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MAPPING THE LANDSCAPE OF ARTIFICIAL INTELLIGENCE IN SURGICAL PRACTICE IN AFRICAN HEALTHCARE SYSTEMS

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ABSTRACT

Background: **Artificial intelligence is transforming surgical practice globally, yet African healthcare systems demonstrate limited adoption. This review examines the use of AI in African surgical practice.**
Methods: **We searched PubMed Central, Google Scholar, MEDLINE, for peer-reviewed papers addressing AI in surgery from 2014 to 2024, focusing on studies relevant to African contexts.**
Results: **Of the 48 papers included, only 8 studies (16.67%) directly explored AI use in surgical applications across Africa. South Africa contributed 6 studies (75%), with minimal representation from other African countries. Current applications focus primarily on diagnostic AI tools rather than comprehensive surgical integration. We identified major barriers, including inadequate infrastructure, high implementation costs, data scarcity, and insufficient regulatory frameworks.**
Conclusions: **AI adoption in African surgery remains nascent and geographically concentrated. Strengthening infrastructure, capacity, and policies could accelerate implementation and enable Africa to contribute to global surgical AI innovation.**

INTRODUCTION

Artificial intelligence (AI) is revolutionizing surgical practice globally, significantly reshaping how surgeons manage patient care throughout all phases: preoperative planning, intraoperative decision-making, and postoperative follow-up [1,2] Machine learning algorithms now assist with surgical risk prediction and forecasting postoperative outcomes, guiding surgical planning and enhancing postoperative care across various specialties [3]

However, various challenges continue to hinder broader adoption of surgical AI across Africa. Weak Information and Communication Technology (ICT) infrastructure, limited availability of high-quality clinical data, concerns about algorithmic bias when applying Western-developed systems to African populations, and the high cost of computing resources all contribute to this slow uptake in surgical settings [1]. As a result, African surgical practice still lags behind global trends in AI integration, leading to persistent disparities in the quality and accessibility of surgical care.

To date, researchers have not conducted a comprehensive systematic review focused on AI use in African surgical practice, leaving policymakers without the evidence-based guidance necessary for strategic decision-making. We find this research gap particularly concerning, given Africa's unique healthcare challenges and heterogeneous technological infrastructure, which often demand context-specific solutions rather than direct adoption of Western-developed systems.

In this clinical review, we address three key research questions: the current state of AI implementation in African surgical practice, the barriers that hinder its widespread adoption, and how stakeholders can overcome these obstacles to ensure equitable access to AI-driven surgical care.

We analysed existing AI applications in African surgery, mapped the geographic distribution of current research, identified persistent implementation barriers, and proposed targeted, evidence-informed strategies to facilitate the sustainable and inclusive integration of AI technologies across the continent.

METHODOLOGY

In this narrative review, we explored the current landscape of artificial intelligence applications in surgical practice across Africa through a comprehensive examination of existing literature. Our approach involved searching multiple electronic databases including PubMed Central, Google Scholar and MEDLINE to identify relevant publications from January 2014 to December 2024. Our strategy combined Boolean operators and Medical Subject Headings (MeSH) where applicable, using the following terms either singly or in combination: Artificial Intelligence, Healthcare, Medicine, Surgery, and Africa.

We included peer-reviewed studies that focused on the use of AI within surgical practice, which demonstrated contextual relevance to Africa. Only studies published in English, that presented original data or comprehensive insights into healthcare AI

implementation were considered. We excluded conference abstracts, editorials, commentaries, and papers that only mentioned Africa superficially or lacked a specific focus on surgery.

We extracted key information from the selected studies, including country of origin, AI technology used, surgical domain of application, implementation setting, reported outcomes, and identified challenges. We synthesized these data thematically to map the landscape of AI in African surgical practice, highlighting geographical trends, uncovered barriers to implementation, and generated evidence-based recommendations for future integration.

We applied SANRA quality assessment to address methodological rigor concerns. The moderate quality scores (mean: 8/12) reflect the emerging nature of surgical AI research in Africa and highlight the need for more methodologically robust studies in this field.

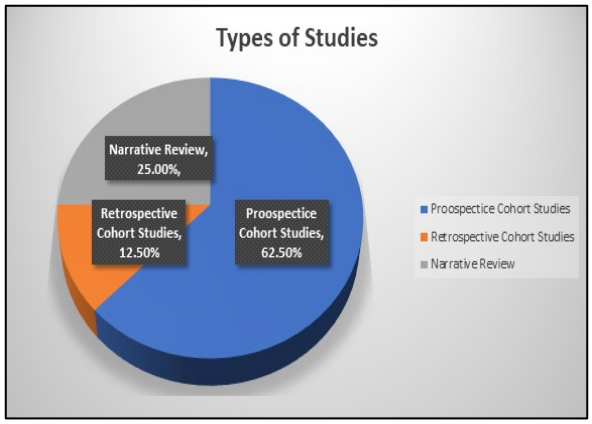
RESULTS

We reviewed a broad set of peer-reviewed articles published between 2014 and 2024 that explored the use of AI in African healthcare. While these studies addressed a range of applications including diagnostics, patient monitoring, and treatment planning only 8 had a specific focus on surgical diagnosis, intraoperative decision-making, or postoperative follow-up. This small number stands out and highlights a clear gap in the research on how AI is being used to support surgical care across the continent.

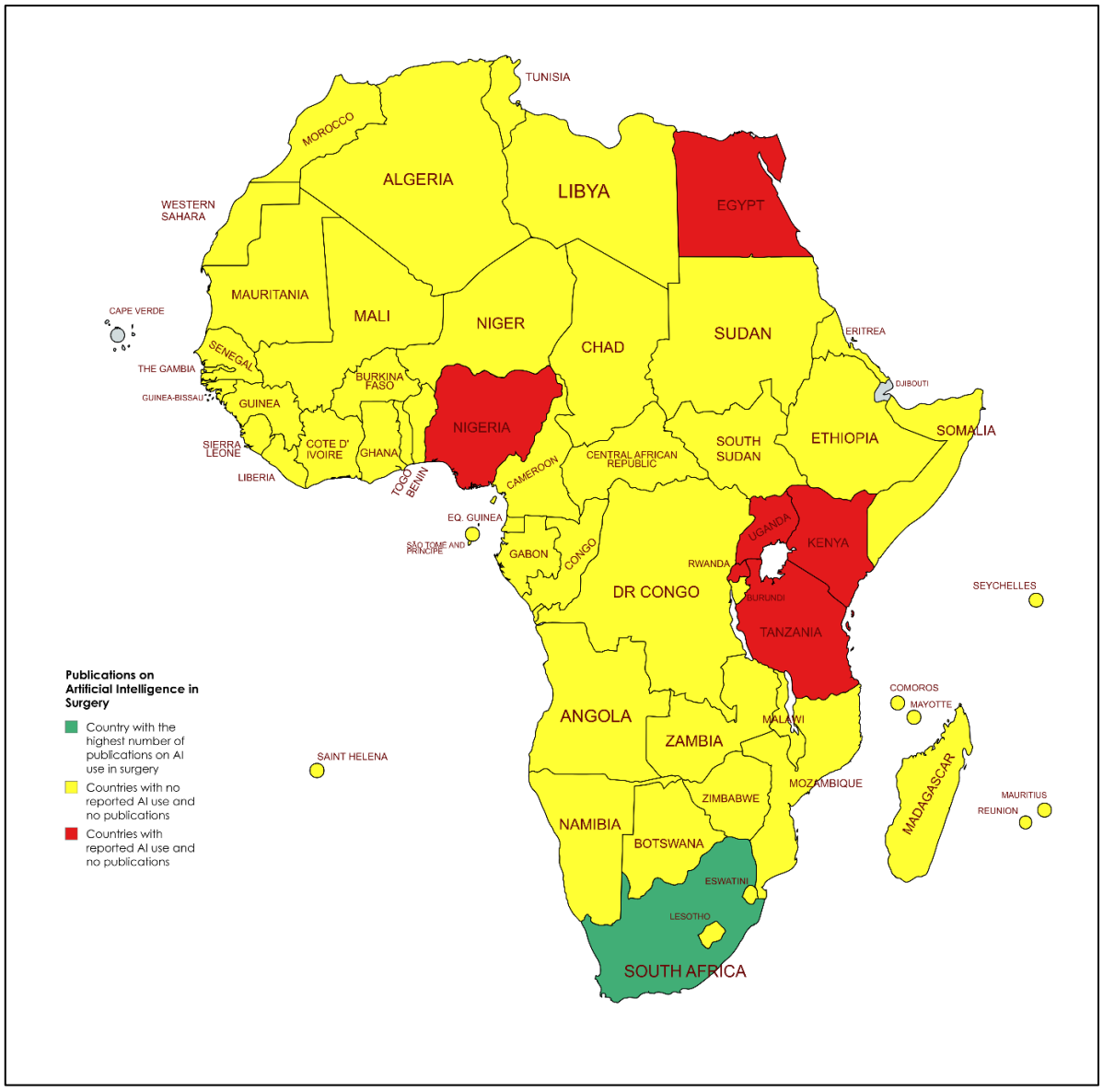
Of these 8 surgical studies, six were conducted in South Africa, while the remaining two referenced Egypt as a leader in AI-driven surgical care. The research designs varied, with most being prospective cohort studies, and a few taking a narrative approach. Some studies also mentioned AI applications in countries like Nigeria, Kenya, Rwanda, Uganda, and Tanzania, though these mentions were brief and lacked detail.

AI was shown to be applied at different stages of the surgical process. Preoperatively, three studies used machine learning to interpret radiological images and clinical data to help diagnose conditions such as breast cancer, colorectal cancer, and paediatric hydronephrosis. Intraoperatively, robot-assisted surgery emerged as the most common AI-based intervention, particularly in South Africa and Egypt. Surgeons in these countries reported benefits like smaller incisions and reduced hospital stays. Postoperative use of AI included predicting cancer recurrence and estimating hospital stay lengths based on patient-specific factors.

It is important to note that we did not assess the quality or risk of bias of the included studies, which limits how strongly these findings can be interpreted. Still, the available evidence suggests growing interest and emerging applications of AI in surgical care though currently concentrated in a few countries and focused areas.



(Figure 1: Distribution of study types included in the review)



(Figure 2: Geographic distribution of publications across Africa)

DISCUSSION

Artificial intelligence continues to reshape surgical practice and education on a global scale, transforming workflows across the entire continuum of care from preoperative planning to postoperative follow-up [1,2]. Surgeons and researchers increasingly deploy machine learning models to interpret radiographic images, enhancing diagnostic precision and informing management strategies [2]. Additionally, predictive algorithms now integrate patient demographics and clinical parameters to forecast postoperative outcomes in various specialities, including cardiothoracic surgery, breast oncology, plastic and reconstructive surgery, and orthopaedics [4].

Orthopedic surgeons have adopted AI technologies in various aspects of musculoskeletal care, including hip fracture management, knee arthroplasty, diagnosis of prosthetic loosening, implant selection, and robot-assisted knee arthroplasty procedures [5,6]. In craniofacial surgery, researchers have developed forecasting models that utilize genetic and clinical data to predict in utero cleft formation, quantify hypernasality, and apply deep learning algorithms to identify critical surgical landmarks on facial images [6]. Postoperatively, clinicians use AI-enabled wearable devices for remote patient monitoring, as seen in mobility tracking systems designed for individuals recovering from hip arthroplasty [5].

Beyond clinical applications, AI has also transformed surgical education. Training programs now incorporate simulation models powered by AI, as well as algorithms that predict proficiency acquisition during robot-assisted surgical training. Together, these innovations contribute to a growing ecosystem of AI-augmented surgical care and learning [4].

Despite these global advancements, AI integration into surgical practice remains limited across Africa relative to other continents. Most African research focuses on diagnostic applications rather than treatment or perioperative management. This trend reflects the relative accessibility of AI-based diagnostics, which require minimal infrastructure, integrate seamlessly into existing clinical workflows, and present lower operational risk. A prominent example is the use of deep learning, particularly convolutional neural networks, for radiological interpretation and histopathological slide analysis in breast cancer diagnosis within South African healthcare settings [7,8]

A complex web of interrelated challenges continues to impede the widespread adoption of artificial intelligence in surgical practice across Africa, reinforcing a persistent cycle of technological exclusion. One of the most critical limitations lies in the scarcity of high-quality, digitized electronic health records. Most healthcare facilities across the continent still depend heavily on handwritten clinical documentation, which restricts the availability of structured data essential for training AI systems [9]. This data deficiency raises concerns about algorithmic bias, as the majority of AI tools are developed using datasets derived from physiologically and demographically distinct populations. Applying these models to African patients without appropriate

contextual adaptation may compromise both their safety and clinical effectiveness [9].

Infrastructure deficits further exacerbate the problem. With internet penetration at only 39% and nearly half the population lacking reliable electricity, basic technological foundations remain underdeveloped [9,10]. These constraints are particularly acute in healthcare settings, where only 30% of hospitals maintain dependable power supply [9,10]. AI systems, which depend on stable electricity and internet connectivity for deployment and functionality, struggle to gain a foothold in such environments. Financial barriers also limit adoption. The high costs of AI implementation, ranging from data annotation at approximately $6.40 per image to annual computing infrastructure expenses of $10,000–$30,000, place these technologies out of reach for many healthcare systems [9]. In addition, the absence of robust legal and regulatory frameworks governing AI use further disincentivizes adoption, as clinicians and institutions remain uncertain about issues related to data governance, liability, and ethical compliance [9].

Our review of the current research landscape reveals considerable geographical disparities in AI healthcare scholarship across the continent. South Africa leads by a substantial margin, contributing 350 AI-related healthcare publications, compared to 77 from Nigeria and 49 from Kenya [11]. Other contributors include Uganda with 29 publications, Ghana 25 publications, Ethiopia 22 publications, Tanzania 17 publications, Egypt 10 publications, and Mali 11 publications while Cameroon, Botswana, Malawi, and Morocco each account for 8 publications respectively [11]. South Africa also dominates the niche field of AI in surgery, accounting for 6 of the 8 studies identified in our review.

South Africa's leadership in AI innovation and deployment stems largely from its well-established infrastructure. By 2023, internet access reached 75.7% of the population, and electricity coverage rose to 86.5% by 2022 [12–14]. The World Bank awarded the country a data infrastructure score of 85.0 out of 100 in 2023, and it holds the highest ranking among African nations on the Global Index on Responsible AI, reflecting its sophisticated statistical capabilities and strong governance frameworks [14]. A 185% increase in AI-related publications, the founding of institutions such as the Centre for AI Research (CAIR), and sustained public investment and government funding constitute 56.3% of all national AI R&D expenditure and have further strengthened South Africa's AI ecosystem [14]. With a projected AI market value of US$2.35 billion and growing international visibility, exemplified by its leadership role in the 2025 G20 Presidency and the AI Action Taskforce, South Africa has positioned itself as the continent's primary hub for AI innovation and implementation [14].

The global distribution of AI-related healthcare publications continues to reflect pronounced disparities between high-income and developing countries. As of 2023, the United Kingdom leads the field with 1,391 publications, followed closely by the United States with 1,343 [10]. South Africa, although ranked third globally with 350

publications, still trails significantly behind these frontrunners. Other countries rounding out the top ten include Australia (291), Germany (260), the Netherlands (227), Spain (208), Canada (198), Switzerland (184), and China (179), underscoring the substantial publication gap between African and non-African nations [11].

This discrepancy also emerges in institutional contributions to the literature. Harvard University leads with 143 AI healthcare publications, followed by several prominent UK institutions: the University of London (124), University College London (116), and the University of Edinburgh (107) [11]. The University of Cape Town is the only African institution to appear among the top ten globally, with 73 publications, highlighting Africa's limited institutional visibility in the global AI healthcare research ecosystem [2].

Funding patterns further reinforce this imbalance. Major international bodies including the Medical Research Council (UK), the Wellcome Trust, and various U.S. National Institutes of Health (NIH) entities serve as the primary sponsors of AI healthcare research in Africa [11]. While such external funding has enabled important advancements, it may also shape research priorities and constrain the growth of autonomous, locally led innovation across the continent.

In our review, we identified two South African studies that explored the application of artificial intelligence and machine learning algorithms in postoperative care. These studies employed logistic regression and naïve Bayes models to analyze patient demographics and clinical parameters, enabling predictions of hospital length of stay and cancer recurrence after surgery [15]. Outside Africa, researchers have increasingly incorporated large language models such as ChatGPT and Gemini into plastic and reconstructive surgery practice. These models offer patients timely, accurate information on cosmetic procedures particularly after hours helping address informational gaps and improving patient engagement [16].

In parallel, AI-supported continuous vital sign monitoring (CVSM) has emerged as a promising tool for reducing the risk of severe postoperative complications, which occur in 10–30% of patients. Aasvang et al. demonstrated that AI-enabled CVSM detects subtle deviations in patient vital signs more effectively than manual intermittent methods, while rule-based alert systems mitigate alarm fatigue among clinical staff [17]. Early evidence suggests that CVSM can support earlier detection of complications and reduce healthcare provider workload, offering a valuable adjunct to traditional postoperative care [17].

Our clinical review highlights both the promise and the challenges of integrating artificial intelligence into surgical practice in Africa. Despite the transformative potential, we identified a notable research gap: only a small fraction of studies directly examines AI applications in surgery, and most of this research activity remains concentrated in South Africa. While some advancements have occurred in the development of diagnostic AI tools and the adoption of robotic-assisted surgery, the broader

integration of AI into surgical workflows continues to face considerable barriers. These include infrastructural deficits, limited availability of high-quality clinical data, high implementation costs, and underdeveloped regulatory frameworks.

To overcome these obstacles, stakeholders must prioritize the development of digital infrastructure, strengthen local research capacity, and design AI systems that reflect the continent's unique demographic and disease profiles. Efforts should also focus on creating sustainable financing mechanisms, establishing harmonized legal and ethical guidelines, and scaling up successful digital health models to support AI deployment in surgical care. By fostering collaborative regional networks and investing in capacity building, African healthcare systems can unlock the full potential of AI in surgery. Over the next decade, these initiatives could significantly enhance surgical outcomes, improve health system resilience, and position Africa as a meaningful contributor to global AI innovation in resource-constrained settings.

FUTURE PROSPECTS

African healthcare systems possess the potential to significantly advance surgical artificial intelligence (AI) over the next decade, provided they address critical gaps in infrastructure, research capacity, and regulatory frameworks. Recent developments highlight this potential: South Africa achieved 76% internet penetration, and Ghana reached 86.4% electricity coverage [11,12]. However, the continent-wide average of only 39% internet penetration underscores the urgent need for policy interventions to close the digital divide affecting surgical departments and operating theaters.

To expand surgical AI beyond a few geographic and institutional centers, researchers must develop mobile-compatible, low-bandwidth applications that align with existing surgical workflows. Simultaneously, they must address the severe shortage of locally generated, high-quality surgical datasets, which currently limits the effectiveness of AI tools across diverse African surgical populations.

Financial and regulatory barriers remain key challenges that require continent-wide coordination. African academic institutions particularly universities in Nigeria, Kenya, Uganda, and Ghana have the potential to expand surgical AI research output provided they invest in surgical research capacity and build collaborative networks focused on perioperative applications. These networks could support the development of algorithms tailored to local surgical disease burdens, operative workflows, and demographic characteristics.

Infrastructure developers must accelerate investments in 5G connectivity and decentralized renewable energy systems to support real-time surgical telemonitoring, intraoperative decision support, and cloud-based preoperative planning. These advancements require urgent resolution of foundational challenges, such as the fact that only 30% of hospitals currently have reliable electricity for continuous surgical operations [10]

Strategic partnerships among African governments, international funders such as Innovation in Global Surgery, and private technology firms will be essential for scaling AI integration in surgical practice. If effectively coordinated, these efforts could result in an increase in surgical AI research output and the establishment of specialized surgical AI research centers. Through such investments, African researchers and clinicians can emerge as global leaders in implementing surgical AI in resource-constrained environments.

Recommendations

To translate the promise of surgical artificial intelligence (AI) into measurable progress across African health systems, we propose the following short-, medium-, and long-term strategies:

Short-Term (1–3 years)

We recommend developing AI-based personalized training modules tailored specifically for African surgical trainees. These modules should incorporate data from both simulations and live procedures to provide real-time, adaptive feedback. This approach addresses the shortage of specialized surgical training programs and complements existing regional initiatives in simulation-based education.

We urge African surgeons and trainees to document and publish their experiences with AI applications, including case reports, implementation studies, and clinical outcome research. To address limited African representation in global AI research, academic institutions and professional bodies should incentivize publication through CPD-linked rewards, subsidized access to journals, and opportunities for regional conference participation.

Medium-Term (3–5 years)

We recommend expanding investment in collaborative, locally led surgical AI research through platforms such as Innovation in Global Surgery and the African Institute for Development Policy (AFIDEP). These partnerships should focus on contextually relevant surgical AI solutions addressing Africa's health system realities, including trauma burden, infrastructure variability, and perioperative resource constraints. The current predominance of AI research in diagnostics highlights the need to advance AI in surgical treatment and perioperative care.

Long-Term (5+ years)

Establishing robust ethical and regulatory frameworks is imperative. As AI begins to influence clinical decisions and operative workflows, clarity on liability, data privacy, and patient safety must be ensured. Surgical associations like the College of Surgeons of East, Central, and Southern Africa (COSESCA) should lead guideline development, while African Union member states work toward harmonizing regulations and building regulatory capacity. Our review found the absence of such frameworks to be a major barrier to AI adoption.

Finally, broad-based capacity-building and policy dialogue are crucial for long-term success. Stakeholders should organize workshops, seminars, and forums highlighting successful African surgical AI

use cases and outlining practical implementation roadmaps. These initiatives will foster a collaborative ecosystem of clinicians, technologists, and policymakers, ensuring sustainable advancement of AI-enhanced surgical care.

Contributors credit statement:

F. M. Ndolo, and L. M. Ngari jointly conducted the literature search, data extraction, analysis, and manuscript preparation. M.A Magoha supervised the project, provided methodological guidance, and critically reviewed the manuscript. All authors approved the final version.

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