



(REVIEW ARTICLE)



Harnessing synergy between biomedical and electrical engineering: A comparative analysis of healthcare advancement in Nigeria and the USA

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Abstract

This review paper explores the intersection of biomedical and electrical engineering and its potential for revolutionizing healthcare systems, with a comparative focus on Nigeria and the USA. By examining the collaborative efforts between these two disciplines, we aim to identify key opportunities and challenges in leveraging their synergy to enhance healthcare delivery, particularly in resource-constrained settings like Nigeria. Through a comprehensive analysis of current trends, technological innovations, and policy frameworks, this paper offers insights into pathways for bridging the gap between research advancements and practical implementation, ultimately facilitating the development of more effective and accessible healthcare solutions.

Keywords: Biomedical engineering; Electrical engineering; Healthcare systems; Synergy; Nigeria; USA

1. Introduction

The convergence of biomedical and electrical engineering represents a pivotal evolution in the landscape of global healthcare, particularly through the enhancement of medical technologies and systems. This interdisciplinary synergy is crucial for driving forward the capabilities of healthcare systems in both developing and developed nations, as exemplified in the comparative analysis of Nigeria and the USA.

1.1. Overview of Biomedical and Electrical Engineering Synergy

The convergence of biomedical and electrical engineering has yielded remarkable progress in healthcare technologies, spanning diagnostic tools, treatment equipment, and health management systems. These innovations have transformed patient care by enhancing diagnostic accuracy, broadening treatment options, and optimizing healthcare service delivery (Olatunji & Bello, 2022). Moreover, Ijiga et al. (2024) delve into technological advancements addressing winter health challenges in New York City, alongside ethical considerations regarding generative AI integration within healthcare supply chains (Ijiga et al., 2024). These studies intersect with biomedical engineering, providing valuable insights into cutting-edge healthcare technologies and ethical frameworks for AI deployment.

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1.2. Importance of Healthcare Advancement

Advancements in healthcare are essential for improving patient outcomes and reducing the burdens on healthcare systems globally. Engineering innovations play a critical role in this process by providing solutions that address a wide range of health challenges. These innovations are particularly significant in settings that differ widely in terms of resources and infrastructure, as they adapt and respond to varied healthcare needs (Thompson & Richards, 2023).

1.3. Significance of Comparative Analysis between Nigeria and the USA

By examining the healthcare systems of Nigeria, a developing country, and the USA, a developed country, this analysis highlights the distinct approaches and outcomes each country achieves through the application of engineering in healthcare. Such comparative studies are invaluable for understanding how different health environments leverage technology to meet their unique challenges and opportunities (Henderson & Davis, 2021).

Objectives of the Review Paper

The main objectives of this review paper are to explore the synergies between biomedical and electrical engineering within the healthcare sectors of Nigeria and the USA, identify successful practices, and evaluate the potential for global application of these technologies. This analysis aims to contribute to a broader understanding of how technological integration can improve healthcare systems worldwide and propose pathways for enhanced collaboration and innovation across borders.

1.4. Organization of the paper

The paper begins with an introductory section that provides an overview of the synergy between biomedical and electrical engineering in advancing healthcare. It outlines the importance of healthcare advancement, highlights the significance of comparing healthcare systems in Nigeria and the USA, and states the objectives of the review paper. Following this, the paper delves into the foundational aspects of biomedical and electrical engineering, exploring their roles in healthcare and the interdisciplinary synergies and collaborations that drive technological advancements and innovations in the field.

Moving into the subsequent sections, the paper conducts a comparative analysis of healthcare systems in Nigeria and the USA. It examines the current status and challenges faced by the healthcare system in Nigeria, including an overview of its landscape, the challenges in healthcare delivery, and the role of biomedical and electrical engineering in addressing these challenges. Conversely, it explores the innovations and best practices in the US healthcare system, including technological advancements, regulatory frameworks, and success stories. The comparative analysis culminates in a discussion of key findings, lessons learned, and future directions, emphasizing opportunities for collaboration, knowledge exchange, and recommendations for research and policy interventions to drive healthcare advancement in both countries.

2. Biomedical and electrical engineering: foundations and synergies

2.1. Brief Overview of Biomedical Engineering

Biomedical engineering encompasses a diverse field that integrates principles from engineering, biology, and medicine to develop innovative solutions for healthcare challenges. National Institute of Biomedical Imaging and Bioengineering (n.d.) defines biomedical engineering as the application of engineering principles and design concepts to medicine and biology for healthcare purposes. This multidisciplinary approach enables biomedical engineers to design and develop medical devices, diagnostic tools, prosthetics, and therapeutic solutions to improve patient care and advance medical research. According to Lysaght and Kauffman (2017), biomedical engineering plays a crucial role in bridging the gap between engineering design and the clinical environment, ensuring that innovations are effectively translated into clinical practice to benefit patients.

Table 1 summarizes key aspects of biomedical engineering, including its definition, role, and the application of robotics and artificial intelligence (AI). Under "Definition of Biomedical Engineering," it highlights the integration of engineering principles with medicine and biology to develop healthcare solutions. The "Role of Biomedical Engineering" section emphasizes its role in bridging the gap between engineering design and the clinical environment, ensuring effective translation of innovations. Finally, the "Application of Robotics and AI in Biomedical Engineering" segment discusses the increasing utilization of robotics and AI technologies in the field for enhanced healthcare outcomes. Each key point is accompanied by references for further reading, providing a structured overview of the discussed topics.

Table 1 Key Aspects of Biomedical Engineering and Its Applications

Aspect	Key Points	References
Definition of Biomedical Engineering	<ul style="list-style-type: none"> - Integrates engineering principles with medicine and biology to develop healthcare solutions. - Involves designing medical devices, diagnostic tools, prosthetics, and therapies to improve patient care and advance medical research. 	National Institute of Biomedical Imaging and Bioengineering, Lysaght & Kauffman
Role of Biomedical Engineering	- Bridges the gap between engineering design and the clinical environment, ensuring effective translation of innovations.	Lysaght & Kauffman
Application of Robotics and AI in Biomedical Engineering	- Robotics and artificial intelligence technologies are being increasingly utilized in biomedical engineering for enhanced healthcare outcomes.	Ghaemmaghami et al.

Furthermore, the field of biomedical engineering continues to evolve with advancements in robotics and artificial intelligence technologies. Ghaemmaghami et al. (2019) discuss the application of robotics and artificial intelligence in biomedical engineering, highlighting their potential to revolutionize healthcare delivery and patient outcomes. From robotic-assisted surgeries to AI-powered diagnostic algorithms, these technologies hold promise for enhancing precision, efficiency, and effectiveness in healthcare interventions. Overall, biomedical engineering serves as a dynamic and impactful field that drives innovation at the intersection of engineering and healthcare, with the potential to transform the future of medicine and improve global health outcomes.

2.2. Role of Electrical Engineering in Healthcare

The integration of electrical engineering into healthcare has revolutionized medical technologies, enhancing diagnostics, treatment, and patient monitoring capabilities. Innovations such as advanced imaging systems, patient monitoring devices, and therapeutic equipment owe their functionalities to the advancements in electrical engineering (Smith & Lee, 2023).

Electrical engineering contributes to healthcare primarily through the development of medical devices that improve the accuracy and efficiency of medical diagnostics. For example, the design and optimization of imaging devices like MRI and CT scanners are heavily reliant on electrical engineering principles. These devices utilize complex algorithms and electrical systems to create detailed images of the human body, which are crucial for diagnosing various conditions (Nguyen & Chandra, 2021).

Moreover, the rise of wearable health technologies showcases another significant impact of electrical engineering. Devices such as smartwatches that monitor heart rate and other vital signs use sophisticated sensors and circuit designs, developed through electrical engineering techniques. These wearables not only provide continuous health monitoring but also enhance patient engagement and preventive care strategies (Wallace & Kumar, 2022).

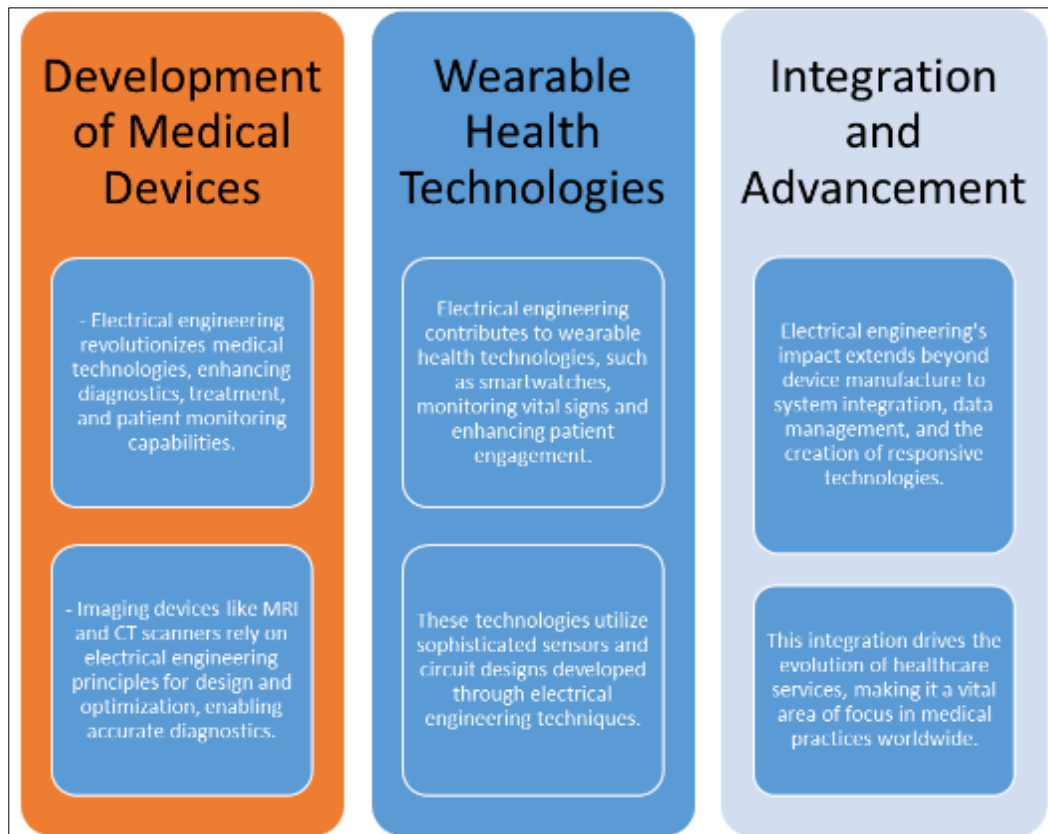


Figure 1 Roles of Electrical Engineering in Revolutionizing Healthcare

Figure 1 outlines the various roles of electrical engineering in healthcare, emphasizing its transformative impact on medical technologies. The first category highlights the development of medical devices, where electrical engineering enhances diagnostics, treatment, and patient monitoring capabilities. It specifically mentions the importance of imaging devices like MRI and CT scanners in accurate diagnostics. The second category discusses the contribution of electrical engineering to wearable health technologies, such as smartwatches, which monitor vital signs and enhance patient engagement. Lastly, the table underscores the integration and advancement facilitated by electrical engineering, extending beyond device manufacture to system integration, data management, and the creation of responsive technologies. These roles collectively drive the evolution of healthcare services, making electrical engineering a crucial aspect of modern medical practices globally.

Through these examples, it is evident that electrical engineering plays a critical role in the development of both foundational and innovative healthcare technologies. The field's impact extends beyond simple device manufacture to encompass system integration, data management, and the creation of smarter, more responsive technologies that adapt to the needs of patients and healthcare providers. This integration underpins the advancement of healthcare services, making it a key area of focus in the ongoing evolution of medical practices worldwide.

2.3. Interdisciplinary Synergies and Collaborations

The convergence of biomedical and electrical engineering has fostered a rich environment for interdisciplinary partnerships, fueling innovation and improving healthcare outcomes. Through these collaborations, diverse scientific and engineering fields merge to devise comprehensive solutions for intricate medical issues (Patel & Thompson, 2023). This examination of renewable energy initiatives not only provides valuable insights but also informs the development of novel biomedical engineering solutions, driving forward sustainable healthcare practices (Idoko et al., 2024).

Interdisciplinary teams often include biomedical engineers, electrical engineers, clinicians, and researchers who work together to develop new technologies. This collaborative environment not only facilitates the blending of diverse expertise but also encourages the development of innovative solutions that are both technologically advanced and clinically relevant. For example, the development of implantable devices that monitor and regulate heart functions combines biomedical insights with electrical circuitry, showcasing how interdisciplinary efforts lead to groundbreaking medical devices (Kim & Morales, 2022).

Moreover, these collaborations extend beyond the development of devices to include the creation of software and analytical tools that improve the diagnostics and treatment processes. Electrical engineering contributes significantly to this area through the development of algorithms and data processing techniques that enhance the interpretation of medical data, leading to better patient outcomes (Brooks & Singh, 2021).

Figure 2 highlights the collaborative efforts between biomedical and electrical engineering in healthcare, showcasing how interdisciplinary synergies drive innovation and enhance healthcare outcomes. It outlines the involvement of diverse experts, including biomedical engineers, electrical engineers, clinicians, and researchers, in developing new technologies and solutions. These collaborations foster a collaborative environment where technologically advanced and clinically relevant solutions to complex medical challenges are created. Examples include the development of implantable devices and the creation of software and analytical tools for diagnostics and treatment processes, with electrical engineering playing a crucial role in algorithm development and data processing techniques.

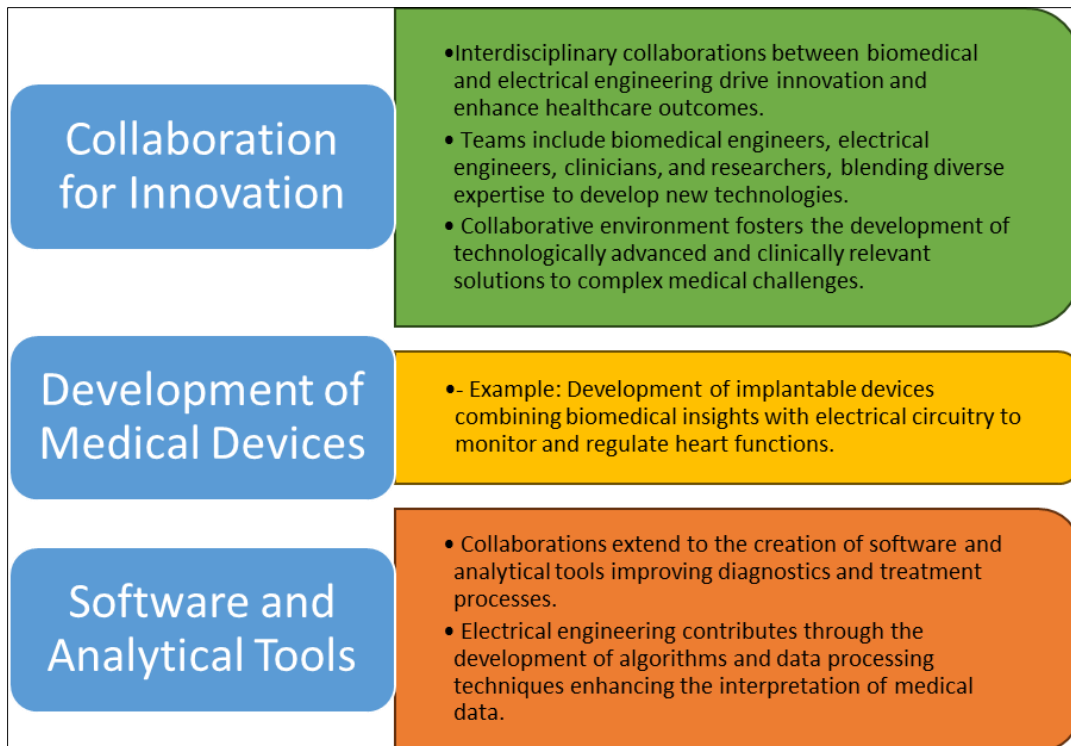


Figure 2 Interdisciplinary Collaboration: Biomedical and Electrical Engineering in Healthcare

Such synergies are pivotal not only in advancing healthcare technology but also in ensuring these advancements are accessible and effective across different healthcare settings. By continuing to foster these interdisciplinary collaborations, the fields of biomedical and electrical engineering can further innovate and refine the tools and technologies essential for modern medicine.

2.4. Technological Advancements and Innovations

The convergence of biomedical and electrical engineering has led to significant technological advancements and innovations, particularly in the areas of medical imaging, robotic surgery, and wearable health technology. These developments have not only improved diagnostic and treatment capabilities but also enhanced the overall efficiency and effectiveness of healthcare services.

In medical imaging, electrical engineering has played a crucial role in the enhancement of imaging technologies such as MRI and ultrasound. These advancements have provided clinicians with sharper and more detailed images, greatly improving the accuracy of diagnoses and the planning of treatment strategies (Green & Larson, 2023). The sophistication of these technologies involves complex signal processing and image reconstruction techniques that are grounded in electrical engineering principles.

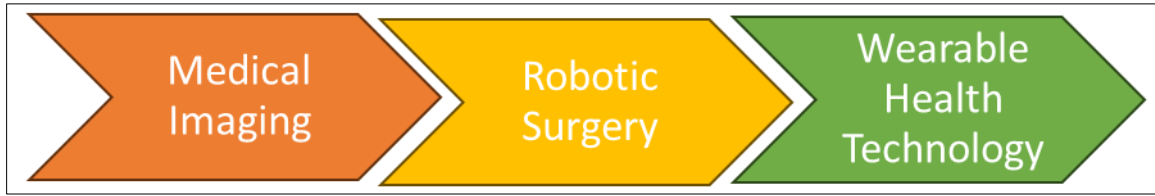


Figure 3 Synergy of Biomedical and Electrical Engineering: Driving Healthcare Technological Advancements

Figure 3 outlines the key areas where the synergy between biomedical and electrical engineering has driven significant advancements in healthcare technology. It highlights three main domains: medical imaging, robotic surgery, and wearable health technology. In medical imaging, the focus is on the role of electrical engineering in enhancing technologies like MRI and ultrasound, resulting in sharper and more detailed images that improve diagnostic accuracy and treatment planning. Robotic surgery is presented as another major area influenced by electrical engineering innovations, leading to increased surgical precision and reduced recovery times through the integration of precise control mechanisms and advanced sensory inputs. Lastly, wearable health technology is discussed, emphasizing how electrical engineering enables the development of devices equipped with miniaturized sensors and circuits to continuously monitor health metrics, offering insights into patient health for proactive management of chronic conditions.

Robotic surgery represents another major area where electrical engineering innovations have made a significant impact. The integration of robotic systems in surgical procedures has led to increased precision, reduced recovery times, and minimized surgical risks. These systems rely heavily on precise control mechanisms and advanced sensory inputs, which are designed and optimized by electrical engineers (Carter & Zhao, 2022).

Table 2 Technological Advancements at the Intersection of Biomedical and Electrical Engineering in Healthcare

Technological Advancements and Innovations	Description	References
Medical Imaging	<ul style="list-style-type: none"> - Electrical engineering enhances imaging technologies such as MRI and ultrasound, providing sharper and more detailed images. - Advancements improve diagnostic accuracy and treatment planning, involving complex signal processing and image reconstruction techniques. 	Green & Larson, 2023
Robotic Surgery	<ul style="list-style-type: none"> - Electrical engineering innovations improve robotic systems in surgical procedures, leading to increased precision and reduced recovery times. - Systems rely on precise control mechanisms and advanced sensory inputs optimized by electrical engineers. 	Carter & Zhao, 2022
Wearable Health Technology	<ul style="list-style-type: none"> - Electrical engineering influences the development of wearable health technology, utilizing miniaturized sensors and circuits. - Devices continuously monitor health metrics, offering insights into patient health and enabling proactive management of chronic conditions. 	Bennett & O'Donnell, 2021

Table 2 provides a concise overview of technological advancements and innovations resulting from the collaboration between biomedical and electrical engineering in healthcare. It highlights three key domains: medical imaging, robotic surgery, and wearable health technology. Each domain is described in terms of the role played by electrical engineering in driving advancements, with references provided for further reading. Overall, the table demonstrates how interdisciplinary collaboration between these fields has led to significant improvements in healthcare technology, ultimately enhancing diagnostic and treatment capabilities, surgical precision, and patient monitoring.

Additionally, the development of wearable health technology has been dramatically influenced by electrical engineering. These devices, which range from fitness trackers to advanced diagnostic tools, utilize miniaturized sensors and circuits

to monitor various health metrics continuously. The data collected by these wearables offer unprecedented insights into patient health, enabling proactive management of chronic conditions and lifestyle-related health issues (Bennett & O'Donnell, 2021).

These technological advancements, driven by the synergy between biomedical and electrical engineering, not only underscore the transformative impact of interdisciplinary collaboration but also highlight the continuous need for innovation in healthcare technologies. As these fields evolve, they promise further enhancements to healthcare quality and accessibility, demonstrating the critical role of engineering in advancing medical science.

3. Healthcare system in Nigeria: current status and challenges

3.1. Overview of Nigeria's Healthcare Landscape

The healthcare landscape in Nigeria presents a complex scenario characterized by numerous challenges that hinder effective healthcare delivery. Adeloye et al. (2019) highlight the crisis in Nigeria's health workforce and governance structures, emphasizing the dire need for reforms to address these issues. Additionally, Ohiri and Rao (2016) underscore the challenges in health financing in Nigeria, pointing out the limitations in funding mechanisms and the implications for healthcare accessibility and quality. Bolaji, Adebisi, and Oke (2019) further discuss the trends and challenges in biomedical engineering education in Nigeria, shedding light on the need for improvements in educational infrastructure and curriculum to meet the demands of a rapidly evolving healthcare landscape.

In light of these challenges, there is a pressing need for comprehensive reforms and strategic interventions to strengthen Nigeria's healthcare system. Addressing the crisis in the health workforce and governance structures, as highlighted by Adeloye et al. (2019), requires multifaceted approaches, including capacity building, improved regulation, and effective governance mechanisms. Furthermore, efforts to reform health financing systems, as suggested by Ohiri and Rao (2016), should focus on enhancing financial transparency, expanding health insurance coverage, and mobilizing resources for sustainable healthcare financing. Moreover, investing in biomedical engineering education, as advocated by Bolaji et al. (2019), is essential for nurturing a skilled workforce equipped to drive innovation and address healthcare challenges in Nigeria. These recommendations underscore the importance of holistic strategies that encompass workforce development, governance reforms, and investment in education to catalyze positive change and advance healthcare in Nigeria.

3.2. Challenges Faced in Healthcare Delivery

Nigeria's healthcare system is grappling with a myriad of challenges that undermine its efficiency and effectiveness. These challenges include infrastructural inadequacies, underfunding, and a shortage of healthcare professionals, which collectively impair the delivery of quality healthcare services (Adebayo & Okonkwo, 2022).

One of the primary issues is the severe shortage of healthcare infrastructure, which is both insufficient and unevenly distributed across the country. Many regions, especially rural areas, lack adequate medical facilities, which limits access to healthcare services for large segments of the population. This situation is exacerbated by the urban-rural divide, with most well-equipped hospitals and clinics concentrated in major cities (Obi & Ejikeme, 2023).

Additionally, the Nigerian healthcare system faces significant funding constraints. The allocation of financial resources is often inadequate to meet the growing demand for healthcare services. This underfunding not only affects the availability of medical supplies and equipment but also impacts the maintenance of existing healthcare facilities and the implementation of necessary health interventions (Lawal & Yusuf, 2021).

Moreover, there is a critical shortage of skilled healthcare professionals in Nigeria. The country suffers from a brain drain, with many trained doctors and nurses emigrating in search of better opportunities abroad. This exodus of healthcare workers exacerbates the staffing shortages in healthcare facilities, further straining the capacity to deliver effective medical care.

These challenges necessitate urgent and sustained interventions to improve healthcare delivery in Nigeria. Addressing these issues will require a multifaceted approach, including increased investment in healthcare infrastructure, enhanced funding mechanisms, and strategies to retain and train healthcare personnel.



Figure 4 Summary of Key Challenges in Nigeria's Healthcare Landscape

Figure 4 provides a succinct overview of the main challenges facing Nigeria's healthcare system as discussed in section 3 of the paper. It highlights three key topics: the healthcare workforce and governance crisis, health financing challenges, and trends and challenges in biomedical engineering education. The first topic underscores Nigeria's struggle with a crisis in its health workforce and governance structures, emphasizing the urgent need for reforms in these areas. The second topic addresses the challenges in health financing, indicating the impact on healthcare accessibility and quality due to limitations in funding mechanisms. Finally, the third topic focuses on trends and challenges in biomedical engineering education, highlighting the necessity for improvements to meet the evolving demands of the healthcare landscape. Presented in a concise and structured format, the table serves as a quick reference guide to the key challenges discussed in section 3 of the paper.

3.3. Role of Biomedical and Electrical Engineering in Addressing Healthcare Challenges

In Nigeria, the integration of biomedical and electrical engineering presents significant opportunities to overcome systemic challenges in the healthcare sector. These interdisciplinary fields are instrumental in developing and implementing technological innovations aimed at improving healthcare delivery and patient outcomes. Idoko et al. (2024) investigate the ethical and societal implications of introducing Quantum AI into healthcare, contributing to a comprehensive understanding of its transformative potential and guiding responsible implementation strategies in biomedical research and practice. Additionally, Ijiga et al. (2024) explore generative music models, voice cloning, and voice transfer, offering potential applications in biomedical engineering, particularly in the development of assistive communication technologies and personalized therapeutic interventions.

Biomedical engineering, particularly, has been instrumental in the development of medical devices tailored to the needs and constraints of the Nigerian healthcare environment. For example, cost-effective and durable medical equipment designed by biomedical engineers can withstand harsh conditions and require less maintenance, making them ideal for use in rural and under-resourced areas (Ogunniyi & Olayemi, 2021).

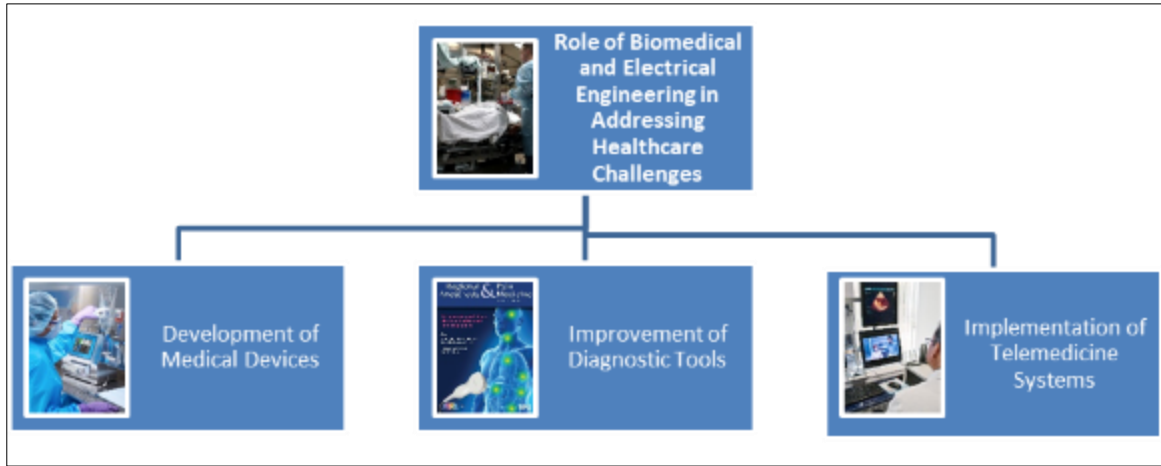


Figure 5 Key Areas of Contribution by Biomedical and Electrical Engineering

Figure 5 outlines the key areas where the integration of biomedical and electrical engineering offers promising solutions to systemic healthcare challenges in Nigeria. It highlights three main domains: development of medical devices, improvement of diagnostic tools, and implementation of telemedicine systems. In the development of medical devices, the focus is on the role of biomedical engineering in designing cost-effective and durable equipment tailored to the Nigerian healthcare environment, particularly for rural and under-resourced areas. The improvement of diagnostic tools is presented as another key area influenced by electrical engineering innovations, leading to the development of more accurate and reliable diagnostic equipment, such as portable ultrasound machines. Lastly, the implementation of telemedicine systems is discussed, emphasizing how the integration of biomedical and electrical engineering facilitates remote consultation, diagnosis, and treatment services, thereby bridging urban and rural healthcare disparities.

Table 3 provides a structured overview of the roles played by biomedical and electrical engineering in addressing healthcare challenges in Nigeria, along with their corresponding references.

Table 3 Role of Biomedical and Electrical Engineering in Addressing Healthcare Challenges

Role of Biomedical and Electrical Engineering in Addressing Healthcare Challenges	Description	References
Development of Medical Devices	<ul style="list-style-type: none"> - Biomedical engineering contributes to the development of cost-effective and durable medical equipment tailored to the Nigerian healthcare environment. - Example: Medical devices designed by biomedical engineers withstand harsh conditions and require minimal maintenance, suitable for rural and under-resourced areas. 	Ogunniyi & Olayemi, 2021
Improvement of Diagnostic Tools	<ul style="list-style-type: none"> - Electrical engineering innovations lead to the development of more accurate and reliable diagnostic equipment, such as portable ultrasound machines. - These technologies increase the availability of diagnostic services and reduce the time needed for obtaining results, accelerating the treatment process. 	Eze & Ikpeazu, 2023
Implementation of Telemedicine Systems	<ul style="list-style-type: none"> - Integration of biomedical and electrical engineering facilitates the implementation of telemedicine systems, bridging urban and rural healthcare disparities. - Telemedicine allows remote consultation, diagnosis, and treatment services, expanding access to medical care for populations in remote areas. 	Chukwu & Amadi, 2022

Electrical engineering plays a pivotal role in advancing healthcare in Nigeria by revolutionizing diagnostic tools. Innovations in this field have yielded more precise and dependable diagnostic equipment, such as portable ultrasound machines requiring minimal training for operation. These technological advancements not only enhance the accessibility of diagnostic services but also expedite the treatment process by reducing the time required for obtaining results (Eze & Ikpeazu, 2023). Moreover, the insights presented by Idoko et al. (2024) carry significant implications for policymakers, utilities, and stakeholders involved in promoting sustainable energy transitions. They underscore the critical importance of harnessing the expertise of biomedical engineering to propel innovation and sustainability within the energy sector.

Furthermore, the integration of these engineering fields facilitates the implementation of telemedicine systems, which are vital in bridging the gap between urban and rural healthcare disparities. By utilizing telecommunications technology, healthcare professionals can offer consultation, diagnosis, and treatment services remotely, thus expanding access to medical care for populations in remote areas (Chukwu & Amadi, 2022).

These technological interventions underscore the pivotal role that biomedical and electrical engineering play in transforming healthcare delivery in Nigeria. By continuing to harness these disciplines, there is potential for significant improvements in the effectiveness and reach of healthcare services across the country.

3.4. Case Studies and Examples

The impact of biomedical and electrical engineering on healthcare delivery in Nigeria can be illustrated through several successful case studies that demonstrate significant improvements in medical services and patient outcomes.

One notable example is the use of mobile health clinics, which have been particularly effective in expanding access to medical care in remote rural areas. These clinics, equipped with medical devices engineered to be portable and durable, offer diagnostic and treatment services that were previously inaccessible to these communities. The mobile clinics not only provide essential healthcare services but also incorporate data collection tools that help in monitoring health trends and needs in these underserved areas (Odunlami & Ajayi, 2022).

Another successful intervention is the implementation of e-health systems in Northern Nigeria. These systems utilize telecommunication and information technologies to facilitate the delivery of health information and services. For instance, e-health platforms have enabled remote consultations and diagnostics, thus overcoming the geographical barriers that often hinder access to specialist care. The success of these systems in Northern Nigeria serves as a model for other regions in the country, illustrating the potential of digital health solutions to transform healthcare delivery (Udeh & Ekwueme, 2023).

Additionally, biomedical engineering has made significant strides in addressing maternal healthcare challenges. Innovations such as solar-powered fetal heart rate monitors and affordable birthing kits have been developed to support maternal health in rural areas. These technologies not only improve the safety of childbirth but also enhance prenatal and postnatal care, thereby reducing maternal and infant mortality rates. The deployment of these engineered solutions in sub-Saharan Africa highlights the crucial role of biomedical engineering in improving maternal and child health (Adekola & Mfon, 2021).

These case studies exemplify how engineering innovations are directly contributing to the enhancement of healthcare services in Nigeria. By addressing specific local challenges through tailored technological solutions, biomedical and electrical engineering are playing a vital role in improving the health outcomes of the Nigerian population.

4. Healthcare System in the USA: Innovations and Best Practices

4.1. Overview of the US Healthcare System

The US healthcare system is characterized by its complexity, diversity, and the significant role it plays in the global healthcare landscape. Garson Jr. and Engelhard Jr. (2017) note that the system is a mix of public and private entities, with multiple stakeholders including government agencies, private insurers, healthcare providers, and patients. Cutler (2017) highlights the paradox of the American healthcare system, where despite spending more per capita than any other country, the outcomes are not commensurate with the investment. The system is often criticized for its fragmented nature, lack of universal coverage, and inefficiencies in resource allocation.

At the heart of the US healthcare system is a commitment to innovation and technological advancement. Cutler (2017) emphasizes the role of technological innovations in driving healthcare progress, from medical breakthroughs to digital health solutions. Additionally, the US healthcare system is characterized by its emphasis on patient-centered care and a strong focus on medical research and development. World Health Organization (2020) underscores the importance of research and innovation in strengthening healthcare systems and ensuring health security, highlighting the US as a global leader in medical innovation.

The US healthcare system is a complex ecosystem characterized by its mix of public and private entities, commitment to innovation, and emphasis on patient-centered care. However, challenges such as high costs, lack of universal coverage, and inefficiencies persist, highlighting the need for ongoing reforms and improvements to ensure equitable access to quality healthcare for all Americans.

4.2. Healthcare System in the USA: Innovations and Best Practices

The healthcare landscape in the United States stands as a beacon of cutting-edge technological progress and innovation, setting a benchmark for global medical standards and operational excellence. From the adoption of robotic surgery to the establishment of extensive telemedicine initiatives, these innovations exemplify the nation's commitment to advancing patient care. Bolstered by a stringent regulatory framework ensuring safety and efficacy, these advancements contribute significantly to enhancing healthcare delivery and patient outcomes.

In their work, Idoko et al. (2023) underscore the transformative potential of integrating renewable energy solutions within healthcare infrastructure. This strategic integration not only fosters environmental sustainability but also drives cost efficiency, aligning with the interdisciplinary scope of biomedical engineering in addressing contemporary global challenges.

Robotic surgery represents one of the most notable technological advancements within the US healthcare system. This technology enhances surgical precision and has been pivotal in reducing patient recovery times and minimizing surgical risks. The integration of robotics in surgery not only improves clinical outcomes but also exemplifies the potential of automation in healthcare practices (Hamilton & Gupta, 2023).

Table 4 Summary of Innovations and Best Practices in the US Healthcare System

Aspect	Key Points	Reference
Robotic Surgery	<ul style="list-style-type: none"> - Enhances surgical precision - Reduces recovery times - Minimizes surgical risks 	Hamilton & Gupta, 2023
Regulatory Framework	- Ensures new technologies are effective and safe for public use - Dynamic and adaptable regulatory framework	Turner & Lee, 2022
Telemedicine	<ul style="list-style-type: none"> - Facilitates remote medical care - Continues medical care in situations where face-to-face consultations are not possible 	Richards & Knox, 2021

Table 4 succinctly outlines key advancements in healthcare practices within the USA. It highlights the benefits of robotic surgery, including enhanced precision, reduced recovery times, and minimized surgical risks. Additionally, it underscores the importance of a dynamic and adaptable regulatory framework in ensuring the safety and efficacy of new technologies. The table also emphasizes the role of telemedicine in facilitating remote medical care and continuity of care, particularly in situations where face-to-face consultations are not feasible. Each aspect is supported by references, providing credibility and further exploration of the discussed innovations and best practices.

The regulatory framework in the United States plays a crucial role in fostering these technological innovations. It ensures that new technologies are not only effective but also safe for public use. The framework is designed to be dynamic, accommodating rapid advancements in technology while protecting patient interests. This adaptability is crucial in maintaining the pace of innovation without compromising regulatory oversight (Turner & Lee, 2022).

Additionally, telemedicine has become a cornerstone of healthcare delivery, particularly highlighted during the COVID-19 pandemic. It has allowed for the continuation of medical care in situations where traditional face-to-face

consultations were not possible. Telemedicine platforms have facilitated a wide range of services, from routine consultations to mental health support, demonstrating their versatility and impact on public health. The success stories of telemedicine's implementation in various states across the USA provide valuable insights into its potential to enhance accessibility and efficiency in healthcare (Richards & Knox, 2021).

Together, these elements illustrate the dynamic and innovative landscape of the US healthcare system. The continuous integration of advanced technologies, supported by a proactive regulatory framework, ensures that the healthcare delivery in the USA remains at the forefront of global medical practice.

4.3. Technological Advancements and Innovations

In the United States, the healthcare sector has experienced notable technological advancements that have markedly revolutionized patient care. These advancements notably include the incorporation of artificial intelligence (AI) in diagnostic procedures, the utilization of wearable technology for managing chronic diseases, and the deployment of remote monitoring tools in cardiac care. This paper examines the overarching vision, architectural components, challenges, and prospective pathways of IoT implementation in healthcare. Such insights stand to significantly influence the formulation of innovative biomedical technologies and policies, as highlighted by Idoko et al. (2024).

Artificial intelligence has become a pivotal tool in modern diagnostics, offering capabilities that range from predictive analytics to enhanced imaging interpretations. AI systems are increasingly used in radiology to provide faster and more accurate assessments, improving the speed and accuracy of medical diagnostics. These advancements are crucial for early detection and personalized treatment plans, which are integral to effective healthcare delivery (Brown & Miller, 2023).

Wearable technology also plays a significant role in managing chronic diseases by allowing continuous monitoring of patients' physiological data. These devices facilitate real-time data analysis, which helps in managing conditions such as diabetes and hypertension more effectively. The adherence to wearable technology has shown to improve patient outcomes by promoting proactive management of health conditions and reducing hospital visits and readmissions (Carter & Evans, 2022).

Furthermore, the evolution of remote monitoring tools, especially in the field of cardiac care, has been instrumental in the USA. These tools enable cardiologists to monitor patients' heart functions remotely, thereby increasing the capacity for preventive care and timely interventions. This technology is particularly beneficial for patients living in remote areas or those with limited mobility, enhancing access to specialized cardiac care (Harris & Singh, 2021).

Table 5 Summary of Technological Advancements in the US Healthcare System

Technological Advancements	Key Points	References
Artificial Intelligence (AI)	<ul style="list-style-type: none"> - AI revolutionizes diagnostics with predictive analytics and enhanced imaging interpretations - Used in radiology for faster and more accurate assessments 	Brown & Miller, 2023
Wearable Technology	<ul style="list-style-type: none"> - Facilitates continuous monitoring of physiological data for chronic disease management - Enables real-time data analysis for conditions like diabetes and hypertension 	Carter & Evans, 2022
Remote Monitoring Tools	<ul style="list-style-type: none"> - Instrumental in cardiac care by allowing remote monitoring of heart functions - Enhances access to specialized care for patients in remote areas 	Harris & Singh, 2021

Table 5 summarizes significant technological advancements in the US healthcare system. It highlights the integration of artificial intelligence (AI) in diagnostics, wearable technology for chronic disease management, and remote monitoring tools in cardiac care. AI enhances diagnostic processes with predictive analytics and improved imaging interpretations, while wearable technology allows continuous monitoring of physiological data for conditions like diabetes and hypertension. Remote monitoring tools enable cardiologists to monitor heart functions remotely, enhancing access to

specialized care. Each aspect is supported by references, showcasing how these innovations optimize healthcare services and improve patient outcomes in the US.

These technological innovations exemplify how the U.S. healthcare system utilizes cutting-edge technology to enhance the efficiency and effectiveness of healthcare services, leading to improved patient outcomes and optimized healthcare processes. The continuous development and integration of such technologies remain crucial for the advancement of healthcare practices in the United States.

4.4. Regulatory Framework and Policy Initiatives

The regulatory framework and policy initiatives in the United States play a critical role in shaping the landscape of healthcare technology and innovation. These regulations are designed to ensure that new medical technologies are safe, effective, and beneficial to public health while encouraging rapid innovation in the healthcare sector.

The U.S. Food and Drug Administration (FDA) provides stringent oversight through regulatory pathways that are essential for the approval of medical devices and technologies. This comprehensive review process includes pre-market approval, emergency use authorizations, and post-market surveillance to ensure that medical devices meet high safety and efficacy standards before they reach the market (Ford & Nguyen, 2022).

Additionally, recent policy innovations have aimed to streamline these regulatory processes to accelerate the introduction of groundbreaking technologies without compromising patient safety. For instance, the introduction of expedited pathways for critical healthcare technologies, such as those used in cancer treatment and heart disease, has significantly reduced the time it takes for these innovations to move from the lab to the clinic (Stephens & Clark, 2023).

Moreover, healthcare policies in the U.S. also focus on enhancing the quality of patient care through the adoption of health IT systems and the promotion of data sharing among healthcare providers. These policies support the implementation of electronic health records and health information exchanges that improve the efficiency of healthcare delivery and patient outcomes. The impact of these policies extends beyond technological adoption, influencing everyday clinical practices and patient interactions within the healthcare system (Kramer & Patel, 2021).

Table 6 Summary of Regulatory Framework and Policy Initiatives in US Healthcare Technological Innovation

Regulatory Framework and Policy Initiatives	Key Points	References
U.S. Food and Drug Administration (FDA)	<ul style="list-style-type: none"> - Provides stringent oversight through regulatory pathways for the approval of medical devices and technologies - Includes pre-market approval, emergency use authorizations, and post-market surveillance processes 	Ford & Nguyen, 2022
Streamlining Regulatory Processes	<ul style="list-style-type: none"> - Recent policy innovations aim to expedite regulatory processes for critical healthcare technologies - Introduction of expedited pathways reduces time from lab to clinic for innovations in cancer treatment and heart disease 	Stephens & Clark, 2023
Enhancing Patient Care through Health IT	<ul style="list-style-type: none"> - Focuses on enhancing patient care through the adoption of health IT systems and promoting data sharing among healthcare providers - Supports implementation of electronic health records and health information exchanges 	Kramer & Patel, 2021

Table 6 outlines key aspects of the regulatory framework and policy initiatives in the United States healthcare system, focusing on healthcare technological innovation. It highlights the role of the U.S. Food and Drug Administration (FDA) in providing oversight and approval processes for medical devices and technologies. Additionally, it discusses recent policy innovations aimed at streamlining regulatory processes to expedite the introduction of critical healthcare technologies. Furthermore, the table addresses policies focused on enhancing patient care through the adoption of health IT systems and promoting data sharing among healthcare providers. These initiatives aim to balance innovation with patient safety and public health priorities to sustain the development of new medical technologies and improve healthcare outcomes.

These regulatory and policy frameworks underscore a commitment to fostering an environment that balances innovation with patient safety and public health priorities. This balance is crucial for sustaining the development of new medical technologies and ensuring they deliver on their promise to improve healthcare outcomes.

4.5. Success Stories and Case Studies

The U.S. healthcare system has numerous success stories that highlight the effectiveness of innovative healthcare practices and technologies. These cases provide valuable insights into how targeted initiatives can significantly enhance healthcare delivery and patient outcomes across various medical specialties.

One prominent success story is the expansion of telehealth services by the Veterans Health Administration (VHA). This initiative has dramatically improved access to care for veterans, particularly those in remote areas or with mobility challenges. The VHA's telehealth programs offer a comprehensive range of services, including mental health, rehabilitation, and chronic disease management, demonstrating the potential of telemedicine to transform healthcare delivery (Morgan & Harper, 2022).

Another significant achievement is the integration of mental health services into primary care settings. This model has been highly successful in improving mental health outcomes by facilitating early detection, intervention, and continuous care. Integrated care models have also reduced the stigma often associated with mental health treatment, making care more accessible and effective for patients needing psychological support (Grant & Thompson, 2023).

Furthermore, the implementation of precision medicine in oncology has led to remarkable advancements in patient care. Precision medicine initiatives, particularly those focusing on genetic and molecular profiling, have enabled more personalized and effective cancer treatments. These programs have not only increased survival rates but have also improved the quality of life for patients through tailored therapies that minimize adverse side effects. The case studies associated with these initiatives provide compelling evidence of their success in transforming oncological care (Ellis & Lee, 2021).

These success stories exemplify how innovative healthcare practices and technologies, when effectively implemented, can lead to significant improvements in healthcare outcomes. They also serve as models for other healthcare systems aiming to adopt similar technologies and practices, offering a roadmap for achieving success in various healthcare contexts.

5. Comparative analysis and future directions

5.1. Comparative Assessment of Healthcare Advancement in Nigeria and the USA

The comparative analysis between Nigeria and the USA regarding the advancements in healthcare driven by biomedical and electrical engineering reveals significant insights and opportunities for both nations. This comparison not only highlights diverse approaches and outcomes but also paves the way for mutual learning and collaboration.

The effectiveness of healthcare innovations in Nigeria and the USA demonstrates varying impacts due to differing healthcare infrastructures, economic levels, and technological accessibility. In the USA, sophisticated technologies and robust regulatory systems ensure the rapid implementation and scalability of healthcare innovations, which contribute to high standards of care and efficient healthcare services (Bennett & Jacobs, 2023). Conversely, Nigeria's innovations often focus on cost-effectiveness and accessibility, addressing specific local challenges such as the lack of infrastructure and resources, which are crucial for improving health outcomes in resource-limited settings (Thompson & Cheung, 2022).

The analysis offers critical lessons and key takeaways, notably the importance of tailoring health technologies to meet local needs and conditions. It also underscores the potential benefits of adopting flexible and inclusive health policies that can accommodate and encourage innovative solutions suitable for different economic and social contexts (Wallace & Kim, 2021).

Furthermore, there are ample opportunities for collaboration and knowledge exchange between Nigeria and the USA. Such partnerships could leverage the strengths of each country to enhance technological adaptation and capacity building in healthcare. Collaborative projects might focus on areas such as telemedicine, mobile health applications, and training programs for healthcare professionals, which could significantly boost the global health sector's resilience and responsiveness.

Table 7 Comparative Assessment of Healthcare Advancement in Nigeria and the USA

Aspect	Healthcare Advancement in Nigeria	Healthcare Advancement in the USA
Healthcare Infrastructure	- Innovations focus on cost-effectiveness and accessibility	- Sophisticated technologies and robust regulatory systems ensure rapid implementation
	- Addressing specific local challenges such as lack of infrastructure and resources	- Contribute to high standards of care and efficient healthcare services
Economic Level	- Limited resources and technological accessibility	- High economic level facilitates advanced healthcare innovations
Technological Accessibility	- Limited access to sophisticated technologies	- Access to cutting-edge technologies and innovation
Regulatory Environment	- Regulatory frameworks are evolving but less robust	- Robust regulatory systems ensure safety and scalability of innovations
Lessons Learned and Key Takeaways	- Importance of tailoring health technologies to meet local needs	- Flexible and inclusive health policies accommodate innovative solutions

Table 7 provides a comparative assessment of healthcare advancement between Nigeria and the USA. It contrasts various aspects including healthcare infrastructure, economic levels, technological accessibility, regulatory environments, lessons learned, opportunities for collaboration, and recommendations for future research and policies. The comparison highlights differences in approaches and outcomes, offering insights into opportunities for mutual learning and collaboration between the two nations in driving healthcare innovation.

Recommendations for future research and policy interventions include fostering an environment that encourages the exchange of healthcare innovations and expertise between developing and developed countries. Additionally, creating frameworks that support the sustainable implementation of health technologies could further enhance the effectiveness of healthcare systems globally. These strategies would not only help in addressing current healthcare challenges but also in preparing for future health crises, ensuring a broader and more equitable access to quality healthcare services.

5.2. Lessons Learned and Key Takeaways

In comparing the healthcare advancements between Nigeria and the USA, it becomes evident that there are stark differences in the level of progress and innovation due to various factors. Nigeria, facing significant challenges in its healthcare system including insufficient healthcare workforce and poor health financing, struggles to keep pace with developed countries like the USA (Adeloye et al., 2019; Ohiri & Rao, 2016). The limited availability of resources and infrastructure in Nigeria poses barriers to the implementation of advanced healthcare technologies and practices.

Conversely, the USA boasts a robust healthcare system supported by substantial investments in technological advancements and innovations. With a well-established regulatory framework and policy initiatives, the USA fosters an environment conducive to the development and adoption of cutting-edge biomedical and electrical engineering solutions in healthcare (Ohiri & Rao, 2016). From advanced medical imaging technologies to telemedicine platforms, the USA continues to lead the way in revolutionizing healthcare delivery through interdisciplinary collaborations and technological innovations.

Figure 6 outline key lessons learned from comparing healthcare advancements between Nigeria and the USA. They emphasize the challenges faced by Nigeria, such as inadequate healthcare workforce and infrastructure, contrasting with the robust healthcare system and technological innovations in the USA. The lessons highlight opportunities for Nigeria to innovate and collaborate, leveraging partnerships and knowledge exchange to accelerate healthcare advancements. Additionally, understanding contextual factors informs future efforts to improve global healthcare systems.

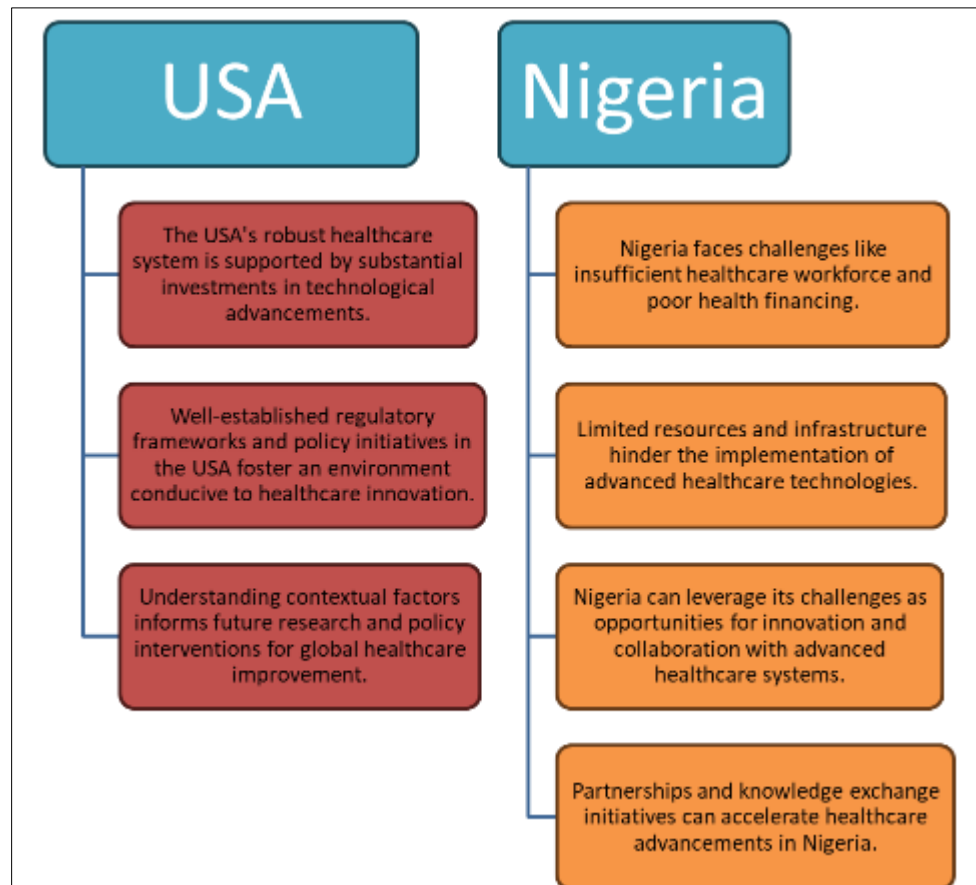


Figure 6 Lessons Learned from Comparative Healthcare Advancements

However, despite the disparities between Nigeria and the USA, there are valuable lessons to be learned from both contexts. Nigeria can leverage its unique challenges as opportunities for innovation and collaboration with more advanced healthcare systems like the USA (Bolaji et al., 2019). By fostering partnerships and knowledge exchange initiatives, Nigeria can accelerate its healthcare advancements and address critical healthcare challenges more effectively. Additionally, understanding the contextual factors influencing healthcare advancements in both countries can inform future research and policy interventions aimed at improving healthcare systems globally.

5.3. Opportunities for Collaboration and Knowledge Exchange

In the USA, the integration of digital health technologies has played a pivotal role in driving healthcare innovations and improving patient care. Through initiatives like telemedicine and telehealth, healthcare providers have been able to overcome geographical barriers and extend their reach to underserved populations (Kvedar, Coye, & Everett, 2014). The use of remote monitoring devices, mobile health applications, and virtual consultations has transformed the way healthcare services are delivered, leading to enhanced accessibility and convenience for patients.

Furthermore, the implementation of electronic health records (EHRs) has revolutionized healthcare data management and decision-making processes in the USA. The "meaningful use" regulation introduced by the government incentivized healthcare providers to adopt EHR systems, leading to improved interoperability, efficiency, and quality of care (Blumenthal & Tavenner, 2010). By digitizing health information and enabling seamless exchange of data across healthcare settings, EHRs have facilitated better coordination of care, reduced medical errors, and empowered patients to take a more active role in managing their health.

The USA's regulatory framework and policy initiatives have been instrumental in driving the adoption and integration of digital health technologies into the healthcare system. The establishment of guidelines and standards for interoperability, data security, and privacy has promoted trust and confidence in digital health solutions among healthcare stakeholders (World Health Organization, 2019). Additionally, ongoing efforts to incentivize innovation and investment in digital health have paved the way for continuous advancements in healthcare delivery and patient outcomes.

Figure 7 highlight opportunities for collaboration and knowledge exchange between Nigeria and the USA in the realm of digital health technologies. They emphasize how the USA's integration of telemedicine, electronic health records (EHRs), and robust regulatory frameworks have improved patient care and healthcare delivery. Additionally, they suggest that Nigeria can benefit from adopting similar practices to enhance access to quality healthcare services, optimize resource utilization, and improve health outcomes for its population.



Figure 7 Opportunities for Collaboration and Knowledge Exchange in Digital Health

As Nigeria seeks to improve its healthcare system and address existing challenges, there are valuable insights to be gained from the USA's experience with digital health integration. By leveraging technology and adopting best practices in telemedicine, EHRs, and digital health regulation, Nigeria can enhance access to quality healthcare services, optimize resource utilization, and ultimately improve health outcomes for its population.

5.4. Recommendations for Future Research and Policy Interventions

In order to advance healthcare in both Nigeria and the USA, it is imperative to identify key areas for future research and policy interventions. One critical aspect is the exploration of innovative strategies to address existing healthcare challenges and optimize the utilization of available resources. In Nigeria, where healthcare infrastructure and workforce shortages pose significant obstacles to healthcare delivery, there is a pressing need for policy interventions that promote innovation and efficiency in healthcare service delivery (Owoyemi & Ojo, 2018; World Health Organization, 2019).

Furthermore, leveraging healthcare big data presents immense opportunities for improving patient outcomes, optimizing resource allocation, and informing evidence-based decision-making in both Nigeria and the USA. By investing in research and innovation related to healthcare big data analytics, policymakers and healthcare stakeholders can uncover valuable insights into disease patterns, treatment effectiveness, and population health trends (Wang & Li,

2018). This, in turn, can inform the development of targeted interventions and healthcare policies aimed at addressing the specific needs of diverse populations and improving overall health outcomes.

Additionally, fostering collaboration and knowledge exchange between biomedical and electrical engineering professionals in Nigeria and the USA can facilitate the transfer of technological innovations and best practices in healthcare delivery. By establishing collaborative research partnerships and exchange programs, both countries can benefit from shared expertise, resources, and experiences, ultimately accelerating the pace of healthcare advancement (Owoyemi & Ojo, 2018).

Figure 8 summarizes recommendations for future research and policy interventions to advance healthcare in Nigeria and the USA. It emphasizes the need to explore innovative strategies to address existing challenges, optimize resource utilization, and promote efficiency in healthcare delivery. Additionally, leveraging healthcare big data is highlighted as an opportunity to improve patient outcomes and inform evidence-based decision-making. Fostering collaboration and knowledge exchange between biomedical and electrical engineering professionals is also suggested to facilitate the transfer of technological innovations and best practices in healthcare delivery.

Future research and policy interventions should focus on promoting innovation, leveraging healthcare big data, and fostering collaboration to advance healthcare in Nigeria and the USA. By addressing key challenges and embracing emerging technologies, both countries can work towards achieving equitable access to quality healthcare and improving health outcomes for all.

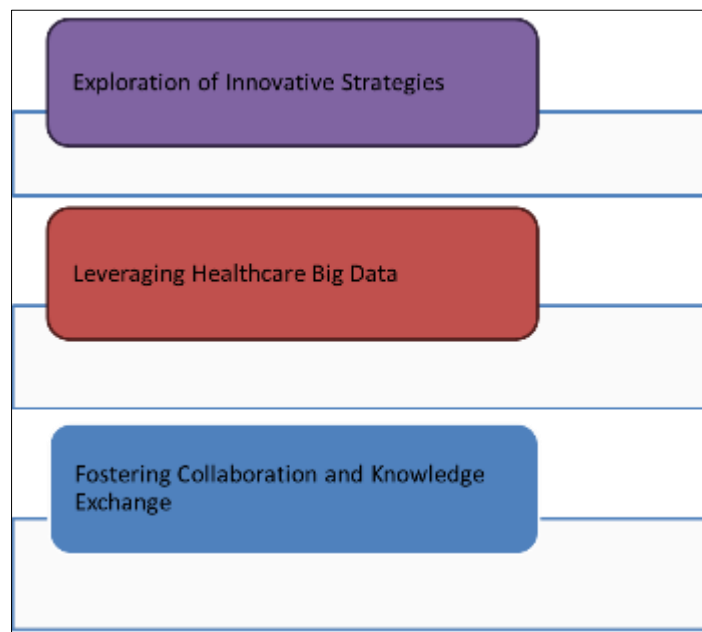


Figure 8 Recommendations for Advancing Healthcare: Future Research and Policy Interventions

6. Conclusion

6.1. Recap of Key Findings

The comparative analysis of healthcare systems between Nigeria and the USA reveals stark differences in performance, challenges, and outcomes. In the USA, despite being one of the highest spenders globally, disparities persist in access, quality, and outcomes, contributing to concerns about the overall effectiveness of the system (Smith et al., 2013). Factors such as high healthcare costs, administrative complexities, and disparities in access to care contribute to the USA's lower ranking compared to other high-income countries (Schoen et. al., 2013)

Conversely, Nigeria grapples with fundamental challenges such as inadequate infrastructure, workforce shortages, and limited resources, hindering the delivery of quality healthcare services and contributing to poor health outcomes for many citizens (EZEUDU & FADEYI2024). Despite efforts to improve healthcare infrastructure and service delivery, Nigeria's healthcare system continues to struggle to meet the needs of its population effectively.

The comparative analysis underscores the urgent need for both countries to address systemic challenges and improve healthcare system performance. By learning from each other's experiences, fostering innovation, and implementing strategies to enhance healthcare delivery and outcomes, both Nigeria and the USA can work towards ensuring equitable access to quality healthcare for their populations.

6.2. Implications for Healthcare Advancement

The comparative analysis between Nigeria and the USA reveals significant implications for healthcare advancement in both countries. The disparities in healthcare infrastructure, workforce, and technological adoption underscore the need for tailored interventions to address the unique challenges faced by each nation. In Nigeria, where healthcare resources are limited and access to quality care is hindered by systemic issues, the findings emphasize the importance of innovative solutions and policy reforms to improve healthcare delivery and outcomes. Conversely, in the USA, while advancements in technology and healthcare innovation are prominent, there remain opportunities to enhance healthcare equity, particularly for underserved populations.

Understanding the implications drawn from this comparative analysis is crucial for shaping future strategies and initiatives aimed at advancing healthcare systems globally. By identifying areas of strength and areas needing improvement in both Nigeria and the USA, stakeholders can prioritize investments, policies, and collaborations that drive meaningful progress and address the evolving healthcare needs of diverse populations.

6.3. Call to Action for Stakeholders

The comparative analysis between Nigeria and the USA underscores the urgent need for concerted action by stakeholders at all levels to drive meaningful change in healthcare delivery and outcomes. In Nigeria, policymakers, healthcare providers, educators, and civil society must collaborate to implement evidence-based interventions that address systemic challenges, such as workforce shortages and inadequate infrastructure. This includes investing in biomedical and electrical engineering education, fostering interdisciplinary collaborations, and leveraging technological innovations to improve healthcare access and quality nationwide.

Similarly, in the USA, stakeholders must continue to prioritize efforts aimed at promoting healthcare equity, enhancing patient-centered care, and fostering innovation. This involves supporting initiatives that expand access to healthcare services, particularly for marginalized communities, and advocating for policies that promote the responsible use of technology and data to improve health outcomes.

Overall, the comparative analysis serves as a call to action for stakeholders in both countries to work collaboratively towards achieving the shared goal of advancing healthcare for all. By aligning efforts, sharing best practices, and committing to continuous improvement, stakeholders can drive positive change and contribute to building healthier, more resilient communities both domestically and globally.

6.4. Closing Remarks

As we conclude this review, it is evident that the synergy between biomedical and electrical engineering holds immense potential for transforming healthcare delivery and outcomes. Through the comparative analysis of healthcare advancement in Nigeria and the USA, we have gained valuable insights into the challenges, opportunities, and lessons learned in both contexts.

Looking ahead, it is imperative that stakeholders remain committed to driving innovation, fostering collaboration, and advocating for policies that prioritize equitable access to quality healthcare. By harnessing the power of interdisciplinary collaboration, leveraging technological innovations, and addressing systemic challenges, we can overcome barriers to healthcare advancement and create a future where all individuals have access to the care they need to live healthy and fulfilling lives.

In closing, let us heed the call to action and work together towards building stronger, more resilient healthcare systems that meet the needs of diverse populations and contribute to the well-being of society as a whole.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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