI efficacy in healthcare and drug delivery platforms. The results support the idea that AI systems are heavily reliant on the quality, interoperability, and constant renewal of health data, but the governance structures of most African settings are poorly defined and not uniformly enforced [27,34,35]. Research focuses on showing that a low level of protection mechanisms, ambiguity of accountability systems, and low regulatory capacity contributes to the lack of trust in AI-assisted clinical and pharmaceutical decisions [36,42]. The latter issues are especially acute in the field of drug delivery and pharmacy practice where AI systems depend on the sensitive prescription, pharmacokinetic, and patient adherence data[32,55].

The literature reviewed points to the fact that existent AI governance models in the healthcare sector focus an unreasonable amount on data privacy and security and little on the issue of algorithmic accountability, responsibility, and transparency in pharmacological decision-making [35,36]. The imbalance is especially problematic when the prescribing, dosing, or the choice of treatment are informed by AI systems. Without a clear definition of the liability structure, there is ethical and legal ambiguity particularly when it comes to adverse drug reactions or clinical harm [44,55]. Such discoveries imply a set of drug-specific AI governance rules such as regular auditing of pharmaceutical workflow algorithms, clear definition of roles among clinicians, developers, and healthcare organizations.

Other than the issue of governance, the review identifies some crucial structural and contextual limitations that put the implementation of AI-based drug delivery technologies within African healthcare systems to a disadvantage. The lack of persistent infrastructure problems like the low levels of digital connectivity, poor interoperability between health information systems, inadequate computational capacity, and issues with scalability remain barriers to successful implementation [22,28]. These limitations make the implementation of advanced AI tools less viable in the normal pharmaceutical practice, especially in resource-constrained environments.

Another issue that becomes critical is data quality and representativeness. A number of studies claim that the lack of representation of African people in the AI training data raises chances of biased results, which can lead to inappropriate, ineffective, or unsafe treatment suggestions [33,42]. This is of particular importance in the realm of precision medicine, in which biased information may be directly turned into disproportionate therapeutic results and increase the presence of health inequalities [39,56].

Moreover, there is always the hindrance caused by human and institutional capacity constraint. The gaps in AI literacy identified in the literature among healthcare professionals, pharmacists, and regulators lower their capacity to critically assess the outputs of algorithms and succeed in fitting them correctly into clinical judgment [21,38]. In the absence of proper training and governance supervision, the AI systems will become black-box decision-making machines that strip them of their professional discretion and their trust with patients.

Lacking of proper training and governance controls, AI systems will pose as opaque decision-making tools and become detractors of professional autonomy and patient trust [19,29,43]. This supports the need to have interdisciplinary capacity-building programs to incorporate AI governance, ethics, and data stewardship in medical, pharmaceutical, and regulatory training [31,45]. Ethical concerns transcend all themes and cannot be separated in issue of governance and implementation. The analysed articles are unanimous on the importance of fairness, transparency, and equity to form the main principles of responsible AI implementation in healthcare [19,43,47]. The patient-centred studies reveal that patient acceptance of AI-driven personalised medicine is reliant on clear consent procedures, understanding of how the data is used, and regarded clinical advantages [50]. Ethical studies of pharmacy practice also reveal the issues connected to algorithm bias, responsibility, and the possibility of marginalisation of vulnerable groups in case AI systems are focused more on efficiency than fairness [55,57].

These ethical issues are heightened in the context of Africa by the wider inequities related to the socioeconomic and health systems. Research on the governance of AI in African countries warns that unless a policy alignment is pursued and a permanent public investment is made, technologies based on AI-enabled drug delivery will likely support the status quo of access to more complex therapies [41,42]. National AI policies and data governance approaches are consequently crucial in determining whether AI can be used to inclusively strengthen health systems or be selective in terms of technological improvement [40,45]. In general, the results indicate that AI-driven technologies in the field of drug delivery can provide significant opportunities to enhance therapeutic accuracy, drug administration, and the efficiency of health care. Technological innovation in itself however is not sufficient. A sustainable implementation requires strong, context-specific data governance systems, drug-related regulation and ethics that safeguard the rights of patients and allow innovation. In line with the concepts of AI implementation and application in the context of the principles of the AUCCPDT, it is necessary to enhance institutional capacity, introduce governance considerations at every stage of the AI lifecycle, to make sure that AI leads to safe, equitable, and effective pharmaceutical care

4.2. Limitations of the Study

There are several limitations to this study that should be acknowledged. First of all, the review included only peer-reviewed articles written in the English language, which probably led to excluding relevant studies living in grey literature or published in regional languages such as French, Arabic or Portuguese, which are widely spoken in many African countries. This linguistic restriction might have prevented the geographical and contextual diversity of the evidence that was incorporated. Second, although a number of scholarly databases were systematically searched, the possibility of publication bias cannot be ruled out, especially in regard to studies that originate from regions with limited funding for research and/or less than spectacular publication infrastructures. Third, although the application of the PRISMA framework increases the methodological transparency and rigour, the process of thematic synthesis includes a certain level of subjective interpretation, which may lead to variability in the categorisation of findings into themes. Second, although multiple academic databases were systematically searched, publication bias. Finally, the pace of innovation in artificial intelligence means that some emerging technologies and real-world applications may not yet appear in the existing literature in the field, and so may not reflect the latest developments in artificial intelligence-led healthcare and drug delivery systems.

Irrespective of these difficulties, this review has a number of key strengths. First, it provides one of the most detailed and organized summaries so far of AI-based drug delivery systems and data governance systems in the context of African health care. Reviewing 41 peer-reviewed articles since

the adoption of the AUCCPDT (2014), the review offers evidence base that highlights the current policy realities and is temporally relevant.

Secondly, the interdisciplinary analytical perspective, which combines the prism of technology, regulation, ethics and infrastructural, is applied to the study instead of analyzing AI applications individually. This strategy allows a subtle realization of the interaction between the governance mechanisms, the quality of data and the capacity of the institution so that it governs the outcomes of real world implementation.

Third, the review clearly predicts African contextual diversity, which acknowledges disparities in healthcare infrastructures, regulatory maturity, and sociopolitical landscapes of different areas. Such context-sensitive analysis enhances applicability of the findings by policy makers, regulators and other stakeholders in the healthcare industry who are interested in developing sustainable and equitable AI-enabled pharmaceutical systems.

Lastly, by determining the barriers to implementation and enabling factors, the review provides actionable insights that can be used in future research as well as policy harmonization activities and capacity-building opportunities to realize the responsible and inclusive adoption of AI in African drug delivery systems.

4.3. Challenges and Future Directions

Although the application of artificial intelligence-based healthcare technologies is becoming increasingly popular, several obstacles still limit their successful use in the African context. The insufficiency of high-quality information, including local representatives of the health and pharmaceutical world, can be regarded as one of the most persistent issues since it lowers the credibility of AI-based drug delivery and clinical decision-support systems. Scalability and long-term sustainability is further limited by infrastructural inequalities (poor digital connectivity, disjointed health information systems, and poor computational capacity). Besides, regulatory and data governance systems in the majority of African countries are underdeveloped and it is not clear how to hold accountable, make patients give their consent, and use sensitive health and medication information responsibly. A closer focus on national data governance systems relative to the African Union Convention on Cyber Security and Personal Data Protection and digital health infrastructure investment and workforce capacity building should be among the priorities in future directions. To determine the real patient outcomes of AI-based drug delivery systems, implementation-based and longitudinal studies are needed. The locally-contextualised ethical principles and harmonisation of cross-country policies will require more attention to ensure the fair and responsible use of AI in the different African medical systems.

5. Conclusions

This systematic review shows that artificial intelligence has a great potential in revolutionizing health care delivery in Africa, especially via AI-based drug delivery solutions and data-driven clinical decision-making. The examples suggest that AI has the potential to contribute to more accurate diagnosis, treatment, pharmaceutical workflows, and easier access to healthcare in low-resource settings. Nevertheless, the results also provide emphasis on the fact that technological innovation is not enough to make an impact sustainable. Effective data governance models, ethical control systems, and regulatory capacity are essential facilitators of fair and secure AI implementation in healthcare. The articles reviewed highlight the need to have national AI plans, coordinated governance frameworks, and specific investments in digital infrastructure and human capital. This is necessary to avoid the continuation of the current health inequities by eliminating the endemic challenges associated with data quality, bias, privacy and institutional capacity. Finally, the effective adoption of AI in African healthcare is possible through the responsible implementation of AI that operates through transparency, inclusivity, and patient trust as AI-driven innovations can deliver meaningful contributions to better health outcomes among different populations.

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