Artificial Intelligence (AI) and Blockchain Technologies in Advancing Sustainable Healthcare Development in Kenya: A Critique of Dependency Theory

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Abstract

This thesis explores the transformative potential of artificial intelligence (AI) and blockchain technologies in advancing healthcare delivery in Kenya through a critique of Dependency Theory. It investigates how these technologies contribute to improving accessibility, efficiency, and quality of care—particularly in underserved regions, while also addressing the structural dependencies that limit Kenya's healthcare autonomy. Using a qualitative methodology, this study examines five case studies—Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS—to highlight both the opportunities and challenges AI and blockchain present in reducing external reliance. Although AI-powered diagnostics and blockchain-based patient data management systems have revolutionised healthcare in Kenya, these technologies remain dependent on foreign capital and expertise for their development and maintenance.

The research finds that while AI and blockchain technologies offer a path to leapfrog traditional barriers in healthcare delivery, their implementation critiques traditional notions of dependency theory. Nonetheless, the thesis identifies significant ethical considerations—including digital inequality, data privacy, and AI biases—that must be addressed to ensure equitable, self-sufficient healthcare provision. This study concludes with recommendations for fostering technological autonomy in Kenya's healthcare system, focusing on building local capacity, addressing infrastructural challenges, and aligning AI and blockchain integration with ethical and socio-cultural contexts. By doing this, this research contributes to the broader discourse on technology and healthcare in developing nations, offering pathways for reducing dependency and achieving sustainable healthcare development in Kenya.

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1. Introduction

The global healthcare landscape is undergoing rapid transformation, driven largely by the integration of artificial intelligence (AI) and blockchain technologies. While much of this progress has been witnessed in the developed world, these technologies hold immense potential to address healthcare challenges in developing countries, such as Kenya. The country, characterised by a high disease burden, underdeveloped infrastructure, limited healthcare resources, and financial constraints, faces systemic challenges in delivering quality healthcare. The introduction of AI and blockchain technologies, however, offers a possible avenue to revolutionise healthcare delivery by enhancing accessibility, improving efficiency, and addressing long-standing disparities (Amjad et al., 2023; Haleem et al., 2021). This study aims to critically explore how these technologies can contribute to sustainable healthcare development in Kenya while evaluating their potential to reduce external dependencies—particularly through the lens of dependency theory.

Kenya's healthcare system, much like those of other developing nations, grapples with systemic issues, including healthcare worker shortages, inefficient resource allocation, and inequitable healthcare access (Phelan, Yates, & Lillie, 2022; Mohiddin & Temmerman, 2020). However, the country has seen promising developments through innovative projects such as: AfyaRekod's blockchain-based health data management system, which empowers patients to own and control their medical records, and, Tambua Health's AI-powered diagnostic tools, which bring critical diagnostic services to underserved areas. These initiatives demonstrate how AI and blockchain technologies can address key healthcare challenges by decentralising services, improving continuity of care, and enhancing diagnostic accuracy (Knaul et al., 2018). While the potential of AI and blockchain technologies to transform healthcare in Kenya is evident, their implementation is not without challenges. Infrastructural limitations, such as unreliable internet connectivity and electricity in rural areas, present significant barriers to the widespread adoption of these technologies (Reddy, 2021; Khot, 2020). Furthermore, the ethical implications of data privacy, digital inequality, and AI biases must be carefully considered in order to ensure equitable outcomes and prevent the reinforcement of new forms of dependency (Esmaeilzadeh, 2022; Sherman, 2022). Addressing these challenges requires collaborative efforts between governments, the private sector, and civil society to ensure that the deployment of these technologies aligns with the specific needs and cultural contexts of Kenya, while promoting local innovation and community engagement (Kalenzi, 2022).

This research is grounded in the framework of dependency theory, which offers a critical lens for understanding Kenya's position within global healthcare and technology systems. Dependency

theory highlights the unequal relationships between developed and developing nations, where the latter often remains reliant on the former for technological solutions, expertise, and funding (Warf, 2001: 14743–14749). However, this study challenges the traditional assumptions of dependency theory by exploring how Kenya's integration of AI and blockchain technologies may foster self-reliance and innovation within the healthcare sector, rather than perpetuating dependency on external actors. The study further investigates whether these technologies, as employed in Kenya, can offer new pathways to overcoming structural barriers and achieving greater healthcare autonomy.

The qualitative approach employed in this research involves a desktop analysis of key literature, policies, reports, and case studies related to healthcare innovations in Kenya. This includes an examination of the projects: Ilara Health, Tambua Health, Sophie Bot, AfyaRekod, and PanaBIOS, which leverage AI and blockchain technologies to address specific healthcare challenges. The case study methodology allows for an in-depth exploration of these initiatives, assessing their impact on healthcare accessibility, efficiency, and quality of care. Although this research is fundamentally qualitative, it also incorporates some numeric data to support and contextualise the findings. Specifically, health outcomes such as malaria and HIV/AIDS infection rates were tracked from 2015 (in line with the SDGs) to 2024 to infer broader changes in healthcare performance during the period when AI and blockchain technologies were deployed. Though it is not possible to directly attribute all changes in health outcomes to the specific case studies explored in this research, the trends in health outcomes provide valuable insights into Kenya’s overall healthcare trends. This offers a more comprehensive perspective on the potential impacts of these technological innovations.

With that, the core research questions guiding this study are as follows:

1. How have AI and blockchain technologies contributed to the improvement of healthcare delivery in Kenya?

2. To what extent have these technologies influenced healthcare outcomes—especially in terms of accessibility, efficiency, and quality of care?

3. How do these technologies align with or challenge the principles of dependency theory, particularly in fostering or hindering self-reliance in Kenya’s healthcare sector?

By critically examining these questions, this research contributes to the broader discourse on technology and global health equity, offering insights into how AI and blockchain technologies can bridge healthcare disparities in developing countries. Importantly, it critiques dependency theory’s

applicability in the context of Kenya's healthcare innovations, exploring whether these technologies perpetuate existing inequalities or foster a more autonomous and equitable healthcare system.

Following this introduction, *Chapter 2: Literature Review* offers a detailed examination of the evolution of AI and blockchain technologies, with a particular focus on their applications in healthcare in developing countries. It also traces the trajectory of healthcare development in post-colonial Kenya, from early independence to recent democratic reforms, providing critical historical context for understanding the current healthcare landscape. Further, the chapter outlines the research design, ethical considerations, and limitations, integrating the methodology into the broader literature review to ground the study's approach. *Chapter 3: Theoretical Framework: Dependency Theory* explores the origins and development of dependency theory, highlighting its relevance to understanding Kenya's healthcare challenges and the influence of technological dependency in the modern era. *Chapter 4: Healthcare Delivery in Kenya* presents an in-depth analysis of Kenya's healthcare system, charting key milestones under the leadership of Uhuru Muigai Kenyatta (2013–2022) and William Kipchirchir Samoei Arap Ruto (2022–Present). This chapter also examines the integration of AI and blockchain technologies through a series of case studies, including Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS. *Chapter 5: Analysis* critically evaluates the impact of these technologies on Kenya's healthcare autonomy, with a focus on ethical considerations and the application of dependency theory to the country's healthcare context. Finally, *Chapter 6: Conclusion and Recommendations* synthesises the key findings of the research, offering policy recommendations for how AI and blockchain technologies can be leveraged to foster a more equitable, accessible, and sustainable healthcare system in Kenya—while addressing the lingering challenges of technological dependency.

This thesis ultimately aims to offer a nuanced understanding of the complex relationship between technological innovation and healthcare development in Kenya, providing a critical lens through which to assess the country's progress toward achieving greater healthcare autonomy and self-reliance. Through this exploration, the study contributes to the growing body of knowledge on AI and blockchain applications in healthcare, with implications for policy development, technological innovation, and global health equity.

2. Literature Review

In an era where technological advancements hold the promise of revolutionising global healthcare, developing countries stand at a critical crossroads, navigating the complexities of adopting cutting-edge innovations. This chapter provides a comprehensive review of the literature on the role of Artificial Intelligence (AI) and blockchain technologies in healthcare, focusing on their evolution, applications, and challenges—particularly within developing countries like Kenya. It begins by tracing the historical foundations of AI and blockchain, outlining their development from theoretical constructs to transformative tools that have revolutionised various sectors, including healthcare. The chapter further explores how these technologies are being adopted in developing nations, where infrastructural and socio-economic challenges often create barriers to implementation. The discussion is contextualised within Kenya's healthcare system, which has been shaped by colonial legacies and continued reliance on foreign aid and external investments. These historical and global influences, as analysed by scholars such as André Gunder Frank and Samir Amin—key proponents of dependency theory—illustrate how external economic and political forces continue to foster reliance on external resources. This hinders the development of a self-reliant healthcare infrastructure in countries like Kenya, echoing Frank's argument that developing nations are locked into exploitative economic relationships with wealthier nations. As Naseemullah (2022: 2239: 2241) cautions, for developing countries to succeed with industrial policies, they must adapt to the limitations of neoliberalism and globalisation, and consider how to engage with multinationals in a way that secures long-term development benefits.

2.1. Foundations of Artificial Intelligence (AI) and Blockchain Technology

Artificial Intelligence (AI) has evolved from mere theoretical constructs to a pivotal element in modern technological advancements, fundamentally altering the way machines interact with and augment human capabilities. The journey of AI, as charted by industry giants like IBM (2023), showcases a transition from basic mechanical inventions to sophisticated systems capable of emulating complex human cognitive functions such as reasoning, learning, and creativity. This evolution reflects a broader narrative of technological progress, where machines extend beyond labour-saving devices to become integral components of our intellectual and social fabric.

The historical context of AI, rooted in the early 20th century, underscores a gradual shift towards the conceptualisation and realisation of artificial intelligence. The seminal contributions of Alan Turing, often celebrated as 'the father of AI', laid the groundwork for this field through the Turing machine and the Turing Test, which collectively proposed a framework for understanding and developing machine intelligence (McKinsey & Company, 2023; Maryville University, 2023).

Despite Turing's foundational role, it was John McCarthy who formally introduced the term ‘AI’ in 1955, marking a definitive point in the field's nomenclature and its academic and research trajectory (Council of Europe, 2014; Tableau, 2023). As AI matured through the late 20th and early 21st centuries, its applications permeated daily life, evidenced by innovations like the Roomba and advances in speech recognition technology (Tableau, 2023). The era from 2011 onwards has been characterised by significant milestones, including IBM's Watson and Google's AlphaGo, underscoring AI's growing competency and the expanding scope of its applicability in various domains (Rosenblatt, 2023).

The impact of AI extends into the realm of business, where it has been instrumental in enhancing operational efficiency and fostering innovation. The advent of machine learning and deep learning has introduced new paradigms for data analysis and interpretation, offering insights that drive strategic decisions across industries (McKinsey & Company, 2023; UNext, 2023). Moreover, the emergence of generative AI models has opened new avenues for content creation, presenting both opportunities and challenges, especially in the context of developing countries where its implications on employment and industry growth are multifaceted (Mannuru et al., 2023). Parallel to AI's growth, blockchain technology has emerged as a transformative force in digital transactions and data integrity. Originating as the backbone of cryptocurrencies, blockchain has evolved to offer a secure, decentralised platform for a myriad of applications across sectors (Kumar, 2023; Hayes, 2023). Its development journey, from the inception phase marked by Haber and Stornetta's cryptographic chains to the current landscape of NFTs and the Metaverse, underscores its potential to redefine data security and ownership in the digital age (Shiksha, 2022).

The interplay between AI and blockchain epitomises the dynamic nature of technological progress, where innovation not only reshapes existing paradigms but also introduces new challenges and opportunities. As these technologies continue to evolve, their integration into societal and economic frameworks will necessitate thoughtful consideration of ethical, security, and regulatory implications, ensuring that their benefits are maximised while mitigating potential adverse impacts.

2.1.1. Artificial Intelligence and Blockchain in Developing Countries

Unlike developed economies where AI is automating tasks, Bhattacharya (2018: 24-25) highlights, developing countries with a gig economy see a different work landscape. Despite its transformative potential, integrating AI faces challenges that include acknowledging human limitations, addressing biases in algorithms, and the need for AI development focused on these markets (Bhattacharya, 2018: 24-25). Therefore, overcoming these challenges is crucial to unlocking AI's unprecedented societal and commercial impact in developing economies. Recent discussions by Addo (2023) delve

into the challenges and opportunities of implementing AI technology in developing countries. The study underscores the limited readiness of these nations to harness AI benefits for research and development, citing disparities in capabilities between developed and developing regions.

To highlight these limits, Kennedy (2023) emphasises the global competition in AI investment, highlighting the dominance of the United States and China—the latter being a developing country itself[1]—leading the race since 2013. The United States invested nearly $250 billion, while China invested $95 billion in 4,643 and 1,337 AI startups, respectively. To contextualise these figures, China's AI investment represented about 0.453% of the collective GDP for all developing countries (excluding itself) and 0.256% for all developing countries (excluding the least developed countries) (UNCTAD, 2022). Although this might seem modest, these percentages gain significance when considering that China's AI contribution surpasses the GDP of 46 out of 54 African countries in 2022. To illustrate, considering Africa's highest GDPs in 2023—led by Nigeria at US$477.38 billion, and Kenya ranking 8th with US$115.99 billion—it becomes evident that Tanzania, with a GDP less than China's AI contribution (US$77.06 billion), signifies this trailing behind in the technology race (Galal, 2023). This stark contrast underlines the challenges faced by many African nations with limited resources when competing in the evolving technological landscape.

A publication by scholars Chatterjee and Dethlefs (2022) speaks to this gap, highlighting that the global AI race is leaving developing countries, particularly in sub-Saharan Africa, the Caribbean, Latin America, and parts of Asia, behind. While 44 countries—including developing economies like China and India—have their own national AI plans, Chatterjee and Dethlefs (2022) add that the digital divide is widening, with wealthier nations such as the US, Singapore, and the UK, leading in AI readiness. According to the pair, this is owing to developing countries prioritising education, healthcare, and sanitation, among other necessities (Chatterjee and Dethlefs, 2022). Further, the environmental toll of large-scale AI models—primarily used in developed countries—disproportionately affects developing nations. As Chaudhary (2023: 1415) points out, the computational demands of AI algorithms require substantial energy consumption, which could strain developing countries' already fragile energy infrastructure and contribute to environmental degradation. Therefore, to harness the potential benefits of AI for development, equitable participation in its development and use is crucial, requiring greater financial and technological support from the developed world (Chatterjee and Dethlefs, 2022). This aligns with dependency theory by highlighting the need for external support: depending on developed nations for financial

[1] While Chinese leader Xi Jinping asserts China's status as a developing country, lawmakers in Washington—particularly in Congress—argue for stripping China of its developing nation label. This debate is fuelled by real-world implications, as China's classification affects its access to preferential tariff treatment and its ability to justify subsidies, prompting geopolitical tensions between the US and China. See Suixi (2023), Kanwit (2023)

and technological assistance impedes the autonomy and sustainable development of developing countries. However, by focusing primarily on the negative impact of relying on external support, dependency theory overlooks the unique strengths, capabilities, and untapped resources that exist within these nations that could flourish from this aid. So, as this study also posits, these technologies can be used to reduce development inequalities.

To this effect, Kamiya (2023) discusses the role of AI in reducing the technological gap between developed and developing countries—with a focus on small and medium-sized enterprises (SMEs). The article highlights the transformative potential of AI in industries like manufacturing, agriculture, and services—by emphasising the need for developing countries to adapt to the changing nature of productive activities, embrace digitalisation, and harness the practical applications of AI to enhance productivity. Further, it suggests practical uses of AI, such as implementing digital twinning systems, using AI-forecast-fed components for local production, and applying Geographic Information Systems (GIS) and analytics in agribusiness. Aptly, the article also underscores that the challenges faced by SMEs in developing countries—such as limited technological knowledge, financial resources, and legal frameworks—stand to impede these technology-based solutions (Kamiya, 2023). To mitigate these challenges, the author advocates for better policy design, continuous development of innovation ecosystems, and the establishment of smart manufacturing centres to facilitate the adoption of AI in production (Kamiya, 2023).

Addo (2023) adds to the above sentiment, highlighting that addressing challenges in developing countries related to AI use requires fostering collective global partnerships, engaging in development cooperation, and promoting bilateral/multilateral collaborations. This approach aims to facilitate knowledge sharing, attract talent, and foster joint problem-solving initiatives. Fortunately, this is already happening, with Addo (2023) specifically highlighting initiatives like the Africa Regional Data Cube and the #Data4COVID19 Africa Challenge—which leverage AI to address issues in food security, urbanisation, and public health within specific African countries. The Africa Regional Data Cube—a collaboration between the Group on Earth Observations, Amazon Web Services, and the Committee on Earth Observation Satellites—provides satellite imagery and analysis to African countries, aiding them in tackling challenges such as food security, water availability, and climate change (Digital Earth–Africa, 2020). Similarly, the #Data4COVID19 Africa Challenge—organised by the *Agence Française de Développement* in collaboration with Expertise France and The GovLab—was a call for innovative proposals from data analysis researchers to address COVID-19 challenges in Africa by developing collaborative data production projects (AFD, 2020). These initiatives represent a step towards using AI as a tool for positive

societal impact—emphasising the importance of global cooperation and collaboration in realising AI's potential in diverse settings.

This adoption of AI technologies in developing nations—alongside global partnerships and collaborative initiatives—suggests a move towards leveraging technological advancements to address local challenges and foster development. However, it is essential to recognise that while these efforts may contribute to reducing the dependency on developed nations for technological innovations, they do not fully resolve the underlying systemic dependencies highlighted by dependency theory. Instead, they represent a step towards a more balanced and equitable approach to technology transfer and development cooperation, where the focus is on building local capacities, enhancing self-reliance, and ensuring that the benefits of technological advancements are distributed more equitably. This nuanced approach acknowledges the potential of AI to contribute positively to development goals, while remaining cognisant of the need for careful management of the relationships between developing and developed countries to avoid reinforcing existing inequalities.

Therefore, to address the concerns shared by the aforementioned authors—including 'poet of code' and responsible AI activist Joy Buolamwini—on the use of AI in developing countries, governments across the globe are initiating projects to protect their vulnerable communities from the technology's drawbacks. For example, the WHO released its inaugural global report on AI in health in 2021, accompanied by six guiding principles for the design and use of AI in the sector. The report emphasises the potential benefits of AI for healthcare, including improved diagnosis speed and accuracy, enhanced clinical care, and support for public health interventions (WHO, 2021). However, it also underscores the importance of placing ethics and human rights at the forefront of AI development, highlighting risks such as unethical data use, algorithmic biases, and threats to patient safety and cybersecurity (WHO, 2021). These risks even inspired an open letter by NGO Future of Life, calling for a moratorium on AI projects. The March, 22nd, 2023 open letter calls for a six-month pause in training AI systems more powerful than GPT-4, cautioning against human-competitive AI, and urging collaborative development of safety protocols and governance systems (Future of Life Institute, 2023). Six months later, an article by WIRED author Will Knight (2023) reveals that contrary to the letter, AI development accelerated—with key signatory Elon Musk even announcing a competing AI company, xAI. Withal, the letter did stimulate mainstream discussions on AI risks, prompting sector leaders to raise awareness of AI risks, and further fuelled ongoing discussions about AI safety, expressing concerns about diverse issues, including disinformation and job losses (Knight, 2023).

Joy Buolamwini, a Ghanaian-American-Canadian computer scientist and digital activist, is a prominent advocate for algorithmic justice—especially for vulnerable communities. She is particularly concerned about biases in facial recognition and biometrics, especially in their applications in policing, education, and healthcare. Her recent best-selling book, *Unmasking AI*, is a groundbreaking exploration of the ethical implications of the technology. Going beyond sensational headlines, the book reveals the "coded gaze", which presents evidence of encoded discrimination and exclusion in technology products (Buolamwini, 2023: 1-336). The book urges experts and non-experts alike to join the fight for civil rights in the AI era, asserting that AI should serve all people—not just the privileged few (Buolamwini, 2023: 1-336; TIME, 2023). Praise for the book includes, among others, recognition that has got her place on the 2023 TIME AI 100 list. Others on the list include South African-born billionaire and technology entrepreneur Elon Musk; Sam Altman and Greg Brockman, the founders of OpenAI; Pelonomi Moiloa, a South African biomedical engineer and founder of Lelapa AI; and Richard Mathenge, a Kenyan responsible technology activist. Mathenge played a key role on the team that contributed to the reading and moderation of toxic material, such as hate speech, racism, violence, and descriptions of sexual abuse, on AI-based chatbots like ChatGPT (TIME, 2023).

Further, representatives from Japan, Kenya, Morocco, Singapore, Spain, the United Kingdom, and the United States convened in New York on September 18, 2023, to explore the transformative potential of accelerating progress towards the United Nations Sustainable Development Goals (SDGs). Participants, including prominent AI firms, universities, and civil society organisations, showcased tangible applications of AI in health, education, food security, energy, and climate action. AI and digital technology, by liberating service providers from costly infrastructure requirements, offer solutions to these challenges. For instance, in Kenya, M-Shwari uses AI to assess the likelihood of default among online loan applicants, which enabled the company to provide small loans to 21 million Kenyans by the end of 2017 (Sonneborn and Graf, 2020). Emphasising responsible governance, inclusive dialogues, and global partnerships, the participants acknowledged AI's potential for inclusive and sustainable growth (Office of the Spokesperson, 2023). However, they also addressed concerns related to potential inequality and bias. According to the United States Department of State, commitments made by co-convening countries and companies encompassed financial assistance, venture capital (VC) funds for AI startups, and widespread AI skills training for actors in developing countries (Office of the Spokesperson, 2023). Ultimately, the commitment to inclusive development and responsible use of AI technologies is crucial in ensuring that the benefits are distributed equitably and contribute to the overall well-being of the global community.

Similarly, blockchain technology is emerging as another transformative force in developing nations, offering unique solutions to their socio-economic challenges. Its decentralised and permissionless nature provides advantages crucial for countries with struggling economies. Decentralisation ensures resilience against abrupt interventions, and permissionless accessibility fosters financial inclusivity, allowing individuals worldwide to use blockchain services without restrictions (ACAMS Today, 2022). The decentralised ledger's immutability enhances transparency, making it a potent tool against corruption—a plague in developing countries. Blockchain also offers a deflationary alternative in the face of hyperinflation, and provides a secure, tamper-proof platform for administrative processes, including voting systems (Cunha, Soja and Themistocleous, 2021). Real-world examples, such as El Salvador accepting Bitcoin as legal tender, showcase the technology's potential impact on inflation on a national scale. However, regulatory challenges, technical and operational issues, resistance to change, and negative perceptions associated with cryptocurrencies hinder widespread adoption (Cunha, Soja and Themistocleous, 2021). Nevertheless, as ACAMS Today (2022) shows, despite challenges like price volatility, global institutional interest in blockchain is rising—with, in fact, expectations of market stabilisation over time. This decreasing volatility could pave the way for more countries to adopt digital currencies strategically in response to inflation (ACAMS Today, 2022).

Real-world examples in India, Kenya, and Nigeria highlight the diverse applications of blockchain in addressing challenges unique to these regions (Reiff, 2023). The field of Blockchain for Development (B4D) gains momentum globally, with countries across Africa, the Caribbean islands, Asia, the Middle East, and Latin America actively exploring its potential applications (Cunha et al., 2020, in Cunha, Soja and Themistocleous, 2021). The Middle East and North Africa (MENA) region, led by the United Arab Emirates, shows significant progress in blockchain adoption, deviating from traditional patterns of ICT adoption. However, challenges arise in defining socio-economic development in the context of blockchain adoption. Avgerou (2010, in Cunha, Soja and Themistocleous, 2021) and Ashraf et al. (2017, in Cunha, Soja and Themistocleous, 2021) highlight that B4D studies often focus narrowly on economic aspects, overlooking the multidimensional nature of development highlighted by the United Nations' Human Development Index (HDI). The inconsistent definition of development and motivations for blockchain adoption complicate the understanding of its potential impact.

Nevertheless, the developmental immaturity of blockchain technology introduces distinct challenges linked to its implementation, requiring specialised attention to facilitate effective integration (Kumar and Dagar, 2021: 1138-1141). Akinradewo et al. (2022: 925-926) identify seven barriers associated with blockchain adoption: social acceptance, high energy consumption, legal and

regulatory uncertainties, system complexity and cost, transactional-level uncertainties, vague supportive data regulation, and poor economic behaviour. Social acceptance stands out as a substantial hurdle, emphasising the importance of addressing societal and ethical barriers in the adoption and implementation of blockchain technology (Akinradewo et al., 2022: 926). Further, a feasibility study by Monethi (2023: 31-47) reveals the limited readiness of nations—particularly in Africa—to harness the benefits of technologies like blockchain for research, development, and rollout. The analysis delves into the hurdles African states and their people face in relation to blockchain technology. That is, whether they can afford its implementation, there is political will for adoption, and the technical expertise and whether there is the infrastructure necessary to support it. The study also examines the legal feasibility, considering the regulatory environment's compatibility with technological advancements—both domestically and internationally. As such, challenges like financial constraints, a lack of technical expertise, and concerns about the regulatory environment emerge (Monethi, 2023: 31-47). Ultimately, the study emphasises that despite its potential, there is the need to consider a broader spectrum of countries, as well as the evolving impact of blockchain on the continent’s development.

Evidently, the success of blockchain applications in fostering development depends on factors such as a country's level of development, political stance on transparency, and existing technological infrastructure. As Gillpatrick, Boğa and Aldanmaz (2022: 107) show, although political instability and a lack of digital infrastructure and capital pose challenges, they also present opportunities for innovation—akin to the rapid adoption of mobile technology in the absence of robust telephone infrastructure. Financial inclusion sees blockchain applications in the form of digital wallets and mobile payment solutions—especially in less developed nations. However, realising the potential of blockchain in increasing financial inclusion necessitates a conducive technological ecosystem, capital mobilisation, and effective public-private collaboration (Gillpatrick, Boğa and Aldanmaz, 2022: 122). Notwithstanding, Chatterjee and Dethlefs (2022) caution that developing nations risk lagging behind if the adoption of these technologies is not swift enough—particularly in the context of the fourth industrial revolution. Evolving into its 3.0 iteration, blockchain has transcended its initial association with finance, extending its impact to sectors such as government and healthcare (Gatteschi et al., 2018, in Gillpatrick, Boğa and Aldanmaz, 2022: 107). The application of blockchain in healthcare focuses on enhancing access to medical data, secure data sharing, and unifying medical records. However, while the technology has proven beneficial in various fields like health, travel, and copyright, Gillpatrick, Boğa, and Aldanmaz (2022: 107, 122) emphasise supply chain, land registry, financial inclusion, and corruption as areas with significant potential impact in developing nations. UNCTAD (2021) underscores blockchain's transformative potential in contributing to sustainable development. Ethereum—the second-largest blockchain

globally—collaborates with UNICEF to raise cryptocurrency donations, showcasing blockchain's role in enhancing financial transparency, accountability, and efficiency (UNCTAD, 2021). While recognising blockchain's potential, a cautionary note emphasises the need for policies to maximise benefits and mitigate harmful outcomes.

The potential of technologies like blockchain in achieving the UN Sustainable Development Goals (SDGs) is acknowledged, emphasising the importance of strategic planning (UNCTAD, 2021). Similarly, in his 2023 article, *Transforming Digital Infrastructure in Developing Nations: A Case for Blockchain Technology*, Tuhu Nugraha explores the potential of blockchain to catalyse economic and technological advancements. Nugraha advocates for a specialised blockchain, 'Layer 1', tailored to the unique needs of developing nations. He acknowledges blockchain's transformative role in the digital economy, but highlights challenges like inadequate infrastructure. The proposed Layer 1 solution aims to address these challenges, fostering financial inclusion, transparency, and supply chain efficiency. The article then emphasises the importance of user-friendly solutions and proposes Indonesia as a potential innovation hub for developing Layer 1 blockchain (Nugraha, 2023).

In Kenya, IBM research scientist Aisha Walcott—an alumnus of Clark-Atlanta and MIT—initiated the development of AI infrastructure in 2013, marking the beginning of Western-trained talent focusing on AI solutions in Africa. Her notable work in Nairobi used deep learning to tackle traffic congestion, leading to a 10% reduction in commuter time through the predictive analysis of traffic patterns (Siyonbola, 2021). Then, a policy brief on *Artificial Intelligence in Kenya*' delved into the multifaceted impacts of AI across various sectors in Kenya. Published in January 2022, it accentuates AI's potential to address prevalent challenges in health, education, agriculture, finance, and business, highlighting its role in economic growth and the Fourth Industrial Revolution (Akello, 2022: 6-7). The brief outlines AI's applications in enhancing disease detection, agricultural productivity, financial inclusion, and personalised education, while also noting the risks it poses, including potential human rights violations and the exacerbation of inequalities. However, Akello (2022: 8-10) also underscores concerns regarding AI's implications for human rights, pointing out issues such as data privacy, the digital divide, and the necessity for a regulatory framework to govern AI usage. It stresses the lack of sufficient data, regulatory guidelines, AI skills, connectivity, and investment in research as major obstacles to AI's adoption in Kenya. Further, the brief calls attention to specific risks like AI bias, surveillance, gender inequality, weaponisations by the government, data protection concerns, and the challenges of online content moderation (Akello, 2022: 12-14). To address these challenges and risks, the brief recommends the development of a comprehensive regulatory framework that: balances innovation with human rights protection;

increased government investment in AI research and broadband connectivity; the promotion of STEM education; and, the private sector's responsibility to develop unbiased AI systems (Akello, 2022: 16). Civil society organisations are also urged to collaborate with the government to create a rights-respecting AI framework and raise awareness about AI's potential harms.

As at February 2024, Kenya is home to 36 leading AI companies and start-ups, showcasing a vibrant ecosystem powered by AI innovation (F6S, 2024a). Among these, M-Shule stands out as Africa's first personalised, mobile learning platform using AI and SMS to offer customised tutoring and assessments; while Bobbi aims to transform the animal healthcare industry with AI and blockchain technology, highlighting Kenya's growing role in global AI development across diverse sectors (F6S, 2024a; Ndemo, 2020: 4). Further, young people in the country are increasingly engaging in data annotation for international AI companies—Caroline Njau, a 30-year-old Kenyan, exemplifies this trend by annotating data for self-driving car technologies at odd hours, showcasing Kenya's emerging role as a digital work hub and the aspirations of its youth to advance in the tech industry (Kidmose, 2024). As for blockchain, the technology has seen varied levels of adoption across Africa, with Kenya, Nigeria, and South Africa leading in its uptake—primarily within the financial sector, notably in cryptocurrency trading, payments, and cross-border transactions (Thegeya, 2023: 4). As Thegeya (2023: 4) adds, these three countries have been pivotal, contributing to over 80% of the continent's blockchain innovations, particularly in finance, insurance, internet, telecommunications, and health. Notwithstanding, despite the lack of uniform regulatory frameworks across Africa, Mauritius and Kenya have established regulatory sandboxes to foster innovation, complementing the enactment of personal data protection legislation by 28 African countries (Thegeya, 2023: 18; Ndemo, 2020: 1).

In a report on the *Intersessional Panel of the United Nations Commission on Science and Technology for Development (CSTD)* for 2020-21, chairperson of the Kenya Blockchain Council Professor Bitange Ndemo highlights the nation's engagement with blockchain technology for sustainable development, emphasising its prospects and challenges (Ndemo, 2020: 1-6). Kenya, renowned as ‘Africa's Silicon Savannah’ for its innovative approach to digital technology, recognises blockchain's potential across various sectors including finance, agriculture, education, and government services (Ndemo, 2020: 4). To this effect, as at February 2024, the country boasts 39 leading blockchain companies and start-ups, spanning various sectors from digital asset management and blockchain development studios, to innovative solutions for agriculture and healthcare (F6S, 2024b). Then, the Blockchain Association of Kenya (BAK) submitted Kenya's first Virtual Assets Service Provider (VASP) bill to regulate the digital asset market—following a request from Kenya's parliament on October 31, 2023—for a draft to be developed (Ekhator, 2024).

The BAK is a non-profit member organisation founded in 2015, which aims to transform Kenya into "…a hub for blockchain and emerging technologies" by fostering collaboration between stakeholders and supporting the community with resources for the welfare of communities in Africa (Digital Assets Policy Safari, 2024). According to the news article by Ekhator (2024), the bill was published for public review on January 22, 2024, and aims to address issues in Kenya's crypto market (such as fraud and high entry barriers) by establishing a consumer protection framework, licensing requirements, and anti-money laundering provisions. BAK plans to revise the draft based on feedback and submit the second draft to the National Assembly's Departmental Committee on Finance and National Planning on February 14, 2024 (Ekhator, 2024). This initiative positions Kenya to enhance its digital asset market and economic recovery goals, with aspirations to attract $1 billion in foreign direct investments by 2027.

Ultimately, a nuanced dialogue has emerged, particularly focusing on their integration within developing economies. Bhattacharya (2018) and Addo (2023) discuss the transformative potential of AI, juxtaposing the enthusiastic adoption in mature economies against the backdrop of significant challenges in developing nations; notably, the need for development focused on local markets and the global disparity in AI investment highlighted by Kennedy (2023). The discourse extends to the implications of such investments, with China's substantial AI funding contrasted against the GDPs of African nations, underscoring a technological race where resources are starkly imbalanced. Chatterjee and Dethlefs (2022) emphasize the widening digital divide, with developed countries leading in AI readiness, while developing regions prioritize necessities over technological advancements. This gap underlines the environmental and infrastructural strains large-scale AI models impose on these nations, necessitating equitable participation in AI development and usage, as advocated by Chaudhary (2023).

Amid these challenges, the literature suggests a pivotal role for AI in bridging the technological gap, with Kamiya (2023) advocating for AI's practical applications to enhance productivity in SMEs across manufacturing, agriculture, and services. The discussion further evolves around global partnerships and collaborative efforts, as highlighted by Addo (2023), to address AI implementation challenges, spotlighting initiatives like the Africa Regional Data Cube and the #Data4COVID19 Africa Challenge as steps towards leveraging AI for societal benefit. In parallel, the discourse around blockchain technology, detailed by ACAMS Today (2022) and others, illuminates its potential to address socio-economic challenges through decentralisation and financial inclusivity. However, the developmental immaturity of blockchain and the barriers to its adoption, identified by Akinradewo et al. (2022) and Monethi (2023), present considerable hurdles, necessitating a focus on the unique challenges and opportunities blockchain offers to developing nations. The narrative

culminates in a reflection on Kenya's vibrant AI and blockchain ecosystem, showcasing initiatives and startups that exemplify the country's engagement with these technologies. The submission of Kenya's first Virtual Assets Service Provider (VASP) bill by the Blockchain Association of Kenya (BAK), as reported by Ekhator (2024), marks a significant step towards regulating the digital asset market. This aligns with broader economic recovery goals and the global discourse on technology's equitable and ethical development.

2.1.2. Artificial Intelligence and Blockchain in Healthcare: Opportunities and Challenges

This section provides a comprehensive exploration of the foundations of Artificial Intelligence (AI) and blockchain technology, focusing on their evolution, applications, and transformative potential in both developed and developing countries. Beginning with an overview of AI's historical development, the chapter highlights key milestones and the growing influence of AI across industries—particularly in the healthcare sector. It also examines blockchain's emergence from cryptocurrency roots to broader applications in data security, transparency, and decentralisation. The chapter then shifts focus to the challenges and opportunities posed by AI and blockchain in developing countries—particularly within healthcare, addressing the technological, economic, and regulatory barriers these nations face.

Although AI and blockchain promise to revolutionise healthcare delivery through improved efficiency, data sharing, and patient empowerment, the realities of implementing these technologies are far more complex. In developing countries, inadequate digital infrastructure, limited technical expertise, and inconsistent regulatory frameworks often undermine the potential benefits of AI and blockchain. Moreover, high costs associated with both developing and maintaining these technologies pose a significant challenge for nations with constrained healthcare budgets. Furthermore, ethical concerns around data privacy and security become more pronounced in these settings, where policies such as the Malabo Convention are either absent or underdeveloped.

Through this analysis, the chapter illustrates the practical implications of these technologies, concluding with a discussion on the ethical concerns surrounding AI and blockchain adoption in healthcare, including privacy, security, and environmental impacts.

- **Opportunities**

In healthcare, AI has undergone significant evolution, with milestones dating back to the late 1950s and early 1960s. The DENDRAL project at Stanford University in 1965, led by AI pioneers Edward Feigenbaum and Joshua Lederberg, employed rule-based methods to deduce the structures of

unknown organic molecules through mass spectrometry data analysis. This marked the beginning of AI's transformative journey in healthcare. The 1970s saw the emergence of pioneering AI health systems like INTERNIST 1, MYCIN, PIP, and CASNET (Naryanan, 2021). INTERNIST-1, developed in 1971, employed a sophisticated ranking algorithm for diagnosis, while MYCIN, developed in 1976, was designed to identify treatments for blood infections (Cedars-Sinai, 2023; Naryanan, 2021; XSOLIS Insights, 2021). In 1989, Cedars-Sinai cardiologists introduced CorSage, a clinical tool that combined AI and statistical techniques to identify patients at high risk of heart conditions. The FDA's approval of AI-powered devices for cancer diagnosis in 2019 and the establishment of Cedars-Sinai's Division of Artificial Intelligence in Medicine further illustrate AI's profound impact on medical diagnostics and patient care. As of June 2023, the FDA has sanctioned approximately 521 AI-powered devices, including Ilara Health's Butterfly iQ Portable Ultrasound, marking a significant increase from the 91 devices approved the previous year (Koncz, 2023; Ilara Health, 2021; Cedars-Sinai, 2023).

The World Health Organization and other entities are exploring AI's potential to bridge health system gaps and address global health disparities—particularly in low- and middle-income countries (LMICs). However, Alami et al. (2020) point out that AI-based health applications, predominantly developed in affluent nations, face challenges in LMICs due to the lack of robust local evaluations, which impedes informed decision-making in resource-constrained settings. They advocate for developing and implementing AI healthcare technologies in LMICs, grounded on five foundational principles to ensure responsible, sustainable, and inclusive deployment. Naryanan (2021) underscores the importance of adhering to WHO's principles, such as preserving human autonomy and ensuring transparency, in the rapidly expanding field of AI healthcare applications. This cautious approach is necessary to prioritize public interest and ethical considerations. AI has catalysed groundbreaking advancements across various dimensions of healthcare, notably in the rapid processing and analysis of extensive medical data, such as diagnostic images. This capability, which surpasses human accuracy, accelerates and refines disease diagnosis, thereby enhancing healthcare delivery efficiency (Moore, 2023). AI's scope extends beyond diagnostics to include real-time monitoring of vital signs, chronic condition management, and healthcare access enhancement—particularly through telemedicine in remote areas (Moore, 2023). Moreover, AI significantly reduces research time, optimizes resource utilization, and curtails errors, contributing to a comprehensive enhancement of patient care and a notable reduction in care costs (FutureLearn, 2023).

Blockchain technology is also emerging as a transformative force in healthcare, offering heightened transparency and accountability in areas such as healthcare financing and medication management

(Access Partnership, 2018). Adere (2022) emphasizes the challenges faced by the pharmaceutical supply chain, such as counterfeiting and sub-standardization, and suggests that blockchain, coupled with IoT, presents a solution by ensuring transparency, traceability, and trustworthiness. However, challenges like regulatory gaps and privacy concerns persist in this approach (Adere, 2022). Adere's review also explores blockchain's role in data management—particularly focusing on IoT and healthcare. He notes challenges in integrating blockchain with IoT due to qualitative aspects such as sensor numbers, low memory, processing limits, and varying latency (Adere, 2022: 13). Blockchain's role in data management activities, including acquisition, processing, security, dissemination, retrieval, and storage, is highlighted. It significantly contributes to data security, ensuring integrity, access control, and privacy in healthcare. Authentication methods range from public-key encryption to biological mechanisms, and data processing involves smart contracts. Dwivedi et al. (2019, in Adere, 2022: 14) highlight the importance of access control and privacy preservation through certificate authority, multi-signature provisioning, encryption, and architectural solutions.

In healthcare applications, Poquiz (2022) identifies uses in revenue cycle management, physician credentialing, electronic health records, and supply chain management. However, the broader adoption of blockchain in healthcare faces challenges from potential government regulations and internal security threats (Poquiz, 2022). Alkhaldi (2022) emphasizes that blockchain significantly enhances data security by implementing advanced cryptography mechanisms, addressing challenges related to breaches and theft in centralized databases. The decentralized nature of blockchain fosters improved transparency and trust within the healthcare ecosystem. It allows multiple doctors from different locations to access the same data in real-time, enhancing collaborative decision-making among healthcare professionals. Patient empowerment is another positive aspect, giving patients ownership of their medical data and allowing them to control access, participate in research, and even monetize their data without intermediaries. Blockchain also streamlines the tedious process of medical credentialing, reducing time and costs for healthcare organizations. To add, it facilitates efficient and transparent clinical trials, secures the healthcare supply chain, and supports advancements in genomic research by enabling the secure storage and exchange of genomic data (Alkhaldi, 2022).

Sharma (2023b) highlights the benefits of blockchain in patient-centric Electronic Health Records (EHRs), offering a comprehensive view of patient records and empowering patients with control over data sharing. The technology ensures high-security standards for data encryption, minimizes the risk of data breaches, and streamlines processes such as insurance and credentialing. In remote monitoring with IoT security, blockchain ensures the resilience of systems, improving control over

healthcare transactions and enhancing transparency (Sharma, 2023b). The decentralization of blockchain ensures traceability and verifiability of transactions and processes, mitigating the risk of fraud or mismanagement. This streamlined approach extends blockchain's impact on healthcare beyond financial aspects to vital areas like supply chain management and financial transactions. It eliminates the need for intermediaries, reducing delays and potential errors, and contributing to increased efficiency and cost-effectiveness in healthcare operations (Texila American University, 2020). Further, blockchain seamlessly integrates into AI in healthcare, enhancing the trustworthiness of AI-based applications (Shinde et al., 2022). The secure and immutable data storage provided by blockchain aligns with the specific requirements of different AI domains, ensuring that the data used by AI algorithms is reliable and tamper-proof. This fosters trust among healthcare professionals and patients, emphasizing the importance of blockchain in supporting the integrity of AI-driven healthcare solutions (Shinde et al., 2022).

Bazel, Mohammed, and Ahmed (2021) highlight decentralization as a core feature of blockchain, distributing power away from central authorities and ensuring robust and efficient healthcare systems. The transparency provided by blockchain allows for a complete and auditable ledger of transactions, addressing data privacy concerns. Immutability ensures the security of healthcare data, and access control is facilitated through blockchain transactions and cryptographic keys. The distributed ledger and consensus mechanisms contribute to reduced operational inefficiencies and lower administrative costs in healthcare systems. Blockchain also provides benefits in terms of data interoperability and global data sharing, addressing limitations in medical records exchange and ensuring standardized data codes for easy access. In healthcare areas like patient record management, blockchain ensures seamless access to comprehensive patient records, reduces duplication of diagnostic tests, and enhances transparency. The technology extends its impact to the drug supply chain, minimizing fraud, improving drug traceability, and reducing the risk of counterfeit drugs entering the market. Research and development in healthcare benefit from blockchain by improving data integrity, transparency, and accuracy in clinical trials. The technology supports collaboration among stakeholders and ensures the quality of genomic and health-related data. Blockchain solutions are particularly relevant in ensuring permissions consistency during medical emergencies, preventing delays in accessing patient records. In telehealth care systems, blockchain enhances security and privacy protection, facilitating seamless data exchange without intermediaries. The transparency and interoperability provided by blockchain also extend to health insurance and billing systems, improving efficiency. Smart contracts automate administrative processes, detect fraudulent claims, and streamline the medical billing process, ultimately reducing resources, time, and expenses (Bazel, Mohammed, and Ahmed, 2021).

An analysis by CyberPanel (2023) shows that the encryption of sensitive data using cryptographic algorithms, such as RSA-256, enhances security, making blockchain a formidable tool against cyber threats. Notably, the use of blockchain in applications or services has demonstrated a remarkable 95% reduction in the risk of hacking. In response to the unique challenges faced by the healthcare industry post-COVID-19, blockchain emerged as a preferred option, promising heightened security, improved patient outcomes, and expanded access to services. Blockchain's applications in healthcare are multifaceted, offering significant benefits. It revolutionizes data management by decentralizing information, addressing issues in conventional processes, and ensuring compliance with regulations like the Health Insurance Portability and Accountability Act of 1996 (HIPAA). In addition, blockchain facilitates cryptocurrency payments, creating a more secure and efficient financial ecosystem for healthcare organizations. This not only streamlines payment processes but also enhances accountability. Further, the technology contributes to improving the quality of care by securing patient data and preventing digital fraud. Patients can grant access to their data, streamlining medical history retrieval and enhancing treatment outcomes. The tamper-proof nature of blockchain addresses the critical issue of securing patient data, countering the alarming number of breaches that occurred between 2009 and 2017, totalling over 176 million compromised records. Beyond these fundamental benefits, blockchain finds diverse use cases in healthcare. It ensures supply chain transparency by tracking medical goods' provenance, vital for combating counterfeit drugs. Patient-centric electronic health records eliminate data silos, providing a comprehensive overview of medical histories, reducing errors, and enhancing care coordination. Insurance and supply chain settlements, facilitated by blockchain-based systems, authenticate organizations, track transactions, and automate contract terms. The technology verifies the credentials of medical staff, enhancing transparency and trust. A particularly impactful use case is IoT security for remote monitoring, especially relevant in the post-COVID era. Blockchain-driven solutions for remote patient monitoring enable healthcare providers to access vital patient data remotely, fostering proactive and preventative care (CyberPanel, 2023).

Further, blockchain technology significantly contributes to the economic aspects of healthcare by offering cost-effective solutions and optimizing resource allocation in healthcare systems (Bompelli et al., 2021). Its decentralized nature eliminates the need for centralized authorities, reducing administrative costs and facilitating a more judicious use of resources. This economic impact aligns with broader goals of improving the efficiency and sustainability of healthcare delivery. Bocek et al. (2017, in Singh et al., 2023) propose a global Health Management System (HMS) in healthcare, connecting patients, doctors, insurers, pharmacists, and researchers. Blockchain innovatively addresses challenges in insurance and claims, patient care, pharma supply chain, neuroscience, telemedicine, medical research, genomics, and electronic health records (EHRs) (Krousel-Wood et

al., 2018, in Singh et al., 2023). Implementing a blockchain-based HMS involves a proposed solution: block creation, patient identity management, data management and interoperability, and consensus and security. Smart contracts are integral to the blockchain solution, and analyzing popular development frameworks aids in platform selection. Comparing traditional and blockchain-based HMS reveals advantages in decentralization, security, and interoperability. Critical challenges include data storage scalability, data access reliability, privacy and security concerns, complex decentralized architecture adaptation, lack of legislative standards, ownership and governance issues, operational cost constraints, low adoption, transparency conflicts, and vulnerability to selfish miners' attacks (Singh et al., 2023).

Ali et al. (2023) introduce a proposed architecture for a healthcare metaverse, combining Explainable Artificial Intelligence (XAI) and Blockchain (BC) technologies. The architecture comprises three environments: the doctor or physician, the metaverse, and the patient. The goal is to provide virtual health services with immersive experiences using artificial intelligence and blockchain. The article details the functionalities of each environment, the role of blockchain in securing data, and the integration of XAI for transparent and explainable AI-based healthcare decisions. Algorithms are presented for the artificial intelligence model and the blockchain-based network, emphasizing the logical flow of data and operations. Comparative analysis with related works and a discussion of metaverse healthcare advantages and challenges are also included. The overarching theme is the potential transformation of healthcare through the convergence of cutting-edge technologies in a virtual, secure, and transparent environment (Ali et al., 2023).

- **Challenges**

The adoption of AI and blockchain into healthcare within developing countries introduces significant security challenges that require careful consideration. As Adnan Naseemullah (2022: 2225: 2239) argues, developing countries face a much more complex and constrained global political economy when adopting such advanced technologies today. Drawing from his critique of ‘dependent development’, this section explores how AI and blockchain technologies are influenced by, among others, the shifting role of state autonomy in the post-neoliberal global order. It addresses how these external power imbalances—alongside local economic and regulatory barriers—affect healthcare systems in developing nations, particularly by limiting opportunities for fully autonomous technological adoption and growth.

The aggregation of sensitive patient data in these systems makes healthcare providers prime targets for cybercriminal activities, putting the entire healthcare system’s integrity at risk (Moore, 2023). In developing countries, where cybersecurity infrastructure is often weak or non-existent, these

systems are even more vulnerable. Privacy breaches targeting AI algorithms, such as membership and property inference attacks, pose substantial risks by potentially divulging confidential information (Moore, 2023). To add, AI systems are susceptible to attacks like data input poisoning and model extraction, which could corrupt training data or help adversaries create competitive models (Moore, 2023). These challenges are particularly difficult to manage in developing countries due to limited financial and technical resources to safeguard against such complex security threats.

Beyond security, the integration of AI in healthcare also raises concerns regarding unemployment, especially in administrative roles (CHG-MERIDIAN, 2021). In developing countries, where healthcare systems already struggle with workforce shortages and economic challenges, automating administrative tasks could lead to job losses without adequate plans for retraining or transitioning workers to new roles. This can have severe socio-economic impacts, as the loss of low-skilled jobs is harder to absorb in economies where opportunities for re-employment are limited. As AI alters healthcare operations, developing countries must develop comprehensive workforce strategies to prevent exacerbating unemployment and social inequality. What is more, AI systems' reliance on large datasets presents another challenge: the accuracy and reliability of AI tools are closely tied to the quality of training data. In developing countries, where diverse datasets may be harder to obtain due to privacy laws or cultural sensitivities, AI systems risk providing inaccurate responses or diagnoses (FutureLearn, 2023). The under-representation of certain ethnic or socio-economic groups in training datasets further compounds this issue, leading to AI systems that may reinforce healthcare disparities (Ohiri, 2023). The absence of high-quality, representative data makes it difficult for healthcare providers to trust and deploy AI tools effectively, particularly when the goal is to provide equitable healthcare access.

Blockchain technology also faces significant challenges in healthcare within developing countries. One of the primary obstacles is the lack of sufficient infrastructure, such as reliable internet connectivity and electricity, especially in rural or underprivileged areas (Reddy, 2021; Casey et al., 2020). Blockchain systems require continuous internet access and stable power for proper operation, and without these, the technology cannot function as intended. In many developing countries, inconsistent infrastructure makes blockchain deployment nearly impossible, limiting the technology's potential for securing patient data and facilitating transparent healthcare operations. Scalability is another major issue with blockchain in developing countries. The computational power and energy consumption required to maintain blockchain networks—especially those using energy-intensive proof-of-work mechanisms—are often unaffordable (J et al., 2023). Many developing countries struggle with energy shortages and high electricity costs, making it difficult to scale blockchain systems effectively. Even if blockchain offers long-term benefits in data security

and transparency, the initial costs of infrastructure setup and energy consumption can be prohibitive for resource-limited healthcare systems.

In addition, healthcare systems generate vast amounts of data, and blockchain's current capacity to manage large datasets is limited. The processing power and storage required to maintain and verify blocks in a blockchain network could strain healthcare infrastructure, making it less efficient than traditional systems (AbdelSalam, 2023; Esmaeilzadeh, 2022). Further, different healthcare entities use various standards for data management, and blockchain's lack of interoperability with existing systems complicates integration (El-Gazzar and Stendal, 2020). Security vulnerabilities are also a concern. Although blockchain is often marketed as secure due to its immutability, this characteristic introduces risks. For example, private permissioned blockchains are susceptible to a "51% attack", where if a single entity gains control of the majority of the network's computational power, they could manipulate or alter the data (El-Gazzar and Stendal, 2020: e17199). Also, public blockchains, widely used for cryptocurrency, consume an immense amount of energy due to the consensus mechanisms they rely on. This poses sustainability challenges, especially for energy-intensive healthcare operations (Esmaeilzadeh, 2022).

Another significant challenge is privacy. Blockchain's immutability conflicts with regulations such as the General Data Protection Regulation (GDPR), which allows individuals to request the deletion of their data. In healthcare, where patients' sensitive data must be protected, blockchain's inability to fully erase information could result in legal and ethical conflicts (AbdelSalam, 2023). While storing patient data off-chain and using blockchain for pseudonymized information might be a workaround, this creates further complications in terms of data security and privacy compliance (El-Gazzar and Stendal, 2020). Finally, the complexity of blockchain technology itself could be a barrier. Most healthcare organisations and professionals may not have the technical expertise required to implement and maintain blockchain systems. This could lead to reliance on external consultants, raising operational costs and further complicating its adoption (AbdelSalam, 2023). Moreover, the lack of clear return on investment, combined with high upfront costs, means that many healthcare institutions might find blockchain an impractical solution for their needs (Esmaeilzadeh, 2022). Thus, while blockchain offers promising applications, these significant technical, regulatory, and organisational challenges raise concerns about its viability in the healthcare sector.

Legal and regulatory frameworks also present significant hurdles. Blockchain's decentralised nature often conflicts with existing privacy and data protection laws, creating regulatory challenges (Miliard, 2018, in Schinckus, 2022). In developing countries, where regulatory systems may be underdeveloped or slow to adapt to new technologies, ensuring compliance with global standards

like the EU's General Data Protection Regulation (GDPR) becomes difficult. Without clear legal frameworks to manage the use of blockchain in healthcare, healthcare providers may be reluctant to adopt the technology, fearing legal and privacy risks. Environmental concerns further complicate blockchain adoption in developing countries. Proof-of-work consensus mechanisms, widely used in blockchain, are energy-intensive and have a significant environmental footprint (Schinckus, 2022). In countries where energy is already a scarce and expensive resource, the high energy demands of blockchain systems pose a major barrier. These countries may not have access to renewable energy sources or the financial capacity to support such energy consumption, making blockchain unsustainable in the long term. This is especially concerning in healthcare, where reliable, low-cost solutions are needed to support large-scale systems without exacerbating energy shortages or increasing costs.

Finally, both AI and blockchain require significant financial investments and technical expertise for successful implementation. Developing countries, which often face budget constraints in healthcare, may struggle to allocate sufficient resources for these technologies (Chatterjee and Dethlefs, 2022). The costs of acquiring the necessary infrastructure, maintaining systems, and training healthcare professionals to effectively use AI and blockchain are substantial. This financial barrier, coupled with a shortage of skilled professionals in AI and blockchain, limits the capacity of healthcare systems in developing countries to adopt these technologies. Without proper investment and capacity-building initiatives, AI and blockchain remain out of reach for many healthcare providers, hindering their potential to transform healthcare delivery in these regions.

2.2. Healthcare Development in Post-Colonial Kenya (1963–2013)

Kenya's healthcare system, deeply influenced by colonial legacies, continues to struggle with structural inequalities, which contribute to its ongoing reliance on external medical expertise, pharmaceuticals, and funding. During the colonial period, the healthcare system was primarily designed to serve European settlers, with minimal consideration for the indigenous population. This created a foundation of unequal access that has persisted post-independence, affecting the development of a self-sustaining healthcare system. Although Jomo Kenyatta, Kenya's first president, sought to address poverty, disease, and ignorance, the healthcare system remained underfunded and inefficient (Achieng, 2023). According to Baynham (1989), Kenya's post-independence economy, heavily shaped by its colonial past, maintained a strong reliance on the UK and Western powers, reflecting the limited capacity to fully manage its healthcare needs independently.

Globalisation and neoliberal policies further entrenched Kenya's reliance on external resources, as foreign aid, external investments, and imported technology became essential to sustaining healthcare services. This was especially evident during Daniel Moi's presidency (1978-2002), when Structural Adjustment Programs (SAPs) imposed by the International Monetary Fund (IMF) and World Bank led to reduced government spending on public services, including healthcare. The introduction of user fees made healthcare less accessible to the poor, exacerbating inequality and increasing dependence on foreign donors to fill the funding gaps (National Treasury, 2001). Moi's government redirected its focus from traditional export crops like coffee and tea—primarily grown in regions politically opposed to him—toward cereals, which benefitted his political base in the Rift Valley. This policy shift, combined with economic mismanagement, severely weakened Kenya's overall economic productivity, including the healthcare sector (Kanyinga, n.d.). This entrenched a cycle of dependency that persisted long after Moi's tenure, shaping the challenges faced by Kenya's healthcare sector today.

Under Mwai Kibaki's presidency (2002-2013), Kenya made notable strides in healthcare reform, particularly in addressing the HIV/AIDS epidemic, with the introduction of subsidised antiretroviral treatments (ARVs) and prevention programs (Munene, 2022). However, this progress was largely driven by external aid from international organisations such as the Global Fund and PEPFAR, highlighting Kenya's continued dependence on foreign funding (ReliefWeb, 2006). While these initiatives significantly improved healthcare access and outcomes, including a rise in life expectancy from 51 to 66 years (ReliefWeb, 2006), the healthcare system's reliance on external support remained a limitation. For instance, Kibaki's refusal to sign the National Social Health Insurance Fund (NSHIF) Bill due to concerns about sustainability and affordability reflected the ongoing challenges in developing a self-reliant healthcare financing model (Koon, Hawkins, and Mayhew, 2020).

Kenya's healthcare system continues to struggle with the adoption of foreign models and technologies that do not fully align with local needs. Imported medical equipment and pharmaceuticals often fail to suit the realities of rural healthcare settings, where infrastructure is lacking, and maintenance costs are high. What is more, Kenya remains reliant on external medical expertise, particularly for specialised care, which further impedes the development of a robust, locally managed healthcare system. Despite efforts to reform healthcare financing, such as the introduction of free primary healthcare and ARV access under Kibaki, a significant portion of healthcare funding still comes from out-of-pocket payments (32%) and donor contributions (26%), rather than sustainable government or insurance-based mechanisms (APHRC, 2015). Baynham (1989) points out that Kenya's economy, shaped by its post-independence history, has undergone

significant changes, with agriculture, industry, and tourism playing key roles in its development. However, the uneven distribution of resources and economic instability—particularly during Moi's administration—has left Kenya vulnerable to external pressures. The healthcare sector, in particular, has been affected by these economic shifts, as external aid continues to play a crucial role in sustaining essential services like HIV/AIDS treatment and malaria prevention programs.

That said, this section provides a comprehensive analysis of Kenya's healthcare development from 1963 to 2013, exploring the challenges, reforms, and progress made in the health sector, influenced by both colonial legacies and the policies of successive post-independence administrations—while also highlighting the country's persistent reliance on external resources and the ongoing need for sustainable, self-sufficient healthcare reforms.

2.2.1. 1963–1978: Early Independence

Kenya's healthcare system has been shaped by the dual forces of colonial legacies and the leadership of its first president, Jomo "Mzee" Kenyatta. He was determined to address the pressing issues of poverty, disease, and ignorance, that plagued the nation at independence. His commitment to these goals placed healthcare at the heart of his vision for Kenya's post-independence development. Despite notable progress, the healthcare sector continued to face significant challenges, including inefficiencies in county referral hospitals, inadequate financing, and shortages of essential resources such as drugs and equipment (Achieng, 2023). Shirk (2019) highlights the important role of mission hospitals, such as Kijabe Hospital, in shaping Kenya's healthcare, recounting how Dr. Bill Barnett, during his return to Kijabe, reminded President Uhuru Kenyatta of his father's commitment to supporting these institutions. Between 1963 and 1978, hospital beds tripled, and government hospitals increased to 52% by 1978. However, the healthcare budget's share of national expenditure declined from 8% in 1964 to 5% by 1992. Infectious diseases, respiratory illnesses, and musculoskeletal conditions remained the leading causes of morbidity, with over 88% of outpatient visits related to preventable diseases (Nganda, 1994: 16-37, 223).

During the colonial period, healthcare systems were predominantly designed to serve European settlers, with limited consideration for the indigenous population. Medical services established by the Imperial British East Africa Company (IBEAC) primarily catered to Europeans and Indians, neglecting indigenous Kenyans, whose healthcare needs were often met by mission hospitals and traditional medicine. It was only in the 1920s and 1940s that dispensaries and health centres began to serve indigenous populations (Gatumu, 2017; Chaiken, 1998: 1701-1714). By the mid-20th century, preventive health measures and decentralised services had been introduced, but these were underfunded and focused more on disease prevention than curative care (Chaiken, 1998:

1712-1714). The colonial emphasis on preventive care and decentralisation laid the groundwork for some post-independence health policies (Otieno, 2023; Gatumu, 2017; Chaiken, 1998). Kenyatta's Harambee philosophy, which promoted collective effort and community-based development, played a key role in the growth of schools and hospitals after independence (Nyangena, 2003: 1-15).

This period of healthcare development, influenced by both colonial legacies and Kenyatta's leadership, serves as a benchmark for evaluating progress in Kenya's healthcare system. However, challenges related to healthcare financing, access, and quality persist, underscoring the lasting impact of structural inequalities that have shaped the system since the colonial era (Otieno, 2023; Chaiken, 1998; Shirk, 2019; Gatumu, 2017). While Kenya has made significant strides from the colonial period through post-independence, systemic challenges endure. The foundations laid by Kenyatta's Harambee philosophy and the colonial focus on preventive care have shaped modern approaches to healthcare. Nevertheless, issues such as inadequate financing, unequal access to services, and inefficiencies—particularly in rural areas—continue to demand reform.

Kenyatta's leadership was also characterised by policies aimed at economic development, land reform, and social unity. He championed Pan-Africanism and sought to create a self-sufficient Kenya through land redistribution and national unity, though his legacy is mixed. Despite being celebrated as a national hero, his government faced criticism for authoritarianism, ethnic favouritism, and corruption. Some critics argue that his policies failed to address interethnic tensions and land ownership disparities (BHM, 2023). The 1963/64 budget, presented shortly after independence, aimed to ensure economic stability and public welfare during the transition to self-governance. Significant allocations were made for development projects, including land settlement schemes, agricultural expansion, and infrastructure improvements. Revenue was primarily generated through customs duties, income taxes, and a new estate duty tax on inheritances. However, the government faced a £5 million deficit, which it sought to address through additional customs duties on motor vehicles, textiles, and luxury goods (National Treasury, 2021).

At the time, Kenya's economic conditions were challenging, with modest GDP growth of 8% in 1962, driven mainly by agricultural recovery. Concerns over rising unemployment, slow growth in the cash economy, and limited capital investment prompted the government to promote both local and foreign investment by offering incentives. The budget prioritised education, healthcare, and agriculture, although some cutbacks were made, including reductions in funding for non-African schools and the suspension of the Kenya Regiment. Foreign assistance was crucial, with Kenya receiving significant support from the British government, including £10.5 million for development

projects and £15 million[2] for recurrent expenses, which helped stabilise the country during its early years of independence (National Treasury, 2021). Key development projects included expanding agriculture, localising the civil service, and establishing an industrial development finance company. The budget also proposed setting up a Central Bank for East Africa and developing hydroelectric power at Seven Forks to meet future energy needs. In conclusion, the 1963/64 budget reflected a delicate balance between managing fiscal deficits, promoting development, and securing foreign aid, while maintaining essential public services and fostering long-term economic growth (National Treasury, 2021). The legacy of development in Kenya, shaped by colonial inequalities and the aspirations of its founding fathers, remains a crucial framework for evaluating future healthcare advancements.

2.2.2. 1978–2002: The Era of Autocracy and Economic Decline

David Moi's administration, spanning from 1978 to 2002, experienced significant fluctuations in both economic performance and healthcare development. At the start of his tenure, Moi inherited a stable economic foundation from Jomo Kenyatta, supported by high export prices for commodities like coffee and tea. This economic stability enabled Moi's government to focus on rural development, with investments in healthcare and education. The 1977/78 budget speech by Finance Minister Mwai Kibaki reflected optimism, with increased government spending in key sectors such as agriculture, health, and infrastructure. However, Kibaki also cautioned against over-reliance on the fluctuating export prices of coffee and tea, vulnerabilities that soon became evident (National Treasury, 1977). Over Moi's 24-year rule, Kenya's economy deteriorated. While the economy grew by 6.9% in 1978, this dropped to 0.6% by 2002. Agriculture, the backbone of Kenya's economy, collapsed multiple times during his presidency. Moi's reliance on loyalty-based appointments, particularly from his ethnic group (Kalenjin, Maasai, Turkana, Samburu), weakened key sectors, as many appointees lacked the necessary expertise to manage public institutions. His personalisation of policymaking further destabilised the economy, with policies often announced at public rallies, leaving technocrats scrambling to interpret and implement them. Public participation was minimal, and institutions like the Treasury struggled to adapt to Moi's unpredictable directives. Furthermore, his administration manipulated agreements with international financial institutions like the World Bank and IMF, often failing to comply after receiving funds. Moi also shifted focus away from traditional export crops like coffee and tea—grown in regions opposed to him—towards maize and wheat, benefiting his home region, the Rift Valley. This shift, coupled with neglect of formal economic rules, significantly reduced Kenya's economic productivity (Kanyinga, n.d.). As a result, Moi's administration left Kenya with a weakened economy and a healthcare system deeply reliant

[2] Owing to the government of the time, the Kenyan budget was presented in British Pounds (GBP)

on external support, setting the stage for continued challenges in achieving sustainable development and self-reliance in the years that followed.

In healthcare, Moi's administration initially made strides in expanding access to basic services, particularly in rural areas. The early years focused on primary and preventative healthcare, with a 14% increase in health spending noted in the 1977/78 budget. However, as the economy declined in the 1980s and 1990s, the healthcare system suffered. The introduction of user fees under Structural Adjustment Programs (SAPs) made healthcare less accessible to the poor, exacerbating inequality. Government funding for health services dwindled, leading to shortages of medicines and equipment, and leaving hospitals and clinics severely under-resourced. By 2001/02, the healthcare system had deteriorated significantly, with indicators such as infant mortality and life expectancy worsening. The HIV/AIDS epidemic in the 1990s further strained the fragile system, exposing its lack of preparedness for major crises (National Treasury, 2001; National Treasury, 1977). By the mid-1980s, Kenya's economy stagnated due to external market shifts and internal mismanagement, including rising corruption. Under pressure from the IMF and World Bank, Moi's government adopted SAPs, which required reduced government spending and economic liberalisation, leading to job losses and a reduction in public services. Finance Minister Chris Okemo's 2001/02 budget speech highlighted the worsening economic situation, with fiscal deficits, high unemployment, and a reduced capacity to fund essential services. By this time, Kenya also faced growing international isolation due to governance issues, further limiting economic growth (National Treasury, 2001).

Moi’s legacy is often associated with his philosophy of peace, love, and unity, a continuation of Kenyatta’s “Harambee” slogan (Presidential Library and Museum, 2022). Upon taking office, Moi promoted national unity and avoided internal conflicts, an achievement considering regional instability. His commitment to peace extended across Africa, particularly during his tenure as Chairman of the Organization of African Unity (OAU) from 1981 to 1983. A notable healthcare achievement under Moi was the expansion of services through the construction of Nyayo Wards in district hospitals and the establishment of Moi Referral Hospital in Eldoret. However, due to economic challenges and World Bank/IMF policies, cost-sharing was introduced, marking a shift away from fully subsidised services. Mohammed Guleid (2018) points out that Moi's approach, rooted in African Socialism, encouraged local fundraising and community support for healthcare, with additional assistance from multilateral organisations like WHO and UNICEF. While this expanded healthcare services, the sector faced challenges in later years due to economic difficulties and underfunding (Guleid, 2018).

By the 1990s, Kenya’s healthcare system had deteriorated, with declining service quality and accessibility due to reduced government expenditure and inefficient resource utilisation (Muga et

al., 2005: 13-26). The doctor-to-population ratio worsened, and many rural areas struggled with inadequate service provision. Although the government introduced the National Health Sector Strategic Plan (NHSSP-I) from 1999 to 2004 to decentralise and reform healthcare, weak management and poor monitoring hindered progress. The cost-sharing policy, intended to bridge funding gaps, proved problematic as rising poverty left many unable to afford even minimal fees. Consequently, healthcare outcomes declined, with infant and child mortality rates rising, immunisation coverage falling from 78% in 1993 to below 60% by 2003, and maternal mortality remaining high despite slight improvements (Muga et al., 2005: 13-26). Preventable diseases such as malaria, respiratory infections, and diarrhoea remained significant burdens, particularly in rural areas where facilities were understaffed and underfunded (Muga et al., 2005: 13-26). The healthcare system's decline during this period further exacerbated inequalities in access to essential services, particularly for rural populations, and hindered Kenya's progress toward achieving better health outcomes and sustainable healthcare development.

In 2001, Moi launched a national social health insurance scheme to address these challenges and provide affordable healthcare. However, the scheme faced legal obstacles, with concerns over its legal framework and criticisms from opposition members in parliament regarding its hasty implementation (Siringi, 2004: 1291). Although the scheme aimed to reform the healthcare system, it only offered comprehensive coverage to a small portion of the population, primarily the wealthy and MPs (Siringi, 2004: 1291). Moi’s administration also targeted population growth through the Kenya Population Project, funded by a KSh1.9 billion loan from the World Bank. This initiative integrated family planning into maternal and child health services to reduce Kenya’s high fertility rate, which was one of the highest in the world in the 1970s. By 2022, the birth rate had declined to an average of 3.4 children per woman, thanks to greater education, career opportunities for women, and the increased use of family planning methods (Omondi, 2024). The final loan payment was made in February 2024 (Omondi, 2024). Despite these efforts, Moi's healthcare legacy is mixed. While his initiatives, such as the establishment of Moi Referral Hospital, laid a foundation for future healthcare expansion, they were insufficient to fully address the healthcare needs of the population. By the end of his presidency, inefficiencies and inequities in healthcare persisted, particularly in rural areas. Efforts to reform the system, such as the national social health insurance scheme, faced significant legal and structural challenges, leaving much of the population without comprehensive coverage. Although Moi's early successes laid some groundwork, ongoing issues, including rising poverty and a strained health sector, highlight the need for continued reforms to achieve equitable and effective healthcare in Kenya (Presidential Library and Museum, 2022).

Essentially, while Moi's administration made some strides in healthcare, particularly with initiatives like the National Social Health Insurance Scheme and the Kenya Population Project, these efforts were limited in scope and impact. The persistent inefficiencies, legal challenges, and uneven access to services, especially in rural areas, left many Kenyans without adequate healthcare coverage, underscoring the need for more comprehensive and sustainable reforms in the years that followed.

2.2.3. 2002–2013: Democratic Consolidation and Healthcare Reforms

Tran (2002) reflects on the economic challenges Kenya faced as Emilio Stanley Mwai Kibaki succeeded Daniel arap Moi as president in 2002. Moi's tenure, though initially promising, saw the country fall into widespread corruption and economic decline. Despite Kenya's relative political stability, the economy stagnated from the 1970s onwards, leading to severe poverty and a decline in living standards. Kibaki inherited a fragile economy where domestic investments and savings had plummeted, and GDP growth was far outpaced by population growth. Once economically comparable to Singapore, Kenya had fallen behind, with rampant corruption leading to a freeze in foreign aid. Kibaki's top priorities were to restore free schooling, which had been discontinued in the 1980s, and to combat corruption. The international community, especially foreign donors, eagerly awaited Kenya's progress in addressing its corruption issues, as aid had been suspended due to corrupt practices during Moi's government. Kibaki's anti-corruption stance rekindled optimism, leading the Kenyan shilling to its highest value in 21 months. However, the economy, still heavily dependent on agriculture—especially tea, coffee, and horticulture—was vulnerable to low global commodity prices and recurrent droughts, which devastated the sector. Tourism, another critical component of the economy, suffered after a terrorist attack in Mombasa in 2002. Despite these challenges, many Kenyans hoped that Kibaki would steer the country toward economic recovery, with expectations of job creation and better governance (Tran, 2002).

President Mwai Kibaki's administration, which spanned from 2002 to 2013, saw notable economic growth and infrastructural improvements, albeit with challenges. Early in his presidency, Kibaki addressed the country's HIV/AIDS crisis by launching campaigns to increase access to antiretroviral treatments (ARVs) and promoting prevention strategies (Munene, 2022). Life expectancy rose from 51 to 66 years during his tenure, and the health sector made advances, including the elimination of ARV treatment fees and the expansion of community-based healthcare strategies (ReliefWeb, 2006). However, Kibaki's refusal to sign the National Social Health Insurance Fund (NSHIF) Bill, due to concerns over its affordability and sustainability, marked a significant setback in healthcare reform (Koon, Hawkins, and Mayhew, 2020). Economically, Kibaki's administration introduced free primary education, which benefitted millions of children, although it led to overcrowded schools and strained resources, resulting in a decline in educational

standards (Munene, 2022). In healthcare, mixed results were evident. A significant portion of healthcare spending went towards recurrent costs such as salaries and drug supplies, with 60% allocated to curative care and only 16% to preventive measures (APHRC, 2015). The reliance on out-of-pocket payments (32%) and donor funding (26%) reflected an urgent need for a more sustainable healthcare financing system (APHRC, 2015). Despite political instability following the 2007 elections and persistent corruption, Kibaki's healthcare and economic reforms laid a foundation for future progress, with notable investments such as the Aga Khan University Hospital's Heart and Cancer Centre (AKDN, 2011).

In May 2003, President Kibaki launched a "total war on AIDS" in response to Kenya's severe AIDS crisis, which resulted in between 500 and 700 deaths daily (KFF, 2003). His efforts included subsidising ARV treatment for 40,000 HIV/AIDS patients, endorsing condom use, and emphasising the importance of the epidemic in government programmes (KFF, 2003). Kibaki's support for the 'ABC' prevention model (Abstain, Be faithful, use Condoms) mirrored Uganda's successful strategy. His commitment earned praise from international figures such as Stephen Lewis, U.N. Special Envoy for HIV/AIDS in Africa (KFF, 2003). However, Kibaki unexpectedly refused to sign the 2004 NSHIF Bill, despite Parliament passing it in December. Concerns about its technical design and affordability were cited as reasons for the decision (Koon, Hawkins, and Mayhew, 2020). Political tensions and a perceived rivalry between Kibaki and former Minister of Health Charity Ngilu also contributed to the bill's rejection (Koon, Hawkins, and Mayhew, 2020). Despite the setback, Kibaki's government remained active in combating diseases. The National Malaria Programme, launched in 2005, was funded by the UN Global Fund and aimed to reduce malaria mortality, which caused around 34,000 child deaths annually (Mail & Guardian, 2005). President Kibaki's commitment to distributing over 3 million insecticide-treated nets and increasing ARV access highlighted his focus on preventive healthcare (Muchangi, 2022).

In 2009, President Kibaki introduced the Community Health Strategy as part of the Kenya Essential Package for Health (KEPH), which emphasised empowering households and communities in healthcare delivery. This strategy focused on disease prevention, family health, hygiene, and health promotion, involving various actors from community health workers to health facility personnel (Tupange Pamoja, 2017: 1-10). Kibaki also launched a national anti-malaria campaign that aimed to distribute 60,000 insecticide-treated nets and reduce malaria-related child deaths by half. Private sector contributions, amounting to KSh 30 million, played a crucial role in funding this initiative (Mail & Guardian, 2005). In response to calls from advocates, Kibaki was urged to declare tuberculosis (TB) a national disaster due to its high mortality rate. Advocates emphasised the need for specific TB legislation, streamlining drug procurement processes, and increasing research into

new TB treatments. International criticism was directed at the World Bank for its comparatively low healthcare funding for TB in Africa (KFF, 2009).

In January 2010, Kibaki reaffirmed Kenya's commitment to combating HIV/AIDS, with plans to prevent mother-to-child transmission and expand ARV access (ReliefWeb, 2010). His administration made significant strides in HIV testing and ART provision, receiving praise from UNAIDS Executive Director Michel Sidibé (ReliefWeb, 2010). In 2009, national HIV testing campaigns exceeded their targets, and Kibaki's Infection, Prevention, and Control Plan (IPCP) addressed TB control, HIV/AIDS, and malaria challenges. By 2011, 48% of TB patients with HIV were receiving ART, though further progress was needed to align with WHO recommendations (WHO, 2012: 1). Kibaki's administration also garnered international recognition for malaria control efforts. Kibaki received the African Leaders Malaria Alliance (ALMA) Award in 2011 for progress in eliminating tariffs on malaria supplies, as well as prohibiting the use of a single drug to treat the disease—owing to concerns over drug resistance (Capital News, 2011). In terms of healthcare spending, Kibaki's administration allocated KSh 234 billion[3] to healthcare in the 2012-2013 Kenya Health Accounts, which constituted 7% of GDP (APHRC, 2015). Of this, 93% was directed towards recurrent expenses such as salaries and drug supplies, while only 7% was allocated for capital expenditure. The majority of funds went to curative care (60%), while preventive measures received just 16%. A substantial 20% of healthcare spending was used for governance, health system, and financing administration, rather than health promotion or disease prevention. Healthcare financing remained heavily reliant on households' out-of-pocket payments (32%), government taxes (31%), and donor contributions (26%), with only 13% coming from health insurance. This highlighted the pressing need for more sustainable financing to reduce donor dependency and enhance the long-term sustainability of Kenya's healthcare system (APHRC, 2015).

All in all, despite Kenya's significant strides in healthcare, including expansion of services and the implementation of reforms, the system remains deeply influenced by colonial legacies, political decisions, and economic constraints. The reliance on donor funding and inconsistent domestic investment have hindered the full realisation of a sustainable, equitable healthcare system. Ongoing reforms, such as those initiated by Mwai Kibaki's administration, have laid important foundations, but systemic issues like inequality, underfunding, and the need for more robust healthcare financing mechanisms persist. Kenya's healthcare progress is a testament to leadership efforts across various regimes, but achieving self-sufficiency and addressing long-standing structural challenges will require continued reforms, better resource allocation, and reduced reliance on external aid.

[3] Approx. US$1.6 billion

2.3. Methodology: Research Design, Ethics, and Limitations

In the evolving landscape of healthcare technology, a nuanced and adaptable research approach is crucial for capturing the full impact of innovations like AI and blockchain. Although this study is primarily qualitative, it integrates numeric data as a complementary tool to support and contextualise the findings. The qualitative analysis focuses on examining literature, policies, reports, and case studies related to AI and blockchain technologies in Kenya's healthcare system. To further enrich the analysis, numeric data—such as health outcomes and system efficiency metrics from 2015 to 2024—is studied where available. This approach provides a more robust understanding of the impact of these technologies on healthcare delivery, ensuring that qualitative observations are grounded in measurable trends and outcomes. However, the emphasis remains on thematic exploration, with the quantitative data serving to enhance and substantiate the qualitative insights. Given the scarcity of comprehensive data in Kenya's health technology sector, this approach is essential for capturing the nuanced impacts of these technologies.

The study focuses on five case studies to provide an in-depth understanding of their broader implications for healthcare delivery in the country. The qualitative methods used are outlined in subsequent sections, highlighting their contributions, strengths, and limitations in critiquing the deployment of AI and blockchain in healthcare settings. A case study approach is adopted, examining five key AI and blockchain initiatives within Kenya's healthcare framework. These case studies draw on a detailed review of relevant literature, policy documents, and vision statements from organisations leading healthcare innovation and sustainability efforts in Kenya. Projects such as AfyaRekod's blockchain-enabled electronic health records management, Tambua Health's AI-driven lung-sound analysis, Ilara Health's AI-integrated diagnostics, PanaBIOS' AI and blockchain-based disease surveillance, and Sophie Bot's AI chatbot for sexual and reproductive health are selected based on their significant impact on healthcare outcomes, efficiency, accessibility, and innovation. The study employs thematic analysis to interpret the qualitative data (Nowell et al., 2017), ensuring a comprehensive critique of AI and blockchain technologies within the post-2015 Sustainable Development Goals (SDGs) framework, thus maintaining relevance to global health and development agendas. To analyse the case studies in this thesis, I will employ the analytical framework of Ndzendze and Marwala (2023), who explore the dual potential of emerging technology to deepen or disrupt global dependencies. This framework is applied to assess how Kenya's healthcare initiatives can reflect broader trends in technological readiness and FDI. In doing so, I aim to evaluate whether these initiatives signal a departure from traditional dependency theory or a continuation of dependency through new technological means.

The research design relies on qualitative methods to ensure that the findings are valid and meaningful. By focusing on context-specific case studies, the approach offers a detailed critique of AI and blockchain technologies in healthcare. The study employs reflexivity and transparency to ensure that conclusions are responsibly drawn, contributing both to academic discourse and providing practical insights for policymakers, healthcare providers, and technology developers working to integrate AI and blockchain into healthcare systems.

Qualitative Analysis

The role of qualitative analysis in reviewing literature, policies, reports, and vision statements is crucial in this study. For instance, Martínez-García et al. (2019: 1-2) emphasise the importance of adapting qualitative research methodologies to effectively analyse the wealth of data available in the healthcare sector—particularly within healthcare institutions, policies, and practices. They also highlight the necessity for user-friendly tools and the careful selection of qualitative research methods to yield meaningful outcomes. Dalglish, Khalid, and McMahon (2020: 1424-1430) note that document analysis is a widely used method in health policy research, despite limited guidance on its application in analysing health policy. The READ approach—comprising the steps to *Ready materials, Extract data, Analyse data,* and *Distil findings*—offers a systematic framework for conducting document analysis in qualitative policy research. This approach enhances researchers' capacity to efficiently navigate extensive documentary data, producing meaningful outcomes from their analysis of healthcare documents (Dalglish, Khalid, and McMahon, 2020: 1426-1430). Bowen (2009: 27-40) also discusses the significance of documents in qualitative research—particularly in case studies, as they enable an in-depth examination of specific phenomena, organisations, or events. Such studies benefit significantly from the rich insights provided by various types of documents.

Bowen (2009: 27-40) highlights that document analysis offers both advantages and limitations. While it provides unique insights, it also faces challenges related to validity, reliability, and representativeness. These concerns can be mitigated through triangulation, which involves comparing data from multiple sources, ensuring a sufficient sample size, and incorporating member checking and peer debriefing (Maxwell, 2005, in Dalglish, Khalid, and McMahon, 2020: 1425). Document analysis is often used in conjunction with other qualitative methods, allowing for cross-verification of findings and reducing bias, as noted by Prior (2003, in Dalglish, Khalid, and McMahon, 2020: 1424-1425). In this study, document analysis plays a key role in examining Kenya’s adoption of AI and blockchain technologies in healthcare, offering a critique of dependency theory. This helps provide a comprehensive and context-rich understanding of the research topic.

Reflexivity in Qualitative Research

Qualitative research is an iterative process, where data collection and analysis influence each other, allowing for a continuous refinement of findings. Reflexivity plays a crucial role in this process—particularly in qualitative studies where interpretation and analysis are deeply intertwined with the researcher's perspective (Watt, 2007, in Dalglish, Khalid, and McMahon, 2020: 1430). As an African woman from a developing country with experience in blockchain-based public service solutions, I am aware of the potential biases I may bring to the research. My experience with the transformative capabilities of these technologies in advancing development has shaped my interest in how AI and blockchain are used to support development goals in other countries. By maintaining objectivity and employing reflexivity, I aim to ensure that my personal background does not unduly influence the findings. This study provides a balanced exploration of AI and blockchain in healthcare development in Kenya, contributing to the broader discourse on technology and development.

Case Study Methodology

As discussed earlier, this research adopts a case study approach to investigate five specific healthcare projects and initiatives that incorporate AI and blockchain technologies in Kenya's healthcare sector. Bowen (2009: 29-31) identifies document analysis as a particularly suitable method for qualitative case studies, as it enables an in-depth examination of specific phenomena, organisations, or events. In this study, the selected case studies focus on AfyaRekod's secure Electronic Health Record (EHR) management, Tambua Health's AI-driven lung-sound analysis, Ilara Health's AI-powered diagnostic solutions, PanaBIOS' disease surveillance using AI and blockchain, and Sophie Bot's AI chatbot for sexual and reproductive health. These case studies are designed to offer a comprehensive exploration of the role AI and blockchain technologies play in improving healthcare outcomes in Kenya.

Case studies, originally developed as a descriptive analysis tool in the 19th century by French sociologist Pierre Guillaume Frédéric Le Play, have evolved into a critical method for testing theories and solutions in contemporary research (Rivero, 2022; Freemantle, 2016: 1). Case studies facilitate an intensive analysis of complex phenomena, enabling researchers to gain nuanced insights that may not be achievable through large-scale surveys (Drew, 2023; Gaille, 2018). They offer a holistic understanding by allowing multiple perspectives and promote the investigation of rare or marginalised phenomena (Lee and Saunders, 2017, in Drew, 2023; Gaille, 2018). Case studies are particularly valuable in real-world settings where researchers cannot control variables, allowing for natural observations (Tetnowski, 2015, in Drew, 2023). However, they are limited in

their generalisability, as findings from specific case studies may not be applicable to broader populations (Drew, 2023; Williamson et al., 2018: 537-564).

Criteria for Project Selection

Following the discussion of the qualitative case study approach, this section outlines the criteria used to select the five AI and blockchain-based healthcare projects examined in this study. These criteria are essential to achieving the study's objectives. First, the projects must be based in Kenya and involve the use of AI and blockchain technologies, as the central focus of this research is to assess their impact on addressing healthcare challenges in the country. Second, the projects must actively operate across one or more of Kenya's 47 counties, ensuring their ability to tackle the unique healthcare challenges of the local context. Further, all the selected projects are led by Kenyan individuals, reflecting a commitment to home-grown solutions tailored to local issues.

Another key criterion is that the projects must have been established after 2015, aligning with the introduction of the Sustainable Development Goals (SDGs). This allows the research to evaluate the projects' contributions to achieving SDG 3, which focuses on good health and well-being. The five selected projects are as follows:

- AfyaRekod, founded in 2019 by John Kamara, employs blockchain technology to securely manage Electronic Health Records (EHRs). It has partnerships with the National Health Insurance Authority (NHIA) and IndyGeneUS to advance Universal Healthcare and precision medicine (Sendoro, 2023; Zawya, 2022).

- Tambua Health, founded in 2017 by Daniel Gathigai and Lewis Wanjohi, uses AI-driven lung-sound analysis for respiratory disease diagnosis, with plans to collaborate with Merck Pharmaceuticals for further development (Mwololo, 2018).

- Ilara Health, established in 2018, provides AI-powered diagnostic solutions to primary healthcare clinics in Kenya and offers financing options through partnerships such as with Jia. It also distributes ResAppDx, a mobile app for diagnosing respiratory diseases (CB Insights, 2023; Jia, 2023; ResApp Health, 2021: 2).

- PanaBIOS, developed by Koldchain in 2020, focuses on disease surveillance using AI and blockchain. Backed by the African Union, it collaborates with the Africa Centre for Disease Control (CDC) to implement Trusted Travel, a platform for verifying COVID-19 test certificates (Tech in Africa, 2020).

- Sophie Bot, created in 2017, is an AI chatbot that provides sexual and reproductive health information. Recognised by Nairobi Innovation Week and UNFPA's iAccelerator program, it

partners with trusted organisations to deliver reliable information (Capital Campus, 2017; Opudo, 2017).

These innovations contribute significantly to improving healthcare outcomes across Kenya by integrating advanced technologies with local healthcare systems. The projects also illustrate the potential for technological innovation to help achieve SDG 3.

Generalisability and Limitations

While the case studies chosen provide valuable insights into how AI and blockchain technologies address healthcare challenges in Kenya, it is essential to note both the scope and limitations of these findings. The selected projects reflect a range of healthcare interventions that have been effectively implemented across different contexts, including underserved peri-urban and rural areas. For example, Ilara Health and Tambua Health explicitly target peri-urban and rural clinics with their AI-powered diagnostic devices, demonstrating the potential for these technologies to reach areas where healthcare infrastructure is limited. AfyaRekod and Sophie Bot have also successfully reached mobile and underserved populations, filling critical gaps in healthcare access. PanaBIOS, developed during the COVID-19 pandemic, stands out as a large-scale initiative using blockchain for disease surveillance and bio-monitoring. By centralising health data and enabling real-time tracking of COVID-19 tests across borders, it addressed a significant public health need, ensuring safe movement in Kenya and across other African countries such as Ghana, Nigeria, and Rwanda, where the Trusted Travel platform was also adopted. This demonstrates how AI and blockchain can be used to support public health interventions even in complex, cross-border contexts.

While the projects demonstrate Kenya's capacity to leverage technology in diverse healthcare environments, it is important to recognise the specific conditions that enabled their success, such as Kenya’s evolving digital infrastructure and support from government initiatives like the Blockchain & Artificial Intelligence Task Force. These factors may not be easily replicated in other developing countries with different socio-political or infrastructural contexts. Also, the generalisability of these findings may be affected by the unique challenges of scaling these technologies to more remote regions or to countries without similar levels of technological investment.

Thematic Analysis and ChatGPT-4

In analysing the documents associated with these case studies, this study uses thematic analysis. According to Sheard (2022: 2), thematic analysis, as introduced by Braun and Clarke (2006), is a foundational qualitative research method used to identify patterns or themes in data. It involves both organising and describing data in rich detail and, when necessary, interpreting research topics. Although widely applied, thematic analysis lacks a universally agreed-upon structure, which can

lead to discrepancies in how it is used (Braun and Clarke, 2006: 79-80). Researchers applying this method must clarify their theoretical approach to ensure transparency (Braun and Clarke, 2006: 81), as the flexibility of thematic analysis allows it to be applied from multiple theoretical standpoints. Braun and Clarke (2021, in Sheard, 2022: 2) later caution that thematic analysis may sometimes be reduced to a descriptive technique, limiting its potential for deeper interpretation. Despite this, thematic analysis remains essential in qualitative research, especially for identifying themes that allow for an exploration of the role of AI and blockchain in healthcare. The thematic analysis used in this study critiques whether these innovations contribute to development or perpetuate dependency within Kenya's healthcare system.

In keeping with the technological focus of this research, thematic analysis in this study is supported by the use of ChatGPT-4, an advanced Large Language Model (LLM). ChatGPT-4's significant processing capacity enables it to compare and analyse large sets of documents. This is because ChatGPT-4 has been trained on a massive body of information, allowing it to understand complex language patterns, identify themes, and generate insights across various topics. This processing capability stems from its multi-layered neural network, which is able to capture relationships between words, sentences, and larger sections of text, making it highly effective in conducting thematic analysis. A team of researchers from Penn State University explored ChatGPT's application in enhancing thematic analysis, finding that it can effectively conduct qualitative analysis when guided by clear, well-designed prompts (Zhang et al., 2023: 1-3). Their research demonstrated how ChatGPT can mitigate some challenges faced by human analysts when properly applied. The process for using ChatGPT involves defining clear research objectives, designing prompts that ensure accuracy, and developing a prompt framework that optimises the model's performance (Zhang et al., 2023: 20-21). The model's ability to quickly parse and interpret large sets of documents allows researchers to expedite qualitative analysis, particularly when dealing with data-heavy projects. By inputting well-designed prompts, researchers can direct ChatGPT-4 to focus on specific themes or areas of interest, thereby automating parts of the analysis that would be time-consuming for humans. Despite its efficiency, human oversight remains necessary to ensure that the model's output aligns with the nuanced goals of the research and that any biases in the data are appropriately managed.

Ethical Considerations

Maintaining ethical standards is central to this research. Key considerations include the responsible use of AI tools like ChatGPT-4 for thematic analysis. The use of ChatGPT-4 in thematic analysis presents several ethical considerations. Researchers must address potential biases in AI models, ensuring transparency and maintaining human oversight to avoid skewing findings. Accountability

remains with the researchers, who should not over-rely on AI, as it cannot fully replace the nuanced understanding required in qualitative research. Data privacy and informed consent are essential, especially when handling sensitive information. In addition, proper attribution of sources used in AI-driven analysis must be ensured to respect intellectual property rights. Ultimately, while ChatGPT-4 can enhance efficiency, careful attention to ethical standards is necessary for responsible research, so human oversight is incorporated at all stages of the research to mitigate potential biases in AI-based analysis and ensure accuracy.

In addition, the study places great importance on proper attribution and intellectual property rights, especially as it relies on document analysis and secondary data. All sources are appropriately cited, and the research avoids using private data without consent. The positionality of the researcher is also considered; as an African woman with experience in blockchain solutions, I remain mindful of the influence my background may have on the interpretation of data. Reflexivity is employed throughout the research to maintain objectivity, and peer debriefing ensures the credibility of the findings.

Risk Management and Limitations

Research on rapidly evolving technologies like AI and blockchain carries inherent risks, such as over-reliance on secondary data and challenges associated with keeping pace with technological advancements. To mitigate these risks, triangulation is employed, cross-verifying qualitative and some numerical findings to enhance reliability. A limitation of this study is the inability to generalise findings beyond Kenya's healthcare system. However, the objective of the research is to provide in-depth, context-specific insights that contribute to a broader understanding of AI and blockchain's role in developing healthcare systems in other contexts.

While this study primarily relies on qualitative methods to assess the impact of AI and blockchain technologies, the absence of retained quantitative data limits the ability to measure these impacts in terms of healthcare outcomes. Future research could address this gap by collecting quantitative data, such as patient outcomes and disease control metrics, to validate the qualitative findings presented here. This mixed-method approach would provide a more comprehensive understanding of the technologies' effects.

2.4. Conclusion

The literature reviewed in this chapter underscores the intricate relationship between colonial legacies, globalisation, and the adoption of new technologies such as Artificial Intelligence (AI) and blockchain in Kenya's healthcare system. Colonial rule established unequal healthcare structures, which continue to influence Kenya's dependency on external medical expertise, pharmaceuticals,

and funding. Despite efforts to reform its healthcare sector, globalisation and neoliberal policies have further entrenched the nation's reliance on foreign aid, investments, and imported technologies. International organisations, such as the Global Fund and USAID, play a crucial role in healthcare funding; however, this dependence perpetuates Kenya's reliance on external resources. Moreover, while the adoption of foreign healthcare models and technologies—including AI and blockchain—offers opportunities for innovation, it also highlights the limitations of relying on solutions that are not fully customised to local needs.

The decision to focus on AI and blockchain technologies in Kenya's healthcare sector, instead of other technologies, arises from their transformative potential to address specific challenges that other solutions may not fully resolve. While technologies such as telemedicine, mobile health (mHealth), and basic electronic health records (EHRs) have contributed to some improvements, AI and blockchain present more advanced and comprehensive solutions that align with Kenya's goals of enhancing healthcare delivery and promoting technological readiness. AI offers significant advantages by enabling the analysis of large volumes of healthcare data, leading to improvements in diagnostic accuracy, treatment planning, and resource allocation. For example, AI can assist in diagnosing diseases like tuberculosis, malaria, and cancer more accurately and efficiently than traditional methods. This is particularly relevant in Kenya, where healthcare infrastructure, especially in rural areas, lacks sufficient specialised medical expertise. Furthermore, AI automates routine tasks, reduces human error, and enhances healthcare delivery efficiency, facilitating more equitable access to quality care across the country. Blockchain technology, in contrast, is vital in ensuring transparency, data security, and trust in Kenya's healthcare system.

Unlike other technologies, blockchain offers a decentralised and immutable ledger that secures sensitive patient data, protects the integrity of medical records, and allows seamless information sharing between healthcare providers. In a country where data management issues and healthcare fraud are persistent challenges, blockchain's ability to provide a tamper-proof system ensures that patients' medical information is secure and accessible only to authorised personnel, fostering trust within the healthcare system.

Kenya's healthcare system, like many in developing countries, is highly fragmented, with various healthcare providers and facilities using incompatible systems. AI and blockchain have the potential to unify these fragmented systems by enabling real-time data sharing and creating secure, interoperable networks. Blockchain ensures the accuracy and security of healthcare data, while AI processes this complex information to improve decision-making and care coordination. Together, these technologies can bridge gaps between healthcare providers, leading to better patient outcomes and a more cohesive healthcare system. Further, AI and blockchain could reduce Kenya's reliance

on foreign healthcare solutions and expertise. By investing in these technologies, Kenya can foster local innovation and decrease dependency on external healthcare models that may not align with its local context. As some scholars observe, countries that improve their technological readiness, especially in AI, are more likely to attract foreign direct investment (FDI) and enhance their global standing. This positions Kenya to develop a more self-reliant healthcare system, reducing its dependence on foreign aid and external resources.

In conclusion, while AI and blockchain hold the potential to transform healthcare in Kenya, their success will depend on how well they are integrated into a system still shaped by historical inequalities and global economic forces. Long-term healthcare reforms must prioritise local adaptability, sustainability, and autonomy, reducing reliance on external models and fostering an inclusive approach to healthcare innovation. Having explored the foundations and applications of AI and blockchain in healthcare, as well as the historical development of Kenya's healthcare system, the next chapter, titled *Theoretical Framework: Dependency Theory*, will introduce the theoretical framework of dependency theory, which will guide the critical analysis of Kenya's healthcare challenges.

3. Theoretical Framework: Dependency Theory

The origins of dependency theory—tracing back to Vladimir Lenin's *Imperialism, the Highest Stage of Capitalism* (1916)—highlight its roots in critiquing the global capitalist system. Lenin's analysis of imperialism laid the foundation for understanding how advanced capitalist nations exploit peripheral economies. This early conception was further developed in 1949 with the emergence of the *Prebisch-Singer hypothesis* by Hans Singer and Raúl Prebisch, which formally introduced the theory into mainstream economic thought (Perera, 2023: 2). Singer and Prebisch observed that peripheral nations, reliant on raw material exports, could purchase fewer manufactured goods from developed nations over time, contributing to their underdevelopment (Singer, 1950: 473-485; Prebisch and Cabañas, 1949: 347-431). The theory's evolution continued with the historical-structural variant, which underscores the role of interest networks—such as businesses, technocrats, and the military—in linking local processes with global interests, thus shaping the nature of dependency in diverse ways (Sánchez, 2003: 35-46). This more nuanced version rejects the deterministic view of dependency and acknowledges potential changes in international relations over time. As a response to the limitations of modernisation theory, dependency theorists—such as André Gunder Frank and Samir Amin—along with proponents of world-systems theory like Immanuel Wallerstein, shifted the focus to external relationships in development (Shrum, 2001: 13608-13609; Warf, 2001: 14744-14745). This particularly highlighted the role of multinational corporations in perpetuating unequal exchange. In this context, AI and blockchain technologies present both opportunities and challenges for developing countries, especially when viewed through the lens of dependency theory. The continued struggle of periphery nations, as providers of raw materials and markets for industrialised countries, remains relevant as Kenya attempts to integrate cutting-edge technologies into its healthcare system amidst global dependencies.

For this exploration, this chapter is organised chronologically. It begins with the early foundations of the theory from 1916 to the 1950s, exploring the pivotal ideas of Lenin and the post-war emergence of the Prebisch-Singer hypothesis. This phase marks the formal birth of dependency theory, which challenged traditional economic paradigms and laid the groundwork for future scholarly contributions. The next section examines the 1960s and 1970s, a period when dependency theory gained significant traction—particularly in Latin America. During this era, scholars like Andre Gunder Frank and Walter Rodney expanded the theory, emphasising the exploitative dynamics of global capitalism and its impact on underdeveloped regions. Their work highlighted the structural obstacles that hinder development in the periphery and focused on the role of multinational corporations and colonial histories in perpetuating economic dependency. Moving into the 1980s and 1990s, the theory faced various critiques and challenges. Scholars such as

Dudley Seers, Immanuel Wallerstein, and Amartya Sen broadened the discourse on development, incorporating multidimensional approaches that accounted for poverty, inequality, and human capabilities. Wallerstein's world-systems theory, in particular, extended the analytical scope of dependency theory by examining the systemic nature of global inequalities. Finally, the chapter delves into contemporary debates from the 2000s to the present. This section explores how scholars like Samir Amin, Maristella Svampa, and South African researchers Bhaso Ndzedze and Tshilidzi Marwala have revisited and adapted dependency theory to address modern concerns such as neo-extractivism, technological dependency, and the Fourth Industrial Revolution. These contemporary perspectives illustrate the ongoing relevance of the theory in analysing global economic inequalities and offer insights into how developing nations might navigate the evolving challenges of globalisation and technological advancement.

In tracing the historical trajectory of dependency theory, this chapter provides a comprehensive analysis of its foundational principles, key critiques, and modern adaptations, shedding light on its enduring relevance in the study of global underdevelopment.

3.1. 1916–1950s: Early Foundations and Post-War Emergence

Proponents of dependency theory—like André Gunder Frank, Samir Amin, and Fernando Henrique Cardoso—argue that global capital accumulation is a driving force behind underdevelopment. This perspective challenges the prevailing notion that adopting Western development models ensures prosperity in the developing world. Instead, dependency theory posits a symbiotic relationship between development and underdevelopment, where wealth is consistently extracted from less affluent regions for the benefit of the developed world (Shrum, 2001: 13608-13609). Walter Rodney famously describes this dynamic as "a relationship of exploitation" (Rodney, 1973: 14: 22). Further, dependency theory critiques the role of science and technology in development, suggesting that the control and distribution of technological and scientific resources exacerbate the dependence of developing nations on more advanced economies. By advocating for the use of 'appropriate' technologies tailored to local conditions, the theory seeks to bridge the knowledge gap and promote more equitable development (Shrum, 2001: 13608-13609). The theory's analysis of core-periphery relations reveals the exploitative interactions that shape the global economic and political structures, particularly the way dominant core nations manipulate peripheral economies (Perera, 2023: 1-8; Sonntag, 2001: 3503). A tangible manifestation of this dynamic is seen in Latin America's response through Import-Substituting Industrialisation (ISI), showcasing the influence of dependency theory on economic policies (Love, 1980: 45-63).

Historically, dependency theory has evolved through complex debates and analyses, involving individuals, institutions, and nations. The theory has been shaped by various forms of dependency, ranging from colonialism to contemporary financial-industrial relationships with multinational corporations (Rojas, 1970). The roots of dependency theory trace back to Vladimir Lenin's 1916 critiques, with its formal emergence marked by the 1949 Prebisch-Singer hypothesis[4], which challenged existing economic paradigms (Perera, 2023: 2). According to Sánchez (2003: 35-46), dependency theory's historical-structural variant also emphasises the role of various interest networks—including businesses, technocrats, the military, and the middle class—in linking local processes to global interests. The Great Depression of 1929–1939 played a significant role in shaping the economic perspectives that influenced the development of dependency theory, particularly in Latin America, where commodity prices collapsed, and export-oriented economies were severely impacted (Yergin and Stanislaw, 2002; Love, 1980: 47-51). The Great Depression was a global economic downturn that originated in the United States with the stock market crash of October 1929, but quickly spread worldwide—severely impacting economies across North America, Europe, Latin America, and other regions, This led to massive declines in output, high unemployment rates, and a collapse in international trade; many export-oriented economies, particularly in Latin America, were hit hard by the sharp drop in commodity prices during this period.

In response to these conditions, Latin American economists like Raúl Prebisch began to critically examine the vulnerabilities of peripheral economies within the global capitalist system. Raúl Prebisch, through his negotiations between the Bank of England and Argentina's Central Bank, became a central figure in the development of dependency theory, advocating for protectionist trade policies and import-substitution industrialisation (Singer, 1950: 473-485; Prebisch and Cabañas, 1949: 347-431). Prebisch's ideas built upon earlier scholars like Werner Sombart, providing a comprehensive analysis of centre-periphery relations and contributing to the solidification of dependency theory (Love, 1980: 45-63). The influence of figures like Theotônio Dos Santos—who directed the Centro de Estudios Socio-Económicos (CESO) in Chile—further expanded the theory. Dos Santos' research on the interdependence of economies integrated social and political dimensions into the theory, highlighting the class and political relations within dependent countries (Kay, 2019: 599-623). In 1967, Dos Santos initiated a research team dedicated to studying dependency relations in Latin America, presenting a seminal 14-page progress report a year later (Kay, 2019: 599-623). Dos Santos's definition of dependence focused on interdependence between economies, integrating social and political dimensions into his analysis, emphasising internal class

[4] See Prebisch and Cabañas (1949) and Singer (1950)

and political relations within dependent countries, and, linking them with dominant nations (Kay, 2019: 599-623).

Together, these foundational developments underscore the importance of dependency theory in shaping global economic thought.

3.2. 1960s–1970s: The Rise and Expansion of Dependency Theory

During the 1960s and 1970s, dependency theory gained significant traction, especially through the contributions of scholars like Andre Gunder Frank. His work, particularly *Capitalism and Development in Latin America*, became instrumental in shaping the discourse on global underdevelopment (Cardoso, 1977: 7-11). Frank, a left-wing economist and activist, argued that underdevelopment was not a product of internal failings but rather a consequence of deliberate actions by developed Western nations to hinder the progress of less-developed countries. His concept of "the development of underdevelopment" framed dependency theory as a critique of global capitalism, wherein wealthier nations exploit poorer ones, perpetuating inequality (Simon and Ruccio, 1986: 195-207). Frank's model, which focused on power-based relationships, employed three forms of explanation: Structural, Functional, and Intentional. These explanations illuminated how imbalances between "metropoles" and "satellites" perpetuate underdevelopment, maintaining a global order that benefits the core at the expense of the periphery (Simon and Ruccio, 1986: 195-207).

Walter Rodney's seminal work, *How Europe Underdeveloped Africa*, similarly influenced the dependency theory discourse by providing a historical analysis of African underdevelopment rooted in colonial exploitation. Rodney argued that European imperial powers, driven by profit, engaged in the transatlantic slave trade and resource extraction, severely undermining Africa's social and economic development (Wengraf, 2021). His analysis underscored how imperialism and colonialism entrenched economic subjugation in African societies, making them dependent on the capitalist systems of their former colonial powers (Rodney, 1973). Rodney's critique extended beyond external forces, urging Africans to recognise their role in challenging the structures of exploitation that continued to oppress them. Accroding to Wengraf (2021), Rodney's work also challenged the racist ideologies used to justify colonialism, revealing the dehumanising impact of European conquests on African societies.

Despite the initial success of dependency theory in Latin America during this period, the limitations of import substitution policies—which had been championed by scholars like Frank—soon became apparent. While these policies aimed to reduce dependency by promoting domestic industrialisation, they failed to achieve sustainable economic development. As a result, the shift

towards a policy of reindustrialisation, particularly in Argentina, did not fully resolve the structural dependency issues that plagued the region (Weissenbacher, 2017: 82). As Maristella Svampa (2014: 17) explains, Argentina's reliance on agricultural and extractive exports following the end of *Convertibilidad* in 2002 exemplified a new form of dependency, where economic stability remained contingent on global commodity prices. This neo-developmental agro-extractive model, though different from the earlier industrial strategies, continued to expose Argentina's vulnerability to external market fluctuations (Svampa, 2014: 17). Aníbal Quijano also played a pivotal role in Latin American sociology during this time, contributing to the evolution of dependency theory by integrating insights from Marxist thought, particularly the ideas of José Carlos Mariátegui. Quijano's work challenged Eurocentric assumptions and emphasised the importance of indigenous communities and social practices in understanding Latin America's socio-economic dynamics (Vegliò, 2021: 663-678). He was instrumental in critiquing the simplistic centre-periphery model, arguing for a more nuanced understanding of urbanisation, marginalisation, and the role of local elites in perpetuating colonial power dynamics (Bhambra, 2023). Ultimately, his contributions led to a re-evaluation of strategies for tackling economic dependency, moving away from the rigid frameworks of earlier dependency theorists.

So, while the 1960s and 1970s saw the rise and expansion of dependency theory—with significant contributions from scholars like Andre Gunder Frank, Walter Rodney, and Aníbal Quijano—the theory still faced challenges. The limitations of import substitution policies—combined with evolving global economic conditions—prompted a rethinking of dependency dynamics. These developments shaped the future of the theory, making it more adaptable to the changing socio-political landscape while continuing to critique the structures of global capitalism.

3.3. 1980s–1990s: The Challenges and Critiques of Dependency Theory

As a response to the criticisms and limitations of dependency theory, scholars, and researchers such as Dudley Seers, Immanuel Wallerstein, Samir Amin, and Amartya Sen emerged as key figures during the 1980s and 1990s. These thinkers engaged in vibrant debates, offering alternative perspectives on development and expanding the scope of dependency theory.

Dudley Seers, a prominent British/New Zealand economist specialising in development economics, played a crucial role in shifting development discourse away from a narrow focus on economic growth towards a more holistic approach that included social development. According to the Institute of Development Studies (2023), Seers advocated for a multidimensional view of poverty and development, emphasising the need to address poverty, inequality, and unemployment alongside economic growth. He believed that development should broaden opportunities and

improve the well-being of individuals, not just focus on economic indicators (Ayodele, 2022: 3-4). His work marked a departure from the growth-centric views that dominated the post-World War II era, and he applied these ideas during his engagement in international politics, particularly during the political upheavals in Chile under President Allende. In his 1969 work *The Meaning of Development*, Seers challenged the narrow definition of development as economic growth, proposing that development should also be evaluated through improvements in social well-being, specifically addressing poverty, unemployment, and inequality (Emeh, 2013: 117). Seers argued that genuine development must encompass improvement in all these areas, aligning his views with Walter Rodney's notion of universal development. Both thinkers believed that development should be driven by common human needs, rather than by economic measures alone. Seers extended his critique in his 1983 book *The Political Economy of Nationalism*, where he challenged both Marxist and conventional Western economic theories, arguing that they underestimated the significance of nationalism in development processes (Seers, 1983). Seers further contributed to the reassessment of dependency theory through his collaboration on the 1981 publication *Dependency Theory: A Critical Reassessment*. He acknowledged that dependency theory's analysis of structural deprivation, including hunger, powerlessness, and lack of infrastructure, was insightful, but noted that its lack of practical policy realism limited its applicability (Ayodele, 2022: 3-4; Seers, 1981). Seers emphasised that a comprehensive approach to development should reduce deprivation, discrimination, and conflict, integrating human rights and conflict reduction into economic development strategies.

Immanuel Wallerstein, an American sociologist and economic historian, developed the world-systems theory in the 1970s as a direct response to dependency theory. His work built upon the structural critiques offered by dependency theorists but expanded their scope to a global level. In *The Modern World-System* (1970), Wallerstein analysed global social systems, emphasising the interactions between core, semi-peripheral, and peripheral regions within the capitalist world economy (Martínez-Vela, 2001: 2; Petras, 1981: 148). His theory posited that global capitalism operates as a world-economy driven by market integration rather than a centralised political authority. Wallerstein's world-systems theory shifted the unit of analysis from nation-states to the global system, arguing that economic development and underdevelopment were two interrelated processes within the capitalist world system. His theory highlighted how core nations (the developed countries) maintained their dominance by exploiting peripheral regions (the developing countries), which were relegated to supplying raw materials and labour while consuming capital-intensive goods from the core. Semi-peripheral states, such as Brazil, India, and South Africa, occupied an intermediary position with a mix of core and periphery characteristics (Goldfrank, 2000, Skocpol, 1977 and Wallerstein, 1974, in Petras, 1981: 148). Wallerstein's

contributions expanded the critique of dependency theory, providing a more comprehensive analysis of global inequality that continues to influence contemporary academic discourse on global development, inequality, and power dynamics.

Samir Amin's contributions to the debate on dependency theory during the 1980s and 1990s were pivotal in reshaping the discourse. Amin, an Egyptian-French economist, argued that underdevelopment and development are two sides of the same global capitalist process. His concept of "de-linking" was central to his critique of the global economic system. For this, Amin (1987) advocated that peripheral nations must break away from the structures of global capitalism to achieve genuine development: however, delinking does not mean isolation, but developing strategies that prioritise the needs of the nation rather than the demands of the global market. His ideas of *auto-centred development* argued that nations could achieve sustainable development by focusing on domestic needs and restructuring their economies away from external dependence. Amin's criticism of the global capitalist system expanded on dependency theory by highlighting the ways in which both economic and political processes were intertwined in maintaining inequality between the Global North and South. He critiqued the simplistic notion of development that many dependency theorists held, instead offering a more nuanced approach that recognised the agency of nations in the periphery to break free from their dependency through strategic economic policies. His work on unequal exchange also added a critical layer to dependency theory, focusing on how the terms of trade systematically disadvantaged the Global South, perpetuating cycles of underdevelopment. Amin contended that only through delinking and a break from the global capitalist logic, could developing nations alter their subordinate status in the world economy. Thus, Amin's contributions during this period expanded the critiques of dependency theory by addressing its limitations and offering a more radical approach to development. His ideas resonated with the broader critiques of the Washington Consensus and offered an alternative vision for countries seeking to escape the entrenched structures of global inequality.

Amartya Sen, a renowned Indian economist and Nobel laureate, also challenged the conventional tenets of dependency theory during this period by proposing a capabilities approach to development. His work emphasised that measuring development solely through economic growth did not offer a comprehensive understanding of human well-being (Jacobson, 2017). Instead, Sen argued that development should be assessed based on individual freedoms, including access to healthcare, education, and political participation. This focus on individual agency and well-being represented a significant departure from the structuralist focus of dependency theory, which centred on the global capitalist system as the primary determinant of underdevelopment. Sen's 1999 *Development as Freedom* redefined development as the expansion of freedoms, moving beyond

traditional measures such as Gross National Product (GNP) growth or industrialisation (Sen, 1999: 36). He argued that true development was achieved through the removal of various forms of "unfreedom", such as poverty, lack of education, and political oppression, which prevented individuals from living the lives they valued (Sen, 1999: 3-33).

Sen's capabilities approach opened new avenues for understanding development by highlighting the importance of human welfare and individual agency. His ideas were instrumental in the creation of the Human Development Index (HDI) by the United Nations Development Programme (UNDP), which incorporated measures of life expectancy, education, and income to assess development. One of Sen's notable contributions was his analysis of famines, particularly the Bengal famine of 1943. He argued that famines were not solely caused by food shortages, but were often the result of entitlement failures and state policy mismanagement (Selwyn, 2023). While Sen's work illuminated the adverse effects of capitalist development, he has been critiqued for placing too much faith in market mechanisms and for underestimating the role of collective action and class struggle in achieving genuine human development (Selwyn, 2023). Nonetheless, Sen's capabilities approach challenged the dependency theory's structural focus by emphasising the role of individual freedoms and well-being in assessing development. This period marked a shift away from the rigid, economic-centric models of dependency theory, introducing more nuanced, multidimensional approaches that considered political, social, and individual factors in global development.

3.4. 2000s–Present: Contemporary Debates: Neo-Extractivism, Technological Dependency, and the Fourth Industrial Revolution

In the 2000s and beyond, contemporary debates on dependency theory reflect a shift from the earlier focus on purely economic dependencies and critiques of capitalist exploitation, towards a more nuanced understanding of development—which now incorporates social, political, technological, and environmental dimensions. This evolution reflects a growing recognition of the complexity of global inequalities and the need for comprehensive approaches to address both development and underdevelopment.

Scholars such as Aníbal Quijano (1962–2007), Samir Amin (1972–2013), Maristella Svampa (1994–2016), Bhaso Ndzedze (2017–2023), and Tshilidzi Marwala (2005–2024)[5] have been instrumental in advancing and reshaping the discourse on dependency theory in these areas. Starting in the early 1990s, Quijano's focus shifted towards decolonial theory, particularly the concept of coloniality of power. He advocated for challenging Eurocentric rationality and decolonising social, cultural, and political-economic relations. His concept of coloniality of power examined both

[5] Years in parentheses show years the scholars produced pertinent work.

external and internal domination, emphasising the need for intercultural communication and the reconstitution of knowledge (Bhambra, 2023). In his 2007 paper *Coloniality and Modernity/Rationality*, Quijano critiques the traditional modernity dichotomy and the notion of historical-structural heterogeneity by highlighting how these concepts have been shaped within a colonial framework that privileges European culture and knowledge systems (Quijano, 2007: 168-178). Quijano argues that the emergence of modernity and rationality—as understood in European terms—was intertwined with colonialism, which established a global power dynamic that marginalised and exploited "non-European" peoples and cultures (Quijano, 2007: 169). This process involved the suppression of indigenous knowledge and practices, as well as the imposition of Western cultural standards as the universal norm—leading to a distorted view of history and social structures that overlooks the diverse, heterogeneous realities shaped by colonial histories (Quijano, 2007: 177). Accordingly, Quijano (2007: 177-178) calls for an epistemological decolonisation that values the multiplicity of ways of knowing and organising society, challenging the colonial underpinnings of modernity and promoting a more inclusive understanding of human development and progress. For Bhambra (2023), Quijano, influenced by dependency theory, explored themes of exploitation, domination, racial discrimination, economic exploitation, gender violence, cultural subordination, and environmental degradation. Quijano expanded the discussion to include Latin America in post-colonial discourse, challenging Eurocentric perspectives and advocating for a holistic understanding of dependency and coloniality of power in the modern/postcolonial world system (Misoczky, 2019: 5-6; Lynch, 2018).

Drawing on Quijano's work, Sabelo Ndlovu-Gatsheni provides critical insights into the interconnectedness of dependency and decolonial theories. He shows how dependency theory evolved into the broader framework of decoloniality, so as to offer a more comprehensive understanding of global inequalities. Ndlovu-Gatsheni (2015: 16-20) critiques the historical and structural aspects of dependency that were not only economic but also deeply epistemic and cultural, emphasising the "theft of history" and the suppression of African knowledge systems. He highlights that dependency theory initially focused on the economic subjugation of the Global South through capitalist exploitation; however, as the theory evolved, it began to address the ways in which colonialism entrenched not only material exploitation, but also the intellectual and cultural domination of colonised people (Ndlovu-Gatsheni, 2015: 13-35). Ndlovu-Gatsheni (2015: 15) then asserts that Africa's integration into global modernity occurred through these enduring matrices of power—which continue to constrain the continent's trajectory, manifesting in both economic dependency and the marginalisation of African epistemologies. Smith and Lester (2009: 196-219) extend this conversation by examining how postcolonial states struggle to recover from the colonial legacy: they argue that while dependency theory effectively critiques the economic dimensions of

inequality, it is insufficient for understanding the full scope of the challenges faced by postcolonial societies. In the context of contemporary debates on neo-extractivism, technological dependency, and the Fourth Industrial Revolution, these two frameworks together offer a more robust analysis of the challenges faced by developing countries. As Ndlovu-Gatsheni (2015: 24-25) points out, the technological advances of the Industrial Revolution risk reinforcing existing patterns of global inequality—unless developing nations actively engage in decolonial strategies that challenge the Eurocentric paradigms of modernity and development. Therefore, the genealogy of dependency theory and decoloniality is one of evolving critique, where the economic focus of the former is expanded by the latter to include cultural, epistemic, and political dimensions. This creates a more comprehensive framework for understanding global inequalities.

Samir Amin, the Egyptian-French economist, also made significant contributions to development economics and critiqued Eurocentric perspectives on capitalism and imperialism. Amin's concepts of delinking and auto-centred development have been particularly relevant in understanding underdevelopment and polarisation within the global accumulation of capital (ROAPE, 2021). For Kvangraven (2022), Amins delinking involves rejecting the imperatives of globalised capitalism and prioritising economic strategies that address the needs of the nation's people over international capital. In *A Note on the Concept of Delinking*, Amin (1987: 435-436) articulates that delinking is not synonymous with complete withdrawal from commercial, financial, and technological exchanges, but rather a strategic refusal to let external forces dictate national development strategy. The aim is to develop autonomously, engaging with the world on terms that prioritise national development objectives over global market demands (Amin, 1987: 442-444). Ultimately, Amin (1987: 435-444) emphasises that underdevelopment and development are interconnected, and that peripheral countries must critically "break" from the global capitalist system to achieve autonomous development. Amin's ideas, particularly regarding delinking, have inspired scholars like Ajl (2020: 82-101), who explores the ecological dimensions of Amin's theories in the context of North African dependency, focusing on sustainable agricultural practices.

Ajl's work further underscores the relevance of Amin's theories in advocating for development models that integrate ecological principles and reduce dependency. Amin's contribution to dependency theory is notable for its creative and multidisciplinary approach. As Kvangraven, Styve, and Kufakurinani (2021: 2-7) highlight, Amin's global historical materialism framework explores the complexities of political conflicts, class interests, and core-periphery relations. His critique of globalisation emphasises the increasing centralisation of capital and its detrimental effects on peripheral countries, exacerbating global inequalities (Kvangraven, 2017: 12-15). Amin's method, which begins with an analysis of global economic structures, explores the dynamics of

imperialism and unequal exchange, extending beyond the core-periphery framework by recognising the significance of various classes across both core and periphery regions (Amin, 2010, in Kvangraven, Styve and Kufakurinani, 2021: 2). His critique of contemporary globalisation, especially financialisation, provides insights into how centralised capital control exacerbates social problems in the Global South (Kvangraven, 2017: 12-15). Samir Amin's influence extends to the ecological realm as well. Ajl (2023) explores Amin's ecological theories in the context of climate change and imperialism, highlighting the need to incorporate ecological sustainability into national development strategies.

Similarly, Maristella Svampa, an Argentine researcher, sociologist, writer, and activist. Her extensive body of work dates back to the early 1990s and covers a wide range of topics, including the evolution of Perónism and the social movements sparked by Argentina's economic crisis at the turn of the century. These movements are associated with the ideologies and leadership of Juan Domingo Perón, characterised by a mix of populist, labour, and nationalist elements. She also explores the complexities of extractive capitalism, dispossession, and peasant and indigenous politics (Webber, 2017). Further, an article by the School for International Training (SIT, n.d.) notes that Svampa is a leading figure in critical interdisciplinary studies related to energy issues and is actively engaged with the Group of Alternative Development. In these fields, Svampa's work primarily focuses on neo-extractivism and environmental issues in Latin America. Extractivism, as a development model, focuses on the large-scale extraction of natural resources, often in minimally processed forms, for export. This model supports an undiversified production framework and relies on international suppliers of raw materials (Gudynas, 2015, in Murillo et al., 2019: 6). According to Gudynas (2009, 2015, in Murillo et al., 2019: 6), this practice has evolved, now characterised by intensive resource use, including water and energy. Both traditional and progressive forms of extractivism in Latin America, driven by state dynamics and market demands, share negative environmental and social consequences (Murillo et al., 2019: 6). The transition away from extractivism, Murillo et al. (2019: 51) argue, requires policies that balance environmental and social considerations, addressing production limits, consumption thresholds, poverty, and wealth redistribution. This shift involves moving from "predatory extractivism" to a "ensible extractivism" with stricter controls and the internalisation of environmental impacts, alongside strategic state control of natural assets to reduce export dependence (Murillo et al., 2019: 6-51). In doing so, the aim is to break away from reliance on external markets for natural resource exports.

The extractivist model, particularly in the face of declining international commodity prices, has deepened economic crises in certain countries, revealing the failure of governments to diversify their economies and their continued reliance on primary product exports. In an interview with

Gerardo Muñoz, a scholar of Modern Languages and Literature, Svampa underscores how this volatile model involves public sector job cuts, inflation, pro-business policies, rising utility costs, and limited social benefits, favouring a select few (Muñoz, 2016: 145). However, ongoing socio-environmental movements, including those focused on territory, indigenous rights, and feminism, challenge these hierarchical views by emphasising eco-dependence and advocating for non-exploitative relationships with nature (Muñoz, 2016: 144-154). In North African nations like Morocco, extractivism—particularly in phosphates, minerals, and fossil fuels—has benefited a privileged few through export earnings and foreign investments, yet it has exacerbated societal disparities (Feminist Economics, 2023). This context underscores the need to rethink dependency in extractive economies.

In the two-part book *Debates latinoamericanos: Indianismo, desarrollo, dependencia, populismo*[6], Svampa (2016) addresses four main debates in the first part: Indianism, development, dependency, and populism. In the section on dependency, Svampa (2016: 13-26) revisits the concept in a contemporary context, arguing for its ongoing relevance in understanding Latin America's global economic position and internal inequalities. She critically assesses how the legacy of dependency—intertwined with coloniality—continues to shape the region's development and challenges the structural dynamics of global capitalism (Svampa, 2016: 13-26). By integrating dependency theory with discussions on indigenous issues, development, and populism, Svampa underscores the importance of engaging with Latin America's intellectual heritage and socio-political realities. These perspectives remain crucial for understanding ongoing struggles for equitable and autonomous development in the region. As Vasconcelos (2022: 247) notes, the debates Svampa tackles have had a significant impact on political parties, labour unions, and social movements, challenging conventional ideas of progress, capital accumulation, and development (Vasconcelos, 2022: 248). For example, in an interview with writer and translator Jessica Sequeira, Svampa recalls:

> "I structured my book … into the four categories … because these themes were prominent in Latin America from 2000 to 2015, and their interplay significantly shaped the regional political landscape. Indigenous struggles gained momentum, challenging the prevailing notion of development in the era of extractivism … These categories were in tension and articulation [in the region], reflecting the complexity of the regional political stage. [So,] I wanted to provide a nuanced understanding of existing populisms, avoiding both uncritical praise—associated with Argentine philosopher Ernesto Laclau–and overly critical perspectives from the right-wing press" (Sequeira, 2022: 324-329).

[6] Book written in Spanish

Webber (2017) highlights that Svampa addresses a "deficit of accumulation" in Latin American social theory, noting that political repression and neglect of intellectual discussions have limited the region's ability to engage with critical social theory. Svampa's work illustrates the generational and regional challenges of revisiting debates central to Latin American critical thought, which have often been sidelined. Ultimately, the book offers valuable historical contextualisation and synthesis, contributing to the understanding of dependency theory and Latin American intellectual history (Webber, 2017). Svampa (2016: 198, in Ruvituso, 2019: 34) notes that while dependency theory had a major impact on Latin America and beyond, it became a victim of its own success, with military dictatorships repressing leftist movements and exiling intellectuals. This shift, along with the region's move towards democratic systems, reshaped intellectual discussions, steering them towards political transitions (Ruvituso, 2019: 34). Essentially, Svampa's contributions critically update dependency theory by addressing contemporary economic, social, and environmental issues. Her work bridges theoretical debates with practical challenges, positioning her as an important figure in discussions of dependency, development, and social change in Latin America and beyond.

In South Africa, Professors Bhaso Ndzendze and Tshilidzi Marwala (2023) explore the impact of artificial intelligence (AI) on international relations, arguing that technological advancements could either reinforce or alter global economic disparities, presenting opportunities for developing nations to improve their standings in the Fourth Industrial Revolution (4IR). In their recent book *Artificial Intelligence and International Relations Theories (2023)*, Ndzendze and Marwala examine AI's transformative influence on global power dynamics, ethics, conflict, and the theoretical foundations of international relations (IR) through nine theoretical paradigms. While addressing dependency, they discuss the relationship between AI and dependency within the broader context of 4IR and its effect on global economic structures. They argue that a country's level of technological readiness, particularly in AI development, significantly influences foreign direct investment (FDI) flows, with nations that excel in AI attracting greater FDI and thus reinforcing existing global economic inequalities (Ndzendze and Marwala, 2023: 105-106). This dynamic aligns with dependency theory, which posits that the global economic system benefits developed countries (the core) at the expense of developing ones (the periphery). In this scenario, AI serves as a double-edged sword, potentially exacerbating the reliance of less technologically advanced countries on AI-leading nations (Ndzendze and Marwala, 2023: 107-108).

However, Ndzendze and Marwala (2023: 113-115) also highlight the potential for countries with lower AI capabilities to disrupt this cycle of dependency by improving their technological readiness, which could attract FDI and foster economic growth. This challenges the deterministic view of dependency theory by suggesting that developing nations can leverage AI and other 4IR

technologies to reduce dependency and progress towards greater economic autonomy. Their research reveals a nuanced relationship between technological readiness and FDI inflows, showing that some countries with initially low technological scores managed to attract increased FDI by improving their AI capabilities (Ndzendze and Marwala, 2023: 122-128). This finding indicates that advancements in AI can mitigate certain aspects of economic dependency, offering pathways for development that counter traditional dependency dynamics. In essence, Ndzendze and Marwala's analysis highlights the dual potential of AI in the global economic landscape, where it can both entrench and challenge existing patterns of dependency. While AI may deepen inequalities, their work submits that strategic investments in AI readiness and innovation offer developing countries the opportunity to enhance their economic standing and reduce dependence on the global core.

The contributions of these contemporary scholars have expanded the scope of dependency theory to include concerns about environmental sustainability, political autonomy, technological advancements, and social justice. While the core themes of unequal exchange and exploitation remain central, these modern adaptations reflect the changing global landscape. The integration of AI, environmentalism, and decoloniality into the conversation illustrates the ongoing relevance of dependency theory, while also demonstrating its flexibility in addressing contemporary global challenges. As a result, the current discourse around dependency theory is not merely about economic relations but also about how societies navigate the complexities of technological progress, environmental degradation, and socio-political autonomy in a deeply interconnected world.

3.5. Conclusion

Ultimately, while dependency theory provides a critical framework for understanding the historical and ongoing patterns of global inequality—particularly the exploitation of peripheral nations by core economies—it must evolve to address the complexities of the contemporary world. The rise of neo-extractivism and Fourth Industrial Revolution technologies such as AI and blockchain presents both challenges and opportunities for developing nations. While these advancements risk deepening dependency through unequal access and technological reliance, they also offer potential avenues for growth and innovation. To navigate this landscape, developing countries must strategically invest in technology, foster local innovation, and address the social and environmental costs of resource extraction. This necessitates a rethinking of traditional dependency frameworks to incorporate the dynamic role that technology and global markets now play in shaping modern economic relations.

Incorporating decoloniality into this discourse reveals a critical lens through which to view contemporary challenges such as neo-extractivism and technological dependency. True

development in the Global South requires dismantling both economic and epistemic structures of power. Decoloniality, therefore, goes beyond addressing economic underdevelopment by also restoring the cultural and intellectual sovereignty of colonised peoples. This approach underscores how colonialism impacted not only the economies of peripheral nations but also their social, cultural, and political realities, ultimately perpetuating a form of dependency that extends beyond the material realm. By investigating dependency theory through the lens of decoloniality, the genealogical link between the two becomes clear: both theories critique the global capitalist system's exploitation of the Global South, but decoloniality advances the conversation by addressing the epistemic violence and cultural subjugation that underpin these economic inequalities.

With the theoretical foundation of dependency theory in place, the subsequent chapter, titled *Healthcare Delivery in Kenya*, will turn to an analysis of Kenya's healthcare system. It focuses on key milestones in the sector, and examines the real-world applications of AI and blockchain technologies through case studies.

4. Healthcare Delivery in Kenya

Kenya's healthcare delivery system operates within a complex network of public, private, and faith-based providers, with the Kenyan Ministry of Health responsible for nearly half of the registered facilities across the country. Despite Kenya's extensive healthcare infrastructure and progressive policies aimed at universal health coverage (UHC), the nation continues to face systemic challenges that exacerbate healthcare inequality—rural regions, in particular. Key healthcare challenges include a high disease burden, insufficient healthcare workers, limited funding, poor infrastructure, and an underdeveloped health data management system. Kenya's healthcare system continues to grapple with significant public health issues such as HIV/AIDS, malaria, tuberculosis, and high maternal and child mortality rates. The government's efforts to expand access to healthcare services, improve healthcare worker availability, and increase funding have led to some progress, but these efforts have been limited by structural constraints and external dependencies. For example, the country still faces an acute shortage of healthcare professionals, particularly in rural areas, and struggles with infrastructure inadequacies, such as unreliable electricity and limited access to medical equipment.

Dependency theory helps explain these challenges by highlighting how developing countries like Kenya remain dependent on foreign capital, technology, and expertise to address their healthcare needs. Kenya's healthcare reforms are often constrained by global financial institutions, donors, and private sector actors, which limits the country's ability to independently develop and sustain its healthcare infrastructure. However, dependency is not solely external. Internally, there are challenges linked to local healthcare financing mechanisms. The National Health Insurance Fund (NHIF), for example, has faced difficulties in providing consistent and adequate coverage, leaving many Kenyans vulnerable to out-of-pocket healthcare expenses. In addition, the lack of comprehensive sexual and reproductive health education contributes to high teenage pregnancy rates and rising HIV infections among young people, particularly young women.

Presidents Uhuru Kenyatta and William Ruto have each played significant roles in advancing healthcare reforms. Under Kenyatta's administration, Kenya saw an expansion of healthcare infrastructure, the introduction of UHC pilots, and investments in maternal and child health. Notable reforms included efforts to provide free healthcare services for vulnerable populations and the introduction of the AfyaCare program in 2018, which aimed to achieve universal health coverage. Despite these efforts, the persistence of healthcare inequality and the reliance on external aid and private sector involvement limited the scope and sustainability of these reforms. For instance, Kenya's healthcare financing still heavily depends on donor funds and external

partnerships, echoing the core-periphery relationships critiqued by dependency theory. The ambitious health plans under Kenyatta, while progressive, underscored the challenges of reducing financial and technological dependence in a globalised healthcare system. President William Ruto's administration has sought to build on these foundations, introducing legislative reforms like the Social Health Insurance Bill and launching critical healthcare infrastructure projects, including a $41.7 million medical oxygen initiative in collaboration with the Global Fund and Amref Health Africa. However, the reliance on external partnerships to drive these reforms reflects ongoing dependency challenges. Although Kenya is striving to develop a more autonomous healthcare system, these partnerships still signal the continued reliance on global institutions for critical healthcare needs.

Kenya is not merely a passive actor in the global healthcare arena. Instead, the country is increasingly adopting AI and blockchain technologies to transform its healthcare system, presenting opportunities for local innovation and technological autonomy. These technologies hold the potential to disrupt the dependency cycle by fostering local solutions that address Kenya's unique healthcare challenges. The integration of AI and blockchain into healthcare delivery represents a strategic shift toward reducing reliance on external systems. AI and blockchain applications like Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS demonstrate how local innovation is addressing gaps in healthcare access, diagnostics, data management, and disease surveillance. These innovations challenge the traditional dependency paradigm by empowering local actors to develop and implement healthcare solutions tailored to the Kenyan context.

For instance, Sophie Bot, an AI-powered chatbot developed by students from Jomo Kenyatta University of Agriculture and Technology (JKUAT), provides young Kenyans with accurate, confidential sexual and reproductive health education. This innovation reduces reliance on external, often inaccessible sources of SRH information and directly addresses cultural barriers to sex education in Kenya. Similarly, AfyaRekod uses blockchain technology to create a universal patient data management system, empowering patients to control their own health data while reducing dependency on fragmented, foreign-driven health information systems. These case studies—which will be explored in greater depth later in this chapter—highlight Kenya's growing capacity to innovate and adopt technologies that align with local needs. They also raise important questions about the ethical and social implications of these technologies, such as data privacy, digital inequality, and the potential for AI bias, which need to be carefully navigated to ensure equitable healthcare outcomes.

This chapter sets the stage for a deeper exploration of Kenya's healthcare innovations, demonstrating how the adoption of AI and blockchain technologies can help challenge the

traditional dependency relationships critiqued by dependency theory. By examining these developments, we can gain a more nuanced understanding of the potential for technological autonomy in advancing sustainable healthcare development in Kenya and other developing nations.

4.1. Kenya's Healthcare Challenges: An Overview

Kenya's healthcare system operates through a network of public and private providers, which include hospitals, clinics, and health centres (Health Rights Advocacy Forum, 2023; Masaba et al., 2020). As of January 2024, the Kenyan Master Facility List (MFL) included a total of 14,504 officially registered health facilities in the country. Among these establishments, approximately 45.8% belong to the Ministry; 44.6% are under the ownership of the commercial private sector; and 9.6% are owned by Faith-Based Organisations (FBOs), Non-Governmental Organisations (NGOs), and Community-Based Organisations (CBOs) (Ministry of Health–Kenya, 2023). This extensive network of health facilities plays a pivotal role in addressing the healthcare needs of the roughly 56.2 million[7] Kenyan people (MacroTrends, 2024), serving as a crucial foundation for assessing the state of healthcare delivery in the country. Per Okoroafor et al. (2022: 3), this demographic suggests that there is the potential for reasonable geographic access to healthcare services for a significant portion of the population, with an approximate 3,857 people for every health facility—or about 300 people per health worker. According to a publication by the WHO (2017), there were 1.30 health workers per 1000 people in 2015 in Africa, equating to about 769 people per health worker—significantly below the 4.5 per 1000 (or 222 people per health worker) recommended for the achievement of SDG 3. With this, it seems the nation is doing better than the average for the African region—however, it is important to note that these figures are just averages and the actual access to healthcare can be influenced by many factors such as the distribution of facilities, transportation infrastructure, and the actual availability of healthcare workers.

Nonetheless, despite significant efforts to deliver quality care, Kenya's healthcare system continues to grapple with a substantial disease burden, with prevailing illnesses being HIV/AIDS, malaria, and tuberculosis (UNICEF, 2021a; IHME, 2019). The CDC reported that the estimated HIV prevalence among individuals aged 15-49 was 4.0% in 2021, with approximately 1.4 million people living with HIV—the same year saw 19,000 AIDS-related deaths for those aged 15 and above (World Bank, 2023b; CDC, 2021). UNICEF (2021a) highlights this as a cause for concern, as infection rates among young people (15-24) in 2020 accounted for 35% of new infections, with two-thirds of these cases occurring among young women. According to Oketch and Chelangat (2022), a 2022 World AIDS Day report reveals a troubling increase in HIV infections in

[7] As at February 2024

Kenya—the first in a decade—with over 2,000 new cases reported. This rise, adds Oketch and Chelangat (2022), is mainly due to ongoing transmission among children, adolescents, and young people, worsened by a shortage of essential supplies required for HIV treatment-related care. The new cases disproportionately affect women and girls—particularly those aged 15-24, who constituted about 70% of these infections (Oketch and Chelangat, 2022). Further, there are notable disparities in treatment accessibility, with younger individuals and residents of certain regions facing significant challenges in obtaining necessary care (Oketch and Chelangat, 2022). This situation underscores the pressing need for immediate action to mitigate these rising infections, aiming to eliminate AIDS as a public health threat in the country.

In 2021, malaria continued to pose a significant health challenge in Kenya, with nearly 3.83 million confirmed cases reported; however, that was a 23.4% decline in the number of reported infections—including presumed and confirmed cases—in 2018 (Kamer, 2023). Sadly, as Kamer (2023) adds, there were 753 new registered deaths due to malaria in the country during the same year. With tuberculosis, the burden of the disease was significant in 2020, with an estimated 139,000 people developing TB in Kenya—including 17,000 children; and coinfection with HIV affected approximately 35,000 (StopTB, 2020). Further, while the average life expectancy has improved to 66 years (from about 61) as of 2020, high child and maternal mortality rates persist (UNICEF, 2021b). In 2020, UNICEF (2021b) shows that the child mortality rate was 52 deaths per 1,000 live births, and the maternal mortality rate in 2017 stood at 342 deaths per 100,000 live births. Ultimately, timely interventions and targeted strategies are vital to reduce the prevalence of these diseases and improve overall healthcare outcomes in the country.

In addition to disease burden, insufficient healthcare workers—particularly in rural areas, inadequate funding, and poor infrastructure also pose significant challenges to Kenya's healthcare system (IntraHealth International, 2021). According to a WHO (2020) report, a major contributor to pervasive health inequalities in rural and remote areas is the shortage of available, appropriate, and motivated health workers. A study investigating nurses' views on rural posts and policy interventions in Kenya reveals that despite bold plans for scaling up priority interventions nationwide, the country faces major human resource challenges—with a special scarcity of skilled workers in the most disadvantaged rural areas (Mullei et al., 2010: 1). According to Pkhikidze et al. (2023), only 56% of primary-level health care facilities have reliable access to electricity, and a mere 15% use information and communication technology (ICT) for supply chain management. In addition, the average distance of health facilities from the nearest road of acceptable quality is approximately 2 km, with some locations facing distances as long as 95 km (Pkhikidze et al., 2023).

These findings underscore substantial challenges in ensuring accessible and efficient healthcare services on the continent, posing significant obstacles to achieving SDG in the country.

Another challenge to note is insufficient sex education—which, coupled with societal discomfort and traditional values—creates further challenges and obstacles for adults when discussing the topic with young people (Mbaka, 2017). Museka (2019) agrees with this sentiment, adding that this issue is prevalent in many African cultures, where discussions about sexual health are often considered taboo or immoral. For young people, as well, since sex education tend to be a sensitive and avoided topic in many households—both in Kenya and globally—they become hesitant to ask important questions (Opudo, 2017). As a result, young people are left to rely on personal experiences or false information for their sexual education (Digital Watch, 2018). The lack of proper information on sexual health thus leads to harmful consequences, thus further reinforcing the need for accessible, reliable, and comprehensive sex education programs. To illustrate, a study by Lindberg and Kantor (2021: 290-297) revealed that nearly half of American teenagers lack sex education that meets national standards—a scenario seemingly distant from Kenya's context yet profoundly relevant. This deficiency, Townsend (2021: 290-297) adds, has led to a surge in unwanted pregnancies, burdened foster care systems, and an increase in chronic diseases, particularly in the country's South. This example from a developed country highlights the critical nature of the issue, emphasising that the challenges and consequences of inadequate sex education transcend geographical and economic boundaries, thereby reinforcing the imperative for robust, accessible, and comprehensive sex education programs worldwide, including in Kenya. Domestically, alarming statistics from the 2022 Kenya Demographic and Health Survey (KDHS) exemplify these challenges: approximately 40% of teenage women without education have been pregnant, compared to only 5% with more than secondary education, and 15% of women aged 15–19 have experienced pregnancy, encompassing live births, pregnancy losses, and current pregnancies (KNBS and ICF, 2023: 15-18). The data presented from the KDHS 2022 not only underscore the critical issue of teenage pregnancy in Kenya, but it also sheds light on the underlying factors contributing to it, such as age, education, wealth, and geographical location.

The existing health data management system in Kenya is also inadequate, characterised by poor capture of service data at delivery points and limited information sharing (Ministry of Health–Kenya, 2022: 12). According to Osigwe (2021), Africa's general lack of data ownership and management is shown by the loss of Ebola Virus data collected by Liberia's Ministry of Health, which is now only accessible through WHO-facilitated reports. Not only that, but the lack of diversity in the data itself leads to less relevant solutions for the continent (Osigwe, 2021). However, digitising healthcare in Africa is impeded by various obstacles such as limited broadband

access, power shortages, incompatible technology, outdated equipment, and insufficient involvement of national research and development (Osigwe, 2021). Further, monopolies and commercial use of health data hinder accessibility and analytics, as health facilities lack access to the data, they upload to Kenya's District Health Information System (DHIS) (Osigwe, 2021). To address these challenges, a collaborative study involving 28 researchers from Africa, Asia, America, and Europe was conducted to design an improved Health Data Management System (HDMS) specifically tailored for Africa (Farnham et al., 2023: 1-8; Osigwe, 2021). The objective of the HDMS is to provide analytical information that supports operational decision-making and strategic planning in the healthcare sector (Farnham et al., 2023: 1-8; Osigwe, 2021). Elsewhere, the HDMS currently tracks key health indicators in sub-Saharan African countries using its District Health Information System 2 (DHIS2) subsidiary; but, despite DHIS2's widespread use in low and middle-income countries, challenges persist in maximising its potential for national and global health agendas (Farnham et al., 2023: 1-8). Nonetheless, this initiative seeks to tackle Africa's health data challenges by improving data quality and accessibility, facilitating operational decision-making in healthcare.

The recent COVID-19 pandemic has also exposed vulnerabilities and weaknesses in healthcare delivery in Kenya. Per Mohiddin and Temmerman (2020), a key challenge highlighted by the pandemic is the disparity between healthcare needs and available resources, such as specialist care and workforce availability. There is an urgent requirement for more doctors, nurses, and community health workers, who would be equitably distributed across the country (Mohiddin and Temmerman, 2020). The pandemic has thus emphasised the importance of enhanced coordination between national and county governments in healthcare delivery (Mohiddin and Temmerman, 2020). Further, a significant portion of the Kenyan population lacks health insurance, leaving many vulnerable to the financial impact of a potential high prevalence of pandemics like COVID-19 (Ouma, Masai and Nyadera, 2020: 2-5). This underscores the need to advance efforts towards universal health coverage, ensuring that all Kenyans can access necessary healthcare services without experiencing financial hardship. In a similar vein, the pandemic has shed light on the underinvestment in Kenya's healthcare sector. According to Oneko (2020), healthcare spending in Kenya has fluctuated between 6% and 7% of the total budget over the past two decades, falling short of the 15% commitment made in the Abuja Declaration. In comparison, the average healthcare spending in Africa is 10% (Oneko, 2020). This underinvestment poses a significant concern, particularly in the context of a global pandemic. Healthcare financing in Kenya stood at only 5% of GDP in 2019, emphasising the need for increased investment in the sector (WHO, 2023b; WHO, 2023a). Still, access to essential healthcare services has been gradually improving, with approximately 42% of the population having had access to such services by 2019 (WHO, 2020c).

4.2. Kenya’s Milestones in Addressing Healthcare Challenges

The healthcare sector in Kenya has undergone notable transformations over the past decade, shaped by the leadership of Presidents Uhuru Muigai Kenyatta (2013–2022) and William Kipchirchir Samoei Arap Ruto (2022–Present). Both administrations have focused on addressing critical healthcare challenges and advancing the country's progress toward universal health coverage (UHC), a central goal of the Sustainable Development Goals (SDGs) framework adopted in 2015. This section explores the key healthcare milestones achieved during these two leadership periods, highlighting the policies, initiatives, and reforms aimed at improving healthcare access, quality, and sustainability in Kenya.

By examining the unique contributions and ongoing efforts of each administration, the following subsections provide a detailed understanding of Kenya’s healthcare journey and its alignment with global health objectives.

4.2.1. Uhuru Muigai Kenyatta (2013–2022)

During Uhuru Kenyatta's presidential tenure in Kenya from 2013 to 2022, the nation's healthcare landscape witnessed ambitious reforms aimed at addressing major health challenges by improving access to quality healthcare and reducing reliance on external funding. This period was marked by a comprehensive plan that included, among others, strengthening the healthcare workforce, combating diseases like malaria and HIV/AIDS, and addressing issues such as teenage pregnancy and COVID-19 response. Despite these efforts, challenges including a shortage of health facilities and professionals persisted, highlighting the need for sustained reform. That said, this section delves into the key healthcare milestones achieved during President Kenyatta's leadership, shedding light on the challenges faced, as well as the strategies employed to move towards achieving universal health coverage (UHC) and better health outcomes.

As Kihiu (2022) and Bwire (2022) posit, Kenyatta’s administration "significantly" improved Kenya's public healthcare system, with the construction of 1,912 new health facilities in 2021—a 43.1% increase from 2013—reflecting his efforts to expand healthcare infrastructure nationwide. Kenyatta's comprehensive plan aimed at achieving universal access to free treatment. Initially focusing on expectant and breastfeeding mothers, people with disabilities, and HIV-positive patients, his vision included establishing fully equipped health centres within a 4.3 km radius of every home, expanding mobile health clinics, and enhancing healthcare workers' compensation packages (Green, 2013: 1348–1349). To fund these improvements, Kenyatta proposed a significant

increase in government funding for the healthcare sector, which marked a substantial boost compared to the existing allocation of 6.5% of the government budget. It is important to note that Kenyatta had already demonstrated a commitment to increasing health funding while serving as the finance minister in 2009, by approving a 40% increase in overall health funding by 2013 (Green, 2013: 1348–1349).

In the area of inadequate sex education, addressing the issue proved contentious. First, the Reproductive Healthcare Bill of 2014—aimed at providing comprehensive sexual education and health services to adolescents—stirred controversy due to conservative views rooted in religion, culture, and society (Gĩthĩnji, 2018). Then, the President's 2015 campaign to combat rising HIV/AIDS rates among teenagers faced further opposition and ridicule (Gĩthĩnji, 2018). Critics, influenced by conservative views on morality and sexuality, mischaracterised the bill as promoting promiscuity among minors, overshadowing the bill's intentions of empowering adolescents with knowledge to reduce HIV/AIDS, STDs, and teenage pregnancies. This resistance not only reflected the broader societal discomfort with open discussions on sex education, it also demonstrated the challenge of addressing sexual and reproductive health in a conservative society. That said, this challenge was seen in insufficient teacher training and a curriculum that still only focused on abstinence (Museka, 2019; Digital Watch, 2018; Gĩthĩnji, 2018; Mbaka, 2017). It was not until five years later that the Kenyatta administration would make another attempt to pass a reproductive rights bill.

The Reproductive Healthcare Bill of 2019 represents a comprehensive legislative framework aimed at safeguarding and promoting reproductive health rights for everyone in Kenya. This Bill outlines the responsibilities of both the National and County Governments in ensuring access to a wide range of reproductive health services—including family planning, safe motherhood, assisted reproduction, and termination of pregnancy under specific conditions (The Reproductive Healthcare Bill, 2019). It emphasises the importance of confidentiality, reproductive health of adolescents, and sets standards for reproductive health care; it also advocates for informed decisions regarding reproductive health, free from discrimination, coercion, or violence (The Reproductive Healthcare Bill, 2019). In the aftermath, Kenya witnessed a gradual but significant decline in HIV prevalence among individuals aged 15 to 49 between 2012 and 2021: from 5.5% in 2012 to 4.0% in 2021 (WHO, 2023b). This decline indicated progress in the country's efforts to combat HIV/AIDS, which was attributed to comprehensive prevention, treatment, and awareness programs. However, sustaining and strengthening these initiatives remained crucial to further reducing HIV prevalence in Kenya's population. The Reproductive Healthcare Bill of 2019, therefore, represents a significant step forward, offering a renewed opportunity to enhance the well-being of Kenyans through

informed and accessible reproductive health services. Nonetheless, the continued effort to navigate the cultural conservatism that influences public health initiatives remains crucial in the broader context of improving sexual and reproductive health outcomes in Kenya and beyond.

To continue, in 2016 IntraHealth in partnership with the Kenyan government initiated the Human Resources for Health (HRH) Kenya Mechanism—a five-year project funded by the US Agency for International Development (USAID)—which aimed at strengthening health professional training and healthcare workforce management in Kenya (IntraHealth International, 2021). How it would works is HRH Kenya focused on galvanising human resource systems, enhancing data use, and offering training programs, while also providing financial support to train over 40,000 health workers (IntraHealth International, 2021). This Afya Elimu Fund—which is a low-interest student loan program—supported healthcare trainees, while HRH Kenya standardised training curricula in collaboration with regulatory bodies and training institutions (IntraHealth International, 2021). Rick and Lal (2022) and the Africa Health Business (2020) detail the Afya Elimu Fund's crucial role in mitigating financial barriers for Kenyan nursing students through low-interest educational loans. This innovative model has mobilised over $16 million since 2017 to support over 22,000 beneficiaries—with an over 50% representation of women; and, by enabling students from underserved communities to pursue nursing, the fund contributes to building a robust healthcare workforce essential for responding to health crises like COVID-19 (Rick and Lal, 2022; Africa Health Business, 2020: 11). HRH Kenya also fostered county-level partnerships to improve health workforce management, resulting in stronger relations and timely issue resolution. The participation of private hospitals—with financed health workers' training in exchange for a commitment to work for a predetermined period (Africa Health Business, 2020: 4)—further enhances the sustainability of this initiative, demonstrating an effective strategy for expanding healthcare access and quality in Kenya. Not only that, but the integration of iHRIS—a health workforce information software—further enhanced the Ministry of Health's ability to track and manage the health workforce during healthcare emergencies (IntraHealth International, 2021).

Then, in 2017—despite the hurdles he faced in 2014 and 2015, President Uhuru Kenyatta signed the Basic Education Amendment Act Bill into law, which codified providing schoolgirls who have reached puberty with free sanitary pads (Ouko-Awori, 2021). While this was part of a broader program aimed at enhancing girls' access to education, the initiative involved the distribution of 140 million sanitary pads over the four months after April 2018 (Gender & Affirmative Action, 2018; Gelardi, 2018). Kenya has always been a pioneer in improving access to menstrual hygiene management resources, having removed taxes on tampons in 2004, and allocating $3 million annually since 2011 to provide free pads to schools in low-income communities (Gelardi, 2018).

This proactive approach promotes gender equality and ensures that girls can attend school without disruptions caused by menstruation.

For healthcare spending, the Kenyan government's efforts to reduce out-of-pocket expenses, as outlined in the Health Sector Strategic Plan 2018-2023, aimed to expand access to affordable healthcare services (Ministry of Health, 2018). However, by 2023, progress in improving the National Health Insurance Fund (NHIF) in Kenya was limited. Research by Oyando et al. (2023: 6) showed that within a year, there was a significant drop-off in NHIF enrolment—a 76.7% attrition rate—indicating difficulties in keeping individuals continuously covered under the scheme. Plus, the NHIF only managed to cover 29.6% of the out-of-pocket healthcare expenses for those enrolled (Oyando et al., 2023: 8-10), highlighting the fund's limited financial protection against healthcare costs for its members. Nevertheless, Kenya continued to make significant strides towards achieving universal health coverage (UHC) under President Kenyatta's leadership, with a strong focus on ensuring affordable access to quality healthcare for all (WHO Africa, 2018). This initiative aimed to provide free basic healthcare services in public health facilities: first, by eliminating user fees at primary and secondary healthcare facilities and then introducing a social health insurance scheme (WHO Africa, 2018). To begin, the government funded these initiatives from the central budget—exploring additional sources like taxes and reallocated funds, and also sought support from partner organisations for specific healthcare system components. Ultimately, the launch of the AfyaCare UHC plan in December 2018 marked a significant milestone, with plans to achieve 100% coverage by 2022 after an initial pilot phase in four counties (Nzwili, 2018). Unfortunately, there is currently no information on the recent[8] progress of the plan.

By then, severe disease burden was still a significant public health and socioeconomic challenge in Kenya. Malaria, in particular, was affecting approximately three-quarters of its 47 counties to varying degrees. In response, Kenyatta's administration established the National Malaria Policy and the 2019–2023 Kenya Malaria Strategy (KMS) framework, which were to be supported by the Monitoring and Evaluation Plan (Elnour et al., 2023: 1-14). The KMS set ambitious targets to reduce malaria incidences and deaths by 75% of the 2016 levels by 2023, focusing on six identified strategic objectives (Elnour et al., 2023: 1-14). To support these efforts, the KMS secured approximately KSh 61.9 billion (around US$ 428 million) over five years; and, since Kenya's health budget had always been a subject of discussion, Health Minister Sicily Kariuki claimed a "more than 30%" increase in the national health sector budget over two financial years (Elnour et al., 2023: 1-14; Africa Check, 2019). Further, the Strategy emphasised the importance of testing all suspected malaria cases before treatment, aligning with best practices recommended by the World

[8] As at September 2024

Health Organisation (Marita et al., 2022: 2). Africa Check's analysis indeed confirmed a 49% increase at the national level, with a total healthcare budget increase of 29.9% when considering both national and county governments (Africa Check, 2019). Nevertheless, Kenya's healthcare spending as a percentage of the total budget consistently ranged from 7.9% to 9.7% over the previous five years—falling short of the Abuja Declaration's 15% target for healthcare allocation (Africa Check, 2019).

Then, like the rest of the world, when COVID-19 hit, healthcare workers in Kenya faced significant challenges, such as a shortage of essential protective equipment, inadequate training for treating COVID-19 patients, existing unresolved grievances leading to strikes, and misappropriation of funds intended for the pandemic response (AMREF Health, 2022; Human Rights Watch, 2021). Health workers also experienced delayed and limited compensation, a lack of health insurance, and inadequate psychosocial support (Human Rights Watch, 2021). In a speech on July 12, 2022, President Kenyatta emphasised the crucial role of a well-trained and supported health workforce for the achievement of UHC—as part of Kenya's Big 4 Agenda (AMREF Health, 2022). He stressed the significance of skilled and well-equipped health workers for the success of healthcare services, whether preventive or curative (AMREF Health, 2022). In response to these, President Kenyatta ordered an investigation into the fund misuse and allocating insufficient resources for healthcare workers that left essential workers vulnerable and without proper support (Human Rights Watch, 2021). Per an article by the Human Rights Watch (2021), the investigation revealed that Kenya had lost KSh 7.8 billion[9] meant for COVID-19 response through corruption; yet, by October 2021 no meaningful changes had come from the investigation. Nevertheless, the government had also implemented measures to support community health services, improve industrial relations, and increase domestic financing for community health—earning them commendation from, among others, the WHO regional director for Africa (AMREF Health, 2022).

Essentially, Kenyatta's tenure laid a crucial foundation for healthcare reform, though the journey toward achieving UHC remains fraught with obstacles. His administration's focus on strengthening the healthcare system through legislative reforms, workforce development, and increased funding marked important steps forward, yet the sustainability of these achievements depends on addressing persistent systemic issues. Moving forward, President William Ruto's administration will need to build on these efforts, tackling the remaining gaps in healthcare infrastructure, governance, and service delivery, especially as Kenya continues to contend with pressing public health challenges.

[9] Approx. US$48.2 million

4.2.2. William Kipchirchir Samoei Arap Ruto (2022–Present)

William Ruto's legacy in the pursuit of universal healthcare can be traced back to when he was still deputy president in Uhuru Kenyatta's government. To illustrate, in 2013, William Ruto met with UNAIDS Executive Director Michel Sidibé and Dr. Mark Dybul—the Executive Director of the Global Fund to Fight AIDS, Tuberculosis, and Malaria—during a joint visit to Kenya (UNAIDS, 2013). During this meeting, Ruto made commitments to strengthen Kenya's response to HIV, health, and development (UNAIDS, 2013). These commitments included implementing the AU's Roadmap for Shared Responsibility and Global Solidarity, establishing a public-private trust fund for domestic health financing, exploring local medicine production, and ensuring inclusive and effective services for all—especially vulnerable populations. Further, representatives of the National Empowerment Network of People Living with HIV (PLHIV) in Kenya emphasised the role of these international organisations in addressing sensitive issues for the identified communities (UNAIDS, 2013). Two years later, the Deputy President responded to concerns raised by Catholic Archbishop John Njue about sex education in schools (DPPS, 2015). According to DPPS (2015), Ruto reassured the clergyman that the government respects religious and cultural views and would collaborate to create a curriculum that would address sex education gaps while upholding religious and cultural sensitivities. Despite these efforts, the Kenya Conference of Catholic Bishops (KCCB) continues to criticise explicit sex education content in textbooks. Their concern is that replacing abstinence teachings with family planning could potentially worsen teenage pregnancy rates and lead to an increase in abortions (Tanui, 2023). Consequently, the debate around sex education in Kenyan schools—driven by religious concerns—remains alive.

Although tuberculosis (TB) remains Kenya's fourth-leading infectious disease cause of death, having claimed approximately 20,000 lives in 2020, Kenya has made substantial strides against it, achieving a 35% decrease in TB-related deaths since 2015—meeting WHO's 20% reduction target (Muchangi, 2023; Mwololo, 2018). In January 2024, Kenya achieved a 38% reduction in TB incidence and a 54% decrease in TB deaths, contributing to global efforts to eliminate TB by 2030 (Muchangi, 2024). These efforts were enhanced by the introduction of new technologies such as AI-based digital chest x-rays. Yet, challenges persist—compounded by disruptions caused by the COVID-19 pandemic (Muchangi, 2023; AMREF Health, 2022). The Ministry of Health (2014: viii) had projected that achieving WHO's 2025 targets of a 75% reduction in TB deaths and a 50% reduction in cases might be challenging due to underinvestment in TB control programs and insufficient funding for prevention, diagnosis, and treatment.

To further strengthen TB control efforts, the Public-Private Mix (PPM) Action Plan for 2021-2023 serves as a guide to boost private sector participation in TB control—aligning with the Tuberculosis

National Strategic Plan for 2020-2023 (Ministry of Health, 2021: vii-viii). The government's strategies include strengthening diagnostic networks, embracing technology, and fostering public-private partnerships, reflecting a comprehensive approach to address TB challenges. Community health workers (CHWs) have also played a pivotal role in achieving advancements in TB care and early detection. In February 2023, Ruto unveiled plans to employ over 100,000 CHWs to make healthcare accessible and affordable (Nzau, 2023). The role of CHWs, along with USAID's support, demonstrates the government's commitment to improving community health (Elisha, 2023).

In response to the COVID-19 pandemic, Ruto launched a US$41.7 million medical oxygen infrastructure project in collaboration with the Global Fund and Amref Health Africa (The Global Fund, 2023). The “Hewa Mashinani” (Oxygen for the Grassroots) initiative includes distributing medical oxygen cylinders to health facilities across all 47 counties and establishing oxygen-producing plants (The Global Fund, 2023). The COVID-19 pandemic highlighted the importance of oxygen in healthcare, and this project aims to improve healthcare resilience and prepare Kenya for future health challenges. Ruto’s comprehensive approach to legislative reforms, healthcare infrastructure, and strategic partnerships reflects his dedication to accessible, affordable, and quality healthcare services. Key health bills enacted in 2024, including the Social Health Insurance Bill, Digital Health Bill, and Primary Healthcare Bill, aim to revolutionise Kenya’s healthcare sector (Kipkemoi, 2023).

That said, Kenyatta and Ruto's administrations provide a compelling context to explore how integrating technologies like AI and blockchain can be a catalyst for addressing key healthcare challenges, reducing disparities, and advancing the country’s goal toward universal health coverage. This analysis will contribute to the broader discourse on how technological advancements can reshape healthcare in developing nations—particularly in navigating the balance between innovation and external dependency.

4.3. Case Studies: AI and Blockchain Applications in Kenya’s Healthcare

The integration of Artificial Intelligence (AI) and blockchain technologies within Kenya’s healthcare sector exemplifies a significant shift in the global movement towards the digital transformation of healthcare. This trend is especially critical for developing countries, where these technologies are employed as strategic tools to overcome systemic healthcare challenges and achieve Sustainable Development Goal 3 (SDG 3), which aims to ensure healthy lives and promote well-being for all ages. As highlighted by Oleske and Islam (2019), health outcomes are crucial in evaluating the effectiveness of healthcare interventions. These outcomes, encompassing physical,

social, and emotional well-being, underscore the complexity of healthcare needs and the importance of personalized interventions.

In Kenya, the adoption of AI and blockchain technologies marks a transformative move towards precision medicine, allowing for the customization of treatments based on individual characteristics such as genetics and lifestyle, thereby improving health outcomes (Iannaccone & Van Winkle, 2023). Health outcomes, which include a wide range of indicators from impairments and symptoms to quality of life and daily activity capabilities, highlight the multifaceted nature of health and the need for comprehensive healthcare strategies (Ward, 2009). Kenya's commitment to integrating AI and blockchain in healthcare is reflected in the projected growth of the country's AI in Healthcare Market, which is expected to surge from $4.83 million in 2022 to $101.48 million by 2030, with a Compound Annual Growth Rate (CAGR) of 46.32% (Upadhyay, 2023). This growth is mirrored by the forecasted expansion of Kenya's medical device market, anticipated to reach $197.9 million by 2026, signalling a broader economic recovery and an increasing openness to technological advancements in healthcare (ITA, 2022). Moreover, the establishment of the Blockchain & Artificial Intelligence task force by the Kenyan government in 2018, led by Dr. Bitange Ndemo (OECD.AI, 2022), underscores a strategic effort to leverage these technologies for societal benefit. This task force, which focuses on enhancing public service delivery, ensuring cybersecurity, and promoting financial inclusion, reflects a comprehensive approach to integrating these technologies across various sectors.

Assessing healthcare outcomes through AI- and blockchain-based interventions is essential to understanding their impact on Kenyan patients. By employing metrics inspired by McKinsey & Company, the Lancet Commission, and the Agency for Healthcare Research and Quality (AHRQ), this section provides a detailed analysis of the efficacy of these interventions. These metrics—including improved healthcare outcomes, disease management, quality of life, patient satisfaction, data-driven insights, enhanced patient-provider communication, mortality rates, and mitigation of unintended consequences—serve as indicators of the benefits offered by these innovations (McKinsey and Company, 2021; Knaul et al., 2018; AHRQ, 2011). In sum, the following chronological exploration of Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS illustrates the evolution and impact of AI and blockchain within Kenya's healthcare sector.

4.3.1. Sophie Bot

Sophie Bot, an AI-based chatbot addressing sexual and reproductive health education in Kenya, plays an innovative role in healthcare and education. Developed by a group of students from Jomo

Kenyatta University of Agriculture and Technology (JKUAT), Sophie Bot reflects local innovation and ingenuity (Capital Campus, 2017). The team, led by Irving Amukusa, the head of the team, and Derick Mureithi, the Chief Technology Officer, also includes Beverly Mutindi, the Chief Financial Officer—and the only female of the group, Rashid Beduni Mwagonga, Nicholas Wambua, and John Nzau Makau (Capital Campus, 2017). Sophie Bot was created in 2017 to address the need for accurate and accessible information on sexual and reproductive health (SRH) topics, such as contraception, family planning, sexually transmitted infections, menstrual health, and pregnancy (Opudo, 2017; AFIDEP, 2016; Digital Watch, 2018).

Initially, the team sought to validate its importance and effectiveness by securing press coverage and showcasing it at the Nairobi Innovation Week (Opudo, 2017). Recognising the limitations of the bot's predefined questions and answers, they made investments in new technology (AI), enabling Sophie Bot to learn from conversations and automate customer support for SRH organisations, expanding its sustainability model (Opudo, 2017). Sophie Bot stands out from unreliable sources by providing a unique and comprehensive approach to sexual health education (Opudo, 2017). It aims to overcome communication barriers, create a supportive environment, and bridge gender gaps in SRH education, positioning itself as one of the few tech-focused solutions that empower women and address gender disparities (Mbaka, 2017; Museka, 2019; Digital Watch, 2018). Leveraging AI technology, Sophie Bot delivers accurate guidance and answers through voice or text interactions, resembling Apple’s Siri (Digital Watch, 2018). By using natural language processing and machine learning algorithms, Sophie Bot can understand user inquiries and deliver personalised responses based on evidence-based information: it operates on a question-and-answer format based on a curriculum developed by the National Council for Population and Development, and endorsed by the Ministry of Health, ensuring reliability and adherence to approved guidelines (AFIDEP, 2016).

Despite facing challenges such as securing funding, the Sophie Bot team's innovation gained recognition in 2016 when they presented the idea at the Nailab—an event organised by the United Nations Population Fund (UNFPA) and Nailab (Capital Campus, 2017). Sophie Bot was recognised as one of the four winning innovations in the iAccelerator program, which focuses on advancements in sexual health (Capital Campus, 2017). In response to the challenge of accessing real-time, up-to-date SRH information, especially for young people, Sophie Bot incorporates verified information from trusted organisations, bolstering its credibility (F6S, 2023). The platform offers anonymity, reliable responses, and additional features like direct interaction with Sophie and an anonymous forum for seeking advice and engaging with peers, fostering a safe and supportive environment (Capital Campus, 2017). Sophie Bot's platform independence, conversational

interface, scalability, and cost-effectiveness provide it with a competitive advantage over traditional customer support approaches (Mbaka, 2017). By employing AI technology, Sophie Bot revolutionises the accessibility of sexual health information in Kenya, continuously improving responses based on user interactions and contributing to the destigmatisation of sex education (Capital Campus, 2017; AFIDEP, 2016).

Sophie Bot's implementation as an AI-driven sexual education platform holds the potential to yield significant positive impacts on healthcare outcomes and disease management. As discussed in the previous chapter, insufficient sex education, societal discomfort, and traditional values pose barriers for adults discussing the topic with young people—particularly prevalent in African cultures (Mbaka, 2017; Museka, 2019). Due to the sensitivity surrounding sex education, both globally and in Kenya, young people are hesitant to ask questions, leading them to rely on personal experiences or unreliable sources (Opudo, 2017; Digital Watch, 2018). This lack of reliable information results in harmful consequences, which underscores the importance of quality comprehensive sexuality education (CSE) to enhance learners' health, knowledge, and empowerment. Although 85% of countries have policies supportive of sexuality education, significant gaps still exist between policy and curricula implementation (UNESCO, 2023)—according to UNESCO's reviews of national policies and programs.

Accessible to all, platforms like Sophie Bot address the knowledge gaps prevalent among young people, effectively dispelling misconceptions, and contributing to a reduction in alarming statistics such as high rates of teenage pregnancy, HIV infections, and maternal deaths among young girls (Harrington, 2019). According to Kahurani (2020), teenage pregnancy has been a longstanding issue in Kenya, with nearly 2 out of 10 girls between the ages of 15 and 19 reported to be pregnant or having given birth. This trend has remained relatively consistent over the past two decades, showing little change in prevalence from 1993 to 2014. Regarding HIV infections, Kenya has made progress in reducing the epidemic through targeted interventions. In 2017, the adult (15–49 years) HIV prevalence was approximately 4.9%, with around 1.5 million people living with HIV. However, a significant portion of new HIV infections (75%) is concentrated in one-third of the counties, and some Counties have prevalence levels comparable to those of southern African countries in 2018 (NACC, 2018: 2-3). The online world has become a crucial source of information on bodies, relationships, and sexuality for young people, with 71% of youth aged 15-24 seeking sexuality education and information online in a year (UNESCO, 2023). UNESCO (2023) reports that only 37% of young people in sub-Saharan Africa possess comprehensive knowledge about HIV prevention and transmission; also, many girls lack essential knowledge as they enter puberty and menstruation, leading to early marriage and unintended pregnancies—particularly in East and

Southern Africa, where pregnancy rates range from 15% to 25%. On that note, the use of artificial intelligence is a powerful educational trend of the 21st century, which also applies to health and well-being education (UNESCO IITE, 2022).

Maternal mortality remains a concern, with a maternal mortality ratio of 355 deaths per 100,000 live births, resulting in nearly 5,000 women and girls dying each year due to pregnancy and childbirth complications (UNFPA, 2023). While skilled birth attendance has improved to about 70% in the past seven years, over 80% of maternal deaths are attributed to poor quality of care. In addition, high child mortality rates persist, with a child mortality rate of 52 deaths per 1,000 live births in 2020 (UNICEF, 2021b). Through comprehensive coverage of relevant topics and cultural sensitivity, Sophie Bot addresses societal discomfort and traditional values that hinder open discussions, further enhancing its potential to positively impact healthcare outcomes. As UNESCO IITE (2022) reveals, experiments with creating chatbots to advance health education have been ongoing for nearly a decade, showing significant growth in recent years. For example, in 2018, Woebot, the first English-language mental health chatbot, was launched, followed by Roo, a chatbot for teens created by Planned Parenthood in 2019 (UNESCO IITE, 2022). The introduction of chatbots like Sophie Bot, along with Nivi, Pregnancy Bot, Lily.Health, and Ada, fosters open conversations about sensitive subjects such as sex, love, and relationships, leading to positive changes in making accurate information accessible to individuals of various age groups (Rajasekharan, 2020).

Sophie Bot gained popularity internationally, with a significant user base. According to Jacky Habib of Women's Advancement Deeply, 30% of Sophie Bot's 4,500 users are from Kenya, and 18% are from the United States (Digital Watch, 2018). According to CEO Amukasa (2019), Sophie Bot had already received over 40,000 questions from more than 4,300 users in 150+ countries by 2019. Although initially targeted at youth aged 18-24, individuals of all ages have sought information, highlighting the need for accessible sexual education across diverse age groups (Museka, 2019). As the chatbot provides personalised and accurate responses to sensitive inquiries, it fosters open conversations about sexual health, leading to positive experiences and increased patient satisfaction. Further, by enabling individuals to engage with healthcare providers more effectively, Sophie Bot contributes to better communication and understanding of healthcare needs, ultimately enhancing patient-provider relationships and healthcare outcomes. To ensure the accuracy and effectiveness of the chatbot, the creators of Sophie Bot are committed to continuously investing in cutting-edge AI approaches and being responsive to user questions. This dedication demonstrates their commitment to enhancing the capabilities and performance of Sophie Bot in delivering reliable and personalised information. Sophie Bot also represents an innovative solution that leverages AI technology to

address the challenges faced by overwhelmed customer support agents (Capital Campus, 2017). Rather than replacing human interaction, Sophie Bot complements and enhances customer support by providing scalable and efficient services (Mbaka, 2017). By automating certain aspects of customer support, Sophie Bot helps organisations in the industry improve their operational efficiency and effectively manage customer inquiries (Mbaka, 2017).

By streamlining customer interactions and reducing reliance on traditional support models, Sophie Bot contributes to sustainable development by minimising resource consumption and enabling organisations to allocate their resources more effectively. As Brandusescu, Freuler and Thaku (2017: 4) show, the trend of using AI to address economic inefficiencies and improve access to services is prevalent across various sectors. In healthcare, Sophie Bot uses AI to process and respond to sexual and reproductive health questions, providing a free chatbot service on popular messaging apps (Brandusescu, Freuler and Thaku, 2017: 4). This aligns with the principles of sustainable development, as it promotes equitable access to essential services while minimising economic inefficiencies.

However, as highlighted in *Chapter 2,* the use of AI in healthcare to address economic inefficiencies raises social and economic concerns about job displacement and its impact on the workforce. While the integration of AI in healthcare through Sophie Bot offers significant potential for positive impacts in accessing reliable sexual education, it is essential to consider and mitigate any unintended consequences. One of the issues to consider is the issue of unequal internet access among the target demographic. A report by Global Information Society Watch in 2013 revealed a gender disparity in internet connectivity in Kenya, where only 1.2% of women had a working internet connection compared to 6.2% of men, while the national internet access rate was at 3.0% (Global Information Society Watch, 2013). This disparity highlights the unequal access to technology and the internet between men and women in Kenya at that time. Another concern is that the use of AI to streamline customer interactions and improve operational efficiency may raise social and economic concerns about potential job displacement in the healthcare workforce (Sharif and Ghodoosi, 2022). Therefore, it is crucial to strike a balance between AI-driven efficiencies and the preservation of human employment opportunities to ensure that Sophie Bot's implementation benefits both patients and healthcare professionals. Thus, to ensure that the benefits of tech-focused solutions like Sophie Bot are equitably distributed, efforts should be directed towards promoting digital literacy, especially among women and girls. In fact, as the Digital Watch (2018) suggests, initiatives aimed at bridging the gender gap in technology access can play a vital role in creating equal opportunities for women to access and benefit from online resources (Digital Watch, 2018). By providing training and support in digital skills, women can gain the knowledge and confidence

to navigate the online world, access reliable sexual education platforms like Sophie Bot, and take advantage of the opportunities offered by technology.

4.3.2. Ilara Health

Kenya has made progress regarding advanced diagnostic technology, with leading private sector hospital groups investing in the latest innovative equipment. According to the ITA (2022), the country shows good prospects for diagnostic equipment, including electrocardiographs (ECG), ultrasound units, scintigraphy apparatus, MRI equipment, angiographies, endoscopies, and biochemistry, haematology, and immunology systems. The government has also responded to the global economic pressures from the COVID-19 pandemic by introducing new economic measures in 2020. This included the allocation of $400 million in funds for additional health-related initiatives, such as enhanced surveillance, laboratory services, isolation units, equipment, supplies, and communication (ITA, 2022).

Ilara Health, established in 2018 by Emilian Popa, Sameer Afzal Farooqi, and Maximilian Mancini, is an AI-powered medical diagnostics company located in Nairobi, Kenya (Pagan Research, 2017). The company's core mission, as a healthcare technology startup, is to enhance access to affordable and precise diagnostics for the estimated 500 million people in Africa who encounter difficulties in obtaining healthcare services—particularly in peri-urban and rural areas (Ilara Health, 2023; CB Insights, 2023; Pagan Research, 2017). Ilara Health operates through a network of primary healthcare clinics (PHCs), specialising in delivering AI-powered diagnostic devices and solutions to primary care doctors. This approach effectively addresses the critical issue frequently faced by these facilities and the lack of access to vital medical equipment (CB Insights, 2023). The implications of this intervention are far-reaching, with their projects directly contributing to enhanced healthcare outcomes in underserved areas. Highlighting the importance of timely and accurate diagnostics, Ilara Health acknowledges the indispensable role of simple blood tests, which influence roughly 70% of medical decisions (Maritz, 2020). Ilara Health's innovative approach, leveraging advanced technology, including AI, reflects the transformative impact of technology across various industries.

Recognising the power of technology, the company uses cutting-edge laboratory equipment and digital tools to revolutionise diagnostic services, underscoring their commitment to delivering top-tier diagnostic services (My 1Health, 2023). This unwavering dedication keeps them at the forefront of developments in diagnostic technology, with consistent investment in innovative tools such as advanced imaging technology and state-of-the-art laboratory testing, thus providing optimal care (My 1Health, 2023). Showing their technological versatility is their broad range of devices, encompassing ultrasound machines, haematology machines, haemoglobin test devices, and

chemistry analysers. These tools facilitate the diagnosis of an array of conditions, from infections to non-communicable diseases like diabetes and hypertension, thus enhancing healthcare delivery significantly (Mureithi, 2022; Maritz, 2020).

Ilara Health's impact has been substantial and far-reaching. As of April 2021, they had partnered with roughly 1,100 clinics scattered across 42 (out of 47) counties within Kenya and issued over 1,700 devices. This extensive network enables them to reach approximately 400,000 patients monthly, reflecting their massive footprint in the healthcare sector (Mureithi, 2022; My 1Health, 2023). Further, Ilara Health promotes sustainable business growth for clinics through strategic partnerships, such as its collaboration with Jia, for affordable financing. This partnership enables Ilara Health to provide financing options to its partner clinics, ensuring they have a consistent supply of essential medicines for their patients (Jia, 2023). Further, this affordable financing supports the growth of these clinics, allowing them to expand their businesses and continue providing essential healthcare services to their communities (Jia, 2023). By facilitating access to necessary resources and supporting the development of local clinics, Ilara Health actively contributes to local economic development.

Ilara Health's impact extends far beyond diagnostics and maternal health. With a distribution contract with ResApp Health Limited, Ilara Health has broadened its sphere of influence. This agreement allows Ilara Health to actively promote, market, and distribute ResAppDx in Kenya, an innovative mobile application developed by ResApp that diagnoses acute respiratory diseases (ResApp Health, 2021: 2). This venture followed a successful pilot evaluation that Ilara Health initiated across five partner sites in Kenya (ResApp Health, 2021: 1). Thus, through strategic collaborations, Ilara Health has successfully bridged the significant diagnostic gap in sub-Saharan Africa. They've equipped over 250 clinics in Kenya's four largest cities with advanced point-of-care diagnostic tools (ResApp Health, 2021: 1). Ilara Health's vision is to extend this successful model, planning to expand their footprint further within Kenya and into new African markets in the upcoming year. The ResAppDx application, using machine-learning technology to analyse cough sounds for diagnosing respiratory diseases, has gained approval as a medical device in Kenya, Europe, and Australia, signifying its safety and effectiveness for its intended medical uses in these regions (ResApp Health, 2021: 1). Consequently, in partnership with ResApp, Ilara Health stands to further revolutionise healthcare outcomes by enabling accurate and accessible diagnosis of respiratory diseases in Kenya.

Ilara Health, an AI-powered medical diagnostics company based in Nairobi, Kenya—and one of the above-mentioned private sector actors—plays a significant role in enhancing healthcare outcomes and promoting sustainable development in Africa. Their primary objective, according to Ilara

Health (2023), CB Insights (2023), and Pagan Research (2017), is to make affordable and accurate diagnostics more accessible to the estimated 500 million people facing healthcare challenges. By establishing a network of primary healthcare clinics, Ilara Health addresses the lack of critical medical equipment in underserved areas, positively impacting sustainable healthcare development, which focuses on promoting good health and well-being (CB Insights, 2023). Through the provision of AI-powered diagnostic devices and solutions, including advanced imaging and laboratory testing, they improve healthcare delivery for various medical conditions, aligning with SDG 9, which emphasises industry, innovation, and infrastructure (My 1Health, 2023; Mureithi, 2022; Maritz, 2020). Ilara Health's strategic partnerships, such as their collaboration with Jia for affordable financing, support the growth of partner clinics and foster local economic development, aligning with SDG 8, which focuses on decent work and economic growth (Jia, 2023). With their extensive reach of approximately 400,000 patients each month and partnerships with over 1,100 clinics across Kenya, Ilara Health contributes to SDG 10 by reducing healthcare inequalities and promoting inclusivity (My 1Health, 2023; Mureithi, 2022).

Ilara Health Labs, a branch of Ilara Health, operates on a foundation of ethical principles and efficiency, providing an array of innovative solutions and high-quality services that enhance healthcare outcomes in Kenya (Ilara Health, 2023). As a renowned diagnostics provider in the country, the company operates from the Ilara Health Diagnostic Centre in Nairobi. The centre is equipped with advanced technology that allows for accurate and expedient diagnoses of a diverse range of medical conditions, from basic blood tests to COVID-19 tests and more sophisticated analyses (My 1Health, 2023). Since the launch of its first lab in April 2020, Ilara Health has developed an extensive network of labs across the nation, significantly improving access to diagnostic services. Serving both primary and secondary healthcare sectors, these labs provide bespoke screening solutions to an array of entities, including clinicians, doctors, corporates, insurance companies, and startups (Ilara Health, 2023). Through the unique 'Build A Lab' service, Ilara Health partners with facilities, offering the option to provide lab services or lease lab equipment for self-operation (Ilara Health, 2021). This approach helps expand diagnostic capabilities, aiding in the early detection and treatment of diseases, thereby improving healthcare outcomes. A committed team of professionals, including radiologic technologists, laboratory technicians, medical laboratory scientists, and pathologists, work in close collaboration with healthcare providers. Their efforts ensure that necessary diagnostic tools are accessible, supporting exceptional patient care and leading to improved healthcare outcomes (My 1Health, 2023). Further, Ilara Health's dedicated customer care, sales, and tele-sales teams respond promptly to queries and provide necessary support for their partners (Ilara Health, 2021). As a B2B healthcare organisation, Ilara Health, through its specialised division Ilara Health labs, empowers healthcare facilities across

Kenya. By enhancing their diagnostic capabilities, the organisation is making a significant contribution to improved healthcare outcomes in the country (Ilara Health, 2023; Ilara Health, 2021).

Ilara Health's commitment to addressing health disparities through strategic partnerships has significantly contributed to improved healthcare outcomes—particularly in the realm of affordable diagnostic devices (Ilara Health, 2021). According to Chetty (2020), with support from the Bill & Melinda Gates Foundation—a collaboration aimed at transforming maternal health outcomes in Kenya, where less than 3% of women adhere to the critical schedule of eight recommended antenatal care appointments—the partners are working to prevent maternal mortality and stillbirths. Recognising the urgency of the situation, Ilara Health has undertaken an ambitious project in collaboration with the Kisumu Ministry of Health and the Kenya Medical Research Institute. The primary objective is to enhance the accessibility of maternal care and ultimately reduce the alarming rate of 595 maternal deaths per 100,000 live births reported in Kisumu County in 2019 (Chetty, 2020). To achieve this goal, Ilara Health leverages the potential of local primary care facilities, the effectiveness of telemedicine, and the convenience of home consultations with healthcare practitioners. By forging these strategic partnerships and employing innovative approaches, Ilara Health is actively working towards disease management and achieving better healthcare outcomes. The focus on maternal health seeks to mitigate the devastating impact of maternal mortality and stillbirths, ultimately leading to improved quality of life for expectant mothers and their families.

Another of Ilara Health's core strategies includes distributing low-cost, AI-powered diagnostic devices directly to primary care physicians operating in peri-urban and rural clinics. This strategic move addresses the prevalent dearth of diagnostic resources in these underserved regions, thus significantly improving healthcare accessibility (Pagan Research, 2017). Ilara Health's commitment to affordability is evident in their partnering with manufacturers that leverage next-generation technology; this advanced technology reduces manufacturing costs significantly, enabling these savings to be passed on to end-users, thus ensuring more accessible and affordable healthcare (Mureithi, 2022). Further, Ilara Health has teamed up with international manufacturers to provide small, portable diagnostic devices that can seamlessly integrate with mobile phones (Maritz, 2020). As a result, enhanced patient-provider communication is facilitated through the deployment of these AI-powered diagnostic devices, leading to better patient satisfaction and improved healthcare outcomes. This innovative approach not only broadens access to healthcare but also benefits clinics and pharmacies. By offering a wider range of services to patients, healthcare providers can expand their revenue, thus improving both healthcare outcomes and the economic viability of these vital institutions.

To add, Ilara Health aims to improve healthcare outcomes and disease management by expanding its service offerings through the development of a cloud-based system for managing health records and finances in clinics. This innovative initiative not only simplifies administrative processes but also empowers healthcare facilities to establish credit ratings (Awosanya, 2019). Access to this system enables clinics to efficiently access patient medical histories, leading to improved follow-up procedures, such as medication reminders and subsequent tests (Awosanya, 2019). Since its pilot phase in March 2019, Ilara Health's approach has demonstrated remarkable revenue growth for partnered clinics, allowing them to offer testing services that were previously outsourced to larger hospitals (Awosanya, 2019). By leveraging technology and innovative business models, Ilara Health seeks to bridge the healthcare access gap, ultimately elevating the quality of care in underserved areas (Awosanya, 2019). Through integrated leasing models, efficient cloud-based systems, and improved access to patient records, Ilara Health showcases its commitment to overcoming challenges associated with healthcare delivery in low-income regions. In doing so, the company not only enables clinics to generate revenue and access critical medical equipment but also enhances the overall quality of care provided in underserved communities. These efforts contribute to improved patient satisfaction, disease management, and enhanced patient-provider communication, fostering a positive impact on healthcare outcomes and overall quality of life for individuals in these regions.

Ilara Health has made significant strides in improving healthcare outcomes, disease management, and quality of life by partnering with ResApp Health Limited to distribute ResAppDx, a mobile application for diagnosing acute respiratory diseases, revolutionising healthcare outcomes for respiratory conditions (ResApp Health, 2021: 2). This collaboration has brought about a revolutionary change in healthcare outcomes for respiratory conditions, benefiting patients in Kenya and contributing to the achievement of Sustainable Development Goal 3 (Good Health and Well-being) and Goal 17 (Partnerships for the Goals). Per ResApp Health (2021: 1), through equipping over 250 clinics in Kenya's major cities with advanced diagnostic tools, Ilara Health has effectively addressed the diagnostic gap prevalent in sub-Saharan Africa. This not only facilitates immediate and accurate disease diagnosis but also plays a crucial role in early disease detection and preventative healthcare. Further, priding themselves on their commitment to excellence and their ability to offer competitive rates, Ilara Health is gradually shifting Africa towards the achievement of universal access to diagnostics (Ilara Health, 2023; Chetty, 2020). This is not only essential for immediate and accurate disease diagnosis, but also instrumental in early disease detection and preventative healthcare. By enhancing access to these essential services, Ilara Health reduces the burden of disease, improves life expectancy, and ultimately enhances the overall quality of life for individuals in Kenya and beyond.

Despite its innovative approach, Ilara Health encounters challenges in operating within the informal and disorganised healthcare settings prevalent in low-income regions, as cautioned by Maritz (2020). These challenges, warn Maritz (2020), include understanding the complexities of healthcare delivery in such contexts and providing comprehensive training to healthcare professionals. Plus, the presence of cash flow constraints frequently experienced by clinics further complicates the timely payment process (Maritz, 2020). Nevertheless, Ilara Health has developed strategies to navigate these hurdles: although the collection of leasing fees remains an issue similar to those encountered in Small and Medium-sized Enterprises (SME) lending, the company has implemented systems and incentives to alleviate this concern (Maritz, 2020). Of note, Ilara Health offers integrated devices through a leasing model, which proves advantageous for clinics located in remote areas that often grapple with limited access to critical medical equipment (Awosanya, 2019). These devices are bundled together and leased to peri-urban and rural clinics, subsequently transforming into revenue-generating assets. The clinics benefit from the flexibility of choosing between subscription or pay-per-test options, or even opting to own the devices with payment spread over a 24-month period. This arrangement fosters a mutually beneficial situation for both Ilara Health and the clinics involved (Awosanya, 2019).

4.3.3. Tambua Health

Tambua Health's innovative approach to addressing healthcare challenges in Kenya has revolutionised healthcare technology. In specialised healthcare areas, Tambua Health uses AI to analyse lung and heart sounds, assisting medical professionals in diagnosing and treating cardiopulmonary diseases. Their mobile-based diagnostic tool employs machine learning to provide valuable insights for respiratory disease diagnosis and treatment (Echoing Green, 2023; Laghmari, 2020). Tambua Health, a healthcare technology company based in Nairobi, Kenya, was established in 2017 by Daniel Gathigai and Lewis Wanjohi—a 21-year-old MIT dropout with expertise in spectral imaging. The company specialises in leveraging artificial intelligence (AI) and machine learning to analyse lung and heart sounds, revolutionising respiratory tract infection diagnoses (Tambua Health, 2022). Their focus on respiratory diseases, including tuberculosis (TB), pneumonia, pertussis, chronic obstructive pulmonary disease, asthma, and lower respiratory tract infections, is crucial in addressing the substantial burden of respiratory conditions in Kenya (Mwololo, 2018). As Mwololo (2018) highlights, respiratory diseases, especially TB, pose significant challenges in Kenya, with TB ranking as the fourth leading cause of death in the country. Unfortunately, a considerable number of cases—approximately 40%—remain undiagnosed and untreated, leading to higher mortality rates (Mwololo, 2018). Tambua Health aims to address this issue by using acoustic technology to provide precise, non-invasive, and radiation-free lung imaging

and lung function testing (Omdena, 2022). By doing so, they aim to reduce misdiagnosis and improve healthcare outcomes not only in Kenya but across Africa (Echoing Green, 2023; Mwololo, 2018).

Tambua Health has made a significant impact on diagnosing respiratory diseases with innovative solutions like the Tambua App and T-Sense technology. The Tambua App uses AI and sound wave analysis to accurately diagnose lower respiratory tract infections, achieving high accuracy rates in TB diagnosis (Mwololo, 2018). It plans to expand its impact by partnering with Merck Pharmaceuticals to segment over 100,000 coughs. The app is user-friendly, accessible to a wide range of users, and reduces the stigma associated with TB. Another invention, T-Sense, generates dynamic lung images by detecting lung sound vibrations, enabling early detection and diagnosis (Laghmari, 2020). The T-Scope device, add Omdena (2022) and Gabriele (2021), is a low-cost, portable ultrasound that empowers doctors to conduct ultrasound exams and receive instant analysis, improving healthcare outcomes in Africa. As Tambua Health aims to improve respiratory health outcomes through AI, there could be unintended consequences such as disparities in technology access and potential bias in disease detection algorithms. Limited access to mobile devices or internet connectivity in resource-limited settings may hinder the reach of Tambua Health's solutions. To add, algorithmic biases in disease detection algorithms could lead to inaccurate diagnoses or differential treatment recommendations for certain patient populations.

Tambua Health's advancements in healthcare technology demonstrate the power of innovation to positively impact multiple aspects of healthcare, ranging from disease management and patient satisfaction to data-driven insights and mortality rates. One of their notable contributions is the Tambua App, a web- and mobile-based platform that uses advanced techniques such as spectral analysis of sound waves, AI, and machine learning (Mwololo, 2018). According to Mwololo (2018), this innovative app has demonstrated remarkable accuracy in detecting lower respiratory tract infections, including tuberculosis (TB), pneumonia, pertussis, chronic obstructive pulmonary disease, and asthma. To illustrate, in a pilot program conducted in Migori County in 2018, Tambua Health diagnosed 850 people through mobile clinics, achieving a high level of accuracy, between 75% and 85%, for TB diagnosis (Mwololo, 2018). This success highlights the effectiveness of Tambua Health's technology in diagnosing respiratory diseases, as well as its potential to significantly improve health outcomes. Further, Mwololo (2018) states that Tambua Health plans to segment over 100,000 coughs in partnership with Merck Pharmaceuticals. This collaborative effort showcases Tambua Health's commitment to expanding their impact and reaching a larger population.

The Tambua App is simple and user-friendly: individuals can record their cough sounds using smartphones or microphones and input relevant clinical information, receiving a diagnosis within seconds through a text message (Mwololo, 2018). As Mwololo (2018) shows, the app's sophisticated algorithms compare the recorded cough sounds with a vast database of respiratory sounds to determine the most likely diagnosis, providing personalised advice and encouraging prompt medical attention. According to Mwololo (2018), the Tambua App has the advantage of reaching a wide range of users, including healthcare facilities, doctors, public health officials, and individuals such as mothers who can use it to diagnose their children. This wide accessibility ensures that Tambua Health's technology can positively impact health outcomes across different demographics. Further, as Mwololo (2018) adds, the app not only improves the accuracy and efficiency of diagnosis but also aims to reduce the stigma associated with TB by offering self-diagnosis options, empowering individuals to take control of their lives.

Another of the organisation’s notable inventions is the T-sense technology and the T-Scope device. T-sense, a patent-pending technology developed during the COVID-19 pandemic (Laghmari, 2020), revolutionises lung imaging by generating dynamic lung images through the detection of sound vibrations as air moves in and out of the lungs. By using sensor arrays placed on the patient's back and employing spatial distribution algorithms trained from their proprietary database of lung sound images, T-sense accurately detects healthy and unhealthy lungs (Laghmari, 2020). This breakthrough plays a crucial role in enhancing disease management and ultimately improving the quality of life for patients. In addition, Tambua Health has developed the T-Scope device, the first FDA and CE-approved software-based low-cost, portable ultraportable ultrasound for point-of-care and specialised imaging (Omdena, 2022; Gabriele, 2021). The T-Scope probe employs AI to enhance the detection of healthy and unhealthy lungs, showcasing their application of AI in their innovative solutions (East Africa Healthcare Federation, 2021: 6). This technology uses neural networks (a type of AI that mimics the functioning of the human brain), sensor arrays (a set of sensors strategically placed on the patient's body), and software, allowing doctors to conduct ultrasound exams and immediately see the results on a “rugged” Android tablet screen (Gabriele, 2021). This advancement in portable ultrasound technology enables data-driven insights, supporting evidence-based decision-making for respiratory care and interventions. In analysing lung sound images and using neural networks, doctors gain valuable information that aids in tailoring treatment plans to individual patients, improving the effectiveness of treatments and enhancing healthcare outcomes. Further, its affordability and accessibility make it a game-changer for African healthcare facilities that have traditionally lacked such diagnostic capabilities (Gabriele, 2021). The quick and accurate diagnostic capabilities of these apparatuses also allow doctors to have meaningful discussions with their patients, ensuring patients are actively involved in their healthcare decisions.

This patient engagement fosters better patient satisfaction and a more positive healthcare experience.

Per Echoing Green (2023), Tambua Health employs the above-mentioned technology to provide cheap, accessible, and reliable diagnostic solutions for respiratory tract ailments. This approach mitigates the disparity in healthcare capabilities, ensuring more equitable access to essential medical services and contributing to better overall healthcare outcomes in underserved regions (Mwololo, 2018). The company's success is particularly remarkable considering its small team of fewer than 15 people and financing of only $3 million (Gabriele, 2021). Their commitment to merging technology, medical expertise, and healthcare enhancement makes a substantial contribution to addressing critical health challenges not only in Kenya but also beyond its borders (Mwololo, 2018). As Mwololo (2018) highlights, Tambua Health's e-health technologies have the potential to revolutionise primary healthcare in Kenya, leading to a reduction in pre-hospital deaths and an overall improvement in healthcare outcomes. In a country where discussions about health are often considered taboo, initiatives like Tambua Health are playing a pivotal role in breaking down barriers, providing accurate health information, and offering essential support to the population. Further, Mwololo (2018) emphasises the potential of Tambua Health's innovative approach to transform primary healthcare in Kenya, reduce pre-hospital deaths, and improve overall healthcare outcomes. Tambua Health's dedication to merging innovation and healthcare has garnered recognition for its positive impact on healthcare access and outcomes. As they continue to innovate and expand their reach, their contributions have the potential to extend far beyond national borders, benefiting communities facing similar health challenges worldwide.

Gabriele (2021) underscores Tambua Health's technology as a catalyst for improved healthcare outcomes, disease management, and quality of life. Through its highly innovative approach and ability to leapfrog existing technology, Tambua Health has the potential to positively impact patient outcomes and enhance disease management practices (Gabriele, 2021). By revolutionising medical imaging through miniaturisation and reinvention, Tambua Health has far-reaching implications for healthcare services. This disruptive technology also has the potential to challenge established players like Siemens in the global market (Gabriele, 2021). By expanding access to advanced medical imaging in emerging markets, Tambua Health can contribute to reducing mortality rates associated with respiratory and other medical conditions. Their innovations align with the vision of organisations such as EDPU Africa in Rwanda, which recognises the transformative potential of emerging technologies like AI in revolutionising healthcare in Africa (East Africa Healthcare Federation, 2021: 6).

In essence, Tambua Health's approach—which combines local expertise with cutting-edge technology—serves as an example of how developing countries can develop autonomous healthcare solutions that cater to their unique challenges. This initiative highlights the potential for local innovation to make substantial contributions to public health, economic development, and the overall well-being of communities.

4.3.4. AfyaRekod

AfyaRekod is committed to making a positive impact on various aspects of healthcare, ranging from enhancing healthcare outcomes and improving disease management to elevating patient satisfaction and overall quality of life. Its projects are specifically designed to address critical healthcare challenges, including inadequate data security, limited accessibility to personal health information, and insufficient patient control. To achieve these goals, AfyaRekod has established a standardised and efficient system for data management, promoting interoperability and seamless communication. In doing so, AfyaRekod strives to contribute to sustainable healthcare development, ultimately ensuring healthier lives and promoting well-being for all. These initiatives serve as tangible examples of how developing countries can innovate, embrace advanced technologies, and engage in collaborative partnerships to effectively tackle healthcare challenges and advance sustainable development.

AfyaRekod's Universal Patient Portal (UPP) is a prime example of how blockchain-based healthcare solutions are revolutionising patient care in Kenya. This automated system, designed with a focus on privacy and data protection, has the potential to transform patient care not only in Africa but globally: by leveraging blockchain technology, healthcare data management in Kenya is bolstered with enhanced data security, privacy, and interoperability (Sendoro, 2023; Zawya, 2022). Per Zawya (2022), AfyaRekod, founded by CEO John Kamara in 2019, employs AI and blockchain technology to improve healthcare management and bridge the gap between care and treatment. Operating in Kenya, Nigeria, South Africa, Cameroon, and Zambia, AfyaRekod uses these technologies to enable real-time access and mobility of health data—addressing the challenges of inadequate medical records and data ownership (Ngila, 2023; Ajimotokan, 2022). The Kenyan Data Protection Act, No. 24 of 2019, plays a vital role in complementing AfyaRekod's Portal in ensuring patient data privacy and security. According to Serianu (2019: 6), this law regulates personal data and safeguards the rights of data subjects, providing a strong legal foundation for protecting healthcare data managed through UPP.

The UPP is a groundbreaking blockchain-driven platform that empowers individuals to securely record, access, and store their health data. It ensures seamless accessibility while granting

authorised healthcare providers access to necessary information (AfyaRekod, 2023; Zawya, 2022). This initiative establishes a decentralised system for exchanging healthcare data, with the primary aim of improving data interoperability across different healthcare facilities. By securely and efficiently sharing patient records, the project facilitates coordinated care and enables healthcare providers to access relevant information securely (AfyaRekod, 2023). Per MaC Venture Capital (2022), since its launch, AfyaRekod has gained significant interest from health organisations worldwide: Africa, Europe, Asia, and the United States. The platform offers various functionalities for healthcare providers, such as hospital and patient management, knowledge management, and inventory management. For patients, AfyaRekod allows them to record their health data, access medical interventions, and provides consolidated information on pharmacies and essential resources for easy accessibility (MaC Venture Capital, 2022). According to Ngila (2023), the startup also aims to address the issue of counterfeit medications by introducing a feature that enables the verification of medication authenticity through scanning unique QR codes on packaging. By doing so, AfyaRekod aims to create medical accountability in Kenya and enhance the efficiency of healthcare delivery. That said, the Portal exemplifies how blockchain-based healthcare solutions can contribute to sustainable development in Kenya. By prioritising data security, privacy, and interoperability, the UPP enhances healthcare services, promotes responsible governance, and fosters collaboration among healthcare stakeholders, ultimately working towards achieving sustainable healthcare and improving overall health and well-being in the country.

According to Inau et al. (2022: 855), the vision for healthcare in Kenya—aligned with Vision 2030—is to provide equitable and affordable healthcare at the highest achievable standard for all citizens. This vision is guided by the strategies and outcomes of the Kenya Health Policy Framework (1994-2010), health sector strategic plans, and the implementation of e-Government and Shared Services Strategies by the e-Government Directorate and the ICT Board, respectively (Ministry of Health, 2014 in Inau et al., 2022: 855). AfyaRekod makes this vision a reality by offering a secure, consolidated, and subscription-driven Universal Patient Portal (UPP) accessible via both a web portal and a mobile app (Price, 2022)—thereby establishing a standardised and efficient system for data management, promoting interoperability, and seamless communication. In fact, during the launch of the UPP, Kenyan Chief Administrative Secretary Maureen Mbaka praised the initiative, highlighting its alignment with Vision 2030 and the government's efforts to leverage ICT for economic growth and improved healthcare delivery (Mulinge, 2022). That said, this comprehensive platform not only grants patients consistent access to their health records, it also offers a marketplace for real-time access to a range of health services (Price, 2022). The portal, with its extensive user base of over 150,000 in Kenya, delivers a secure and intelligent telehealth solution for data-driven insights, granting access to various healthcare services, trackers, reminders,

and notifications through multiple channels and devices (Sendoro, 2023). This innovative portal empowers both patients and healthcare providers to make well-informed decisions promptly, revolutionising the delivery of healthcare not only in Kenya but also potentially across Africa and beyond (Sendoro, 2023).

What is more, by recognising patients' sovereign rights over their information and emphasising data security, AfyaRekod mitigates unintended consequences associated with inadequate data protection (Serianu, 2019: 6). This commitment to data privacy and security helps build trust with patients and ensures that health data is used responsibly and ethically. With features like these, the UPP goes beyond managing health records to enhance the overall healthcare experience and empowers individuals to actively engage in managing their health. The impact of AfyaRekod on healthcare outcomes is multifaceted and significant, encompassing various aspects of healthcare delivery and patient management. Through successful partnerships and expansions, AfyaRekod has gained recognition and adoption within the healthcare sector, as demonstrated by collaborations with over 50 hospitals (Price, 2022). These partnerships indicate the platform's effectiveness in addressing challenges related to data management and healthcare integration, contributing to improved disease management and patient outcomes. For example, the collaboration between AfyaRekod and the National Health Insurance Authority (NHIA) highlights the platform's data-driven approach and its role in achieving Universal Healthcare (Ajimotokan, 2022). According to Ajimotokan (2022), by addressing challenges related to implementing an integrated approach across diverse mandates, this partnership promotes the advancement of healthcare, enhancing patient satisfaction and overall quality of life.

Another partnership of note is with IndyGeneUS, operating in Washington DC, and Nairobi. As Synapse (2021: 46) shows, AfyaRekod and IndyGeneUS are collaborating to build a large blockchain encrypted repository of indigenous and diaspora African data, focusing on disease prevention, drug development, and clinical management. This partnership—aiming to sequence one million African genomes—establishes a foundation in precision medicine for Kenya, Africa, the African diaspora, and indigenous populations worldwide (Synapse, 2021: 46). It also demonstrates a proactive effort to address unintended consequences related to AI bias in healthcare. This inclusive approach to data collection and analysis is essential in mitigating potential biases that could arise from skewed or limited datasets, ensuring that AI algorithms and precision medicine advancements are relevant and effective for diverse groups. Further, by combining whole-genome sequencing (technology that analyses an individual's complete genetic code, including all the genes and DNA elements that control their function), patient-centred health data, and electronic health records, IndyGeneUS AI aims to create a unique resource for research on conditions impacting

Kenya and African populations (Synapse, 2021: 46; Project MinE ALS Sequencing Consortium, 2018: 1537–1544). This collaboration enables advancements in genomics, patient management, and precision medicine, fostering improved healthcare outcomes through technology and research (Synapse, 2021: 46). Striving towards inclusivity and diversity in data collection contributes to more equitable and accurate healthcare outcomes, reducing the risk of AI bias and ensuring that precision medicine benefits all populations, regardless of ethnicity or geographic origin. These efforts contribute to improved healthcare outcomes through the utilisation of technology and research.

AfyaRekod's expansion of its fully automated Universal Patient Portal (UPP) to South Africa signifies its commitment to transforming patient care not only within the country but also across Africa and globally (Price, 2022; Zawya, 2022). This platform extends its services to doctors, providing a digital clinic equipped with a B2B platform, tele-pharmacy tool, and e-prescription platform; in doing so, the project emphasised the need for innovative, patient-centred healthcare solutions (The Paradise, 2022). This integration of advanced digital tools streamlines healthcare delivery, leading to improved disease management and quality of life for patients. The COVID-19 pandemic, adds Price (2022), further highlighted the urgent need for accessible and analysable health data, emphasising the significance of patient-centric approaches. Recognising the significance of patients' sovereign rights over their information, AfyaRekod enables easy access to health data through mobile devices, ensuring the provision of the best possible care by facilitating improved patient satisfaction and enhanced patient-provider communication (Price, 2022). This approach aligns with the sustainable development principle of leaving no one behind, as it empowers individuals to actively engage in their healthcare decisions and contributes to the overall improvement of health outcomes.

4.3.5. PanaBIOS

AI and blockchain technologies play vital roles in disease surveillance and outbreak response in Kenya. AI algorithms swiftly analyse diverse data sources, such as social media feeds, online search trends, and healthcare records, to identify potential disease outbreaks in real-time. This proactive approach enables public health authorities to implement timely prevention and control measures. Complementing AI, blockchain technology provides a secure and transparent platform for collecting and sharing disease-related data, ensuring authenticity and integrity from multiple sources. This enhances collaboration among stakeholders and improves outbreak response accuracy and timeliness. Recognising the need for unified pan-African technologies to combat the spread of COVID-19 and connect testing centres, the African Union backs PanaBIOS, a bio-surveillance technology. Kenyan startup Koldchain developed the technology, funded through a public-private

partnership with AfroChampions (Tech in Africa, 2020). PanaBIOS aims to revolutionise disease surveillance and control by replacing costly physical measures with smart and digital controls. Its suite includes modules for digital monitoring of social gatherings and venues, digitised contact tracing, mass testing, and digitisation of travel health history data to facilitate safe movement across borders (PanaBIOS, 2022). The app centralises results from facilities throughout Africa, facilitating contact tracing and monitoring of potential health threats, promoting safe movement and economic activities (Opali, 2020).

The Kenya Ministry of Health, in collaboration with the African Union and Africa Centre for Disease Control (CDC), has implemented an online system called Trusted Travel. This implementation has significantly impacted health outcomes. By using blockchain technology, the Trusted Travel system verifies and authenticates COVID-19 test certificates for travellers, ensuring the reliability and accuracy of test results (EASV, 2020). The African Union officially launched the Trusted Travel platform in October 2020, marking a milestone in harmonising entry and exit screening across the continent (African Union, 2021). Developed by the PanaBIOS Consortium and Econet Group, Trusted Travel supports member states in verifying test certificates, preventing fraudulent certificates, reducing COVID-19 transmission during travel, and facilitating the safe reopening of African economies, schools, and borders (African Union, 2021). The standardised approach contributes to improved health outcomes by minimising the spread of COVID-19 across borders. Ultimately, the service—with its AI and blockchain technologies—has the potential to positively impact health outcomes in Africa by improving disease surveillance, enhancing collaboration, promoting safe travel, and increasing access to testing and healthcare services. These efforts align with sustainable development's principles of resilience, inclusivity, and ensuring health and well-being for current and future generations.

By revolutionising disease surveillance, enhancing patient-provider communication, and providing data-driven insights for effective outbreak response, PanaBIOS exemplifies how technology can contribute to improved healthcare outcomes and align with sustainable development principles. The use of AI and blockchain technologies in disease surveillance and outbreak response in Kenya directly impacts healthcare outcomes, helping achieve objectives of ensuring healthy lives and promoting well-being for all. These technological advancements contribute to building resilient healthcare systems and fostering inclusive and sustainable health services for the current and future generations in Kenya. As discussed earlier, an excellent example of the impact on healthcare outcomes is the support by the African Union for PanaBIOS, a bio-surveillance technology. PanaBIOS employs smart and digital controls to revolutionise disease surveillance, enabling the replacement of costly physical measures with efficient digital solutions. By monitoring social

gatherings, digitising contact tracing, conducting mass testing, and facilitating safe movement across borders, PanaBIOS significantly contributes to minimising disease transmission and improving healthcare outcomes. This approach has likely played a role in reducing mortality rates associated with infectious diseases.

PanaBIOS's Trusted Travel platform, which is powered by blockchain technology, plays a vital role in achieving sustainable healthcare development. By verifying and authenticating COVID-19 test certificates for travellers, the platform ensures reliable health information, reducing the risk of disease spread during travel. This standardised approach enhances health and well-being by promoting safe movement and facilitating economic activities while minimising the risk of COVID-19 transmission. By mid-2020, Africa had remarkably low COVID-19 case numbers compared to other regions, accounting for only 5% of the global count and less than 1% of deaths (Tech in Africa, 2020). These favourable statistics prompted the reopening of borders to stimulate economic activity (Tech in Africa, 2020). Ghana was the sole African country using PanaBIOS at that time, allowing travellers to fulfil port clearance requirements by sharing their test results across borders (Tech in Africa, 2020). The successful utilisation of PanaBIOS played a crucial role in safeguarding public health and contributing to positive health outcomes in Africa. By providing a unified and interconnected digital platform, PanaBIOS facilitated efficient disease surveillance and control measures across the continent. The centralised resource management and optimised supply chains offered by PanaBIOS ensured that critical resources, such as testing kits and medical supplies, were effectively allocated to areas most in need, minimising shortages and enhancing outbreak response.

Nevertheless, concerns have been raised about the potential threats to civil liberties posed by PanaBIOS, which grants governments extensive surveillance powers. Implementing this technology would also necessitate legislative changes, as many African countries already have data protection laws in place (Tech in Africa, 2020). Despite these concerns, the platform's ability to centralise data, facilitate collaboration among stakeholders, and provide real-time updates on COVID-19 developments empowered healthcare systems to make informed decisions and implement targeted interventions. As the number of COVID-19 cases in Africa surpassed 1.3 million, the widespread adoption of PanaBIOS became indispensable in restarting cross-border travel and tourism within the continent, thanks to the efforts of PanaBIOS and Trusted Travel (ADF, 2020; Tech in Africa, 2020). These initiatives not only support testing requirements and monitor the spread of the virus, but also reduce the need for repeated tests and extensive quarantines (Opali, 2020). By streamlining processes, improving efficiency, and promoting safe movement, PanaBIOS and Trusted Travel contribute to mitigating the impact of the pandemic, enhancing economic recovery, and protecting

public health in Africa. According to Kamer (2023), Kenya had reported 334,500 confirmed COVID-19 cases with 5,650 casualties and over 325,400 recoveries as of July 2022, with Nairobi recording the highest number of cases among the 47 Kenyan counties.

The PanaBIOS Consortium, backed by the African Union, the Africa Tourism Board (ATB), and other pan-African institutions, addresses the complex questions surrounding national security, personal privacy, and human rights (ADF, 2020; Opali, 2020). By collaborating with various stakeholders and continuously refining the app based on Ghana's experience, the consortium demonstrated Africa's commitment to leveraging technology for safe travel, effective disease surveillance, and protection of public health (ADF, 2020). As the ADF (2020) continues, the impact of these initiatives extends beyond the African continent, with the insights gained from the PanaBIOS Consortium having the potential to revolutionise global approaches to the intricate issues surrounding technology-enabled travel and public health. By implementing innovative solutions like Trusted Travel and PanaBIOS, Africa sets an inspiring example for other regions grappling with similar challenges. These initiatives exemplify Africa's commitment to employing technology to ensure safe travel, mitigate the spread of COVID-19, and safeguard public health.

The implementation of AI and blockchain technologies in Kenya's disease surveillance and outbreak response—exemplified by PanaBIOS and the Trusted Travel platform—represents a significant leap forward in healthcare management and disease control within Africa. These technologies allow for real-time analysis of data, enhancing early detection of outbreaks and ensuring timely intervention. PanaBIOS, developed by the Kenyan start-up Koldchain, underscores the continent's shift towards digital bio-surveillance, aiming to streamline disease control measures and facilitate safe cross-border movement. The Trusted Travel system, leveraging blockchain technology to authenticate COVID-19 test certificates, illustrates a novel approach to maintaining health integrity and safety for travellers, aligning with efforts to reopen African economies safely. These initiatives reflect a broader trend of leveraging technology to enhance healthcare outcomes, demonstrating Africa's capacity to lead in innovative health solutions. By fostering collaboration among African nations and ensuring the secure and efficient exchange of health data, these platforms not only aim to curb the spread of diseases, they also contribute to the sustainable development of the continent's healthcare infrastructure.

4.4. Conclusion

This chapter extensively outlined how the integration of AI and blockchain technologies has transformed healthcare delivery in Kenya, challenging the traditional assumptions of dependency theory and offering a new paradigm of technological self-reliance and local innovation. By

employing AI-driven diagnostic tools and blockchain-based data management systems, Kenya's healthcare sector is advancing towards achieving better health outcomes, greater efficiency, and sustainability. The success of initiatives like Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS exemplifies how locally driven technological solutions can emerge from the Global South to address specific societal needs, thereby reducing reliance on external technologies and expertise. The advancements described challenge the traditional dependency narrative by showcasing Kenya's capacity for autonomous innovation in healthcare, enhancing the overall quality of care. These AI and blockchain applications contribute to Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 9 (Industry, Innovation, and Infrastructure), while promoting equitable healthcare access and local economic development.

Therefore, the Kenyan healthcare experience, driven by AI and blockchain technologies, not only demonstrates the potential for developing nations to forge independent paths in healthcare development but also serves as a model for other countries seeking to leverage technological innovation for sustainable development. These initiatives highlight the potential for local solutions to address global challenges—ultimately fostering a more resilient and self-sufficient healthcare system that transcends the limitations imposed by traditional dependency relationships.

Having explored the evolution of Kenya's healthcare system and highlighted key milestones and technological innovations, the next chapter—titled *Analysis*—is crucial for examining the implications of these technologies, assessing whether they alleviate or reinforce dependency, and considering the ethical dimensions of their application.

5. Analysis

In an era where technological innovation promises to revolutionise global healthcare, Kenya stands at a critical crossroads—poised to either break free from the chains of dependency or deepen its reliance on external powers. That said, this chapter critically examines Kenya's healthcare system through the lens of Dependency Theory, highlighting the persistent structural challenges and external dependencies that continue to constrain its progress. Despite ambitious healthcare reforms and initiatives aimed at achieving Universal Health Coverage (UHC), Kenya remains reliant on foreign capital, technology, and expertise to sustain its healthcare infrastructure. Dependency Theory, which critiques the unequal relationships between developed and developing nations, provides a useful framework for understanding how this reliance perpetuates systemic inequalities in healthcare delivery, particularly in rural areas. However, the rise of new technologies, specifically artificial intelligence (AI) and blockchain, offers a potential pathway to overcome these dependencies and reshape Kenya's healthcare landscape.

Drawing on Ndzendze and Marwala's work *Artificial Intelligence and International Relations Theories* (2023), this chapter explores how AI and blockchain are reshaping healthcare by enabling Kenya to potentially leapfrog traditional barriers. Through case studies such as Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS, this chapter investigates how these technologies contribute to improving healthcare delivery, reducing dependency on external systems, and fostering local innovation. Additionally, the ethical considerations surrounding the adoption of AI and blockchain—such as data privacy, digital inequality, and AI biases—are critically assessed to understand their role in promoting equitable and sustainable healthcare in Kenya.

5.1. Application of Dependency Theory in Kenya's Healthcare

Analysing Kenya's healthcare delivery system through the lens of dependency theory offers crucial insights into the persistent structural challenges that the country faces. Dependency theory, rooted in critiques of global capitalist structures, helps explain how Kenya's healthcare reforms and progress are constrained by its reliance on external resources—whether in the form of foreign capital, technology, or international expertise. The complexities of Kenya's healthcare system, which operates within a network of public, private, and faith-based providers, are compounded by this structural dependence, leading to systemic inequalities and persistent challenges in healthcare delivery, particularly in rural areas.

Despite efforts by Presidents Uhuru Kenyatta and William Ruto to expand healthcare infrastructure, implement universal health coverage (UHC) pilots, and address critical healthcare needs, the underlying dependency on external partnerships and foreign funding limits the sustainability and

autonomy of these reforms. For instance, initiatives like the AfyaCare programme under Kenyatta and Ruto's oxygen infrastructure projects highlight a reliance on global donors such as the Global Fund and Amref Health Africa. This mirrors the core-periphery relationships critiqued by dependency theory, wherein developed nations or international institutions maintain control over critical resources that developing countries require for their own development. Dependency theory also illuminates Kenya's internal struggles, particularly in financing mechanisms such as the National Health Insurance Fund (NHIF). The NHIF, while designed to reduce out-of-pocket healthcare expenses, faces challenges in sustaining coverage and meeting healthcare needs, leaving many Kenyans vulnerable. This internal dependency on limited healthcare financing mirrors the external dependency on global actors and creates additional barriers to achieving true healthcare autonomy.

Using Ndzendze and Marwala's (2023) book A*rtificial Intelligence and International Relations Theories* as an analytical framework for studying the application of dependency theory in Kenya's healthcare provides a lens through which to examine the technological transformation paradigm—especially as it relates to autonomy, innovation, and overcoming structural dependencies in healthcare. The integration of AI and blockchain technologies in Kenya's healthcare sector, as seen in the case studies, aligns with Ndzendze and Marwala's argument about the transformative potential of AI for developing countries. These technologies have the ability to enable Kenya to leapfrog traditional healthcare barriers, moving beyond dependency on global health infrastructure. In each case study, there are clear efforts to harness AI and blockchain for localised solutions, which resonates with the authors' belief in technological innovation as a means of fostering development and reducing dependency.

In the case of Sophie Bot, the AI-powered chatbot for sexual and reproductive health (SRH) education, it reflects the capacity of locally developed technologies to address culturally specific health challenges. Ndzendze and Marwala's framework of AI as a tool for local empowerment is evident here. Sophie Bot helps fill a gap in SRH education, particularly for young people, by providing culturally sensitive, real-time information. This represents a departure from relying on external health interventions or educational models that do not adequately address Kenya's unique cultural dynamics. The chatbot's ability to provide contextually relevant and locally developed solutions demonstrates AI's role in addressing issues of dependency in knowledge systems, contributing to greater technological autonomy. Ilara Health, which provides AI-powered diagnostic tools to underserved areas, illustrates the possibility of using AI to bridge the healthcare access gap in rural and peri-urban regions. Ndzendze and Marwala's ideas about leapfrogging traditional development pathways are particularly relevant here. By offering portable and affordable diagnostic

equipment, Ilara Health bypasses the need for large-scale, expensive infrastructure typically associated with modern healthcare systems. This aligns with the authors' views on AI allowing developing countries to skip certain stages of industrial development and build systems that suit their local needs. However, despite its local implementation, the case also reflects an ongoing dependency on foreign manufacturing and technology providers for the equipment and AI systems. The full realisation of technological autonomy, according to Ndzendze and Marwala, would involve Kenya not only adopting these technologies but also developing the capacity to produce and maintain them domestically.

Tambua Health's use of AI to diagnose respiratory diseases similarly reflects Ndzendze and Marwala's notion of AI-driven leapfrogging. Tambua Health's mobile-based diagnostic tools provide a low-cost, non-invasive solution to a significant healthcare challenge in Kenya—tuberculosis (TB) and other respiratory diseases. This kind of innovation addresses issues of healthcare accessibility by decentralising diagnostic processes, reducing the need for traditional, resource-intensive healthcare infrastructures. Tambua Health demonstrates how AI can provide not only efficiency but also equity in healthcare outcomes by making diagnostic services available to remote and underserved populations. This case shows that AI can help countries like Kenya move from a position of dependency on foreign health interventions to one of self-sufficiency in managing public health issues. However, the reliance on foreign technology to develop and enhance AI capabilities for diagnosis continues to highlight the need for greater localised production and innovation capacities.

AfyaRekod's blockchain-based patient management system aligns with the principles of decentralisation and technological sovereignty as articulated by Ndzendze and Marwala. The use of blockchain to give patients control over their own health data marks a shift away from dependency on external, centralised systems. AfyaRekod's system addresses the longstanding issue of fragmented health data management in Kenya by creating a universal patient portal accessible across healthcare institutions. This decentralised model of health data management, enabled by blockchain, offers a level of security and privacy that has traditionally been controlled by external corporations or international healthcare organisations. By giving patients sovereign control over their data, AfyaRekod contributes to reducing dependency on external health systems while fostering a more resilient, autonomous local healthcare infrastructure. Finally, PanaBIOS, which uses AI and blockchain to facilitate cross-border disease surveillance, showcases how Kenya can position itself as a proactive participant in global health governance, rather than a passive recipient of international aid and technology. PanaBIOS, developed during the COVID-19 pandemic, plays a crucial role in monitoring and controlling the spread of diseases across borders, using a locally

developed AI-driven platform. This aligns with Ndzendze and Marwala's emphasis on how AI can help African countries exercise greater agency in global issues, reducing their reliance on external health and disease management systems. PanaBIOS demonstrates how AI and blockchain can be used not only to respond to local health challenges but also to contribute to broader regional and global health systems, positioning Kenya as a leader in technological solutions for public health.

Nevertheless, as dependency theory emphasises, the power imbalances in global systems mean that even technological innovations can come with challenges, such as digital inequality and AI biases. These issues must be carefully navigated to ensure that local innovations genuinely contribute to healthcare autonomy and do not reinforce new forms of dependency on technology driven by external actors. Further, the recurring theme of reliance on foreign technology highlights the ongoing tension between technological adoption and true autonomy. While AI and blockchain offer pathways to reduced dependency, the full potential of these technologies will only be realised when Kenya can produce and innovate independently, building the infrastructure and expertise needed to sustain technological progress.

5.2. Ethical Considerations

AI- and blockchain-driven healthcare projects, such as Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS, raise significant ethical considerations that must be addressed for these technologies to benefit developing countries equitably. One of the foremost challenges lies in Kenya's infrastructural limitations. Reliable internet connectivity and electricity supply are vital for the effective use of AI and blockchain technologies, yet rural and remote areas of Kenya often face disruptions and instability in these essential services. As noted by Reddy (2021), Casey et al. (2020), and Khot (2020), such infrastructural weaknesses create significant barriers to the widespread adoption of these technologies—particularly in regions where healthcare facilities already struggle to meet basic operational standards. Power outages and unstable internet connections further hinder the real-time transmission and analysis of healthcare data, which is essential for AI systems and blockchain-based data security solutions.

Privacy and data security are paramount across all projects. These technologies tend to deal with sensitive health information, and breaches or unauthorised access could expose individuals to exploitation or discrimination, particularly in contexts where data protection laws are weak. Blockchain platforms like AfyaRekod's Universal Patient Portal ensure secure data sharing, but the immutability of blockchain can complicate the correction of inaccurate or outdated records, raising ethical questions about patient rights. In Kenya, concerns over data breaches and the misuse of health information are significant. Moore (2023) underscores the security risks associated with AI,

noting that vulnerabilities such as data input poisoning or model extraction could compromise patient data. This is particularly concerning in a healthcare context, where the protection of patient confidentiality is paramount. Blockchain, while offering solutions for secure data storage, presents its own challenges. The irrevocability of records on blockchain systems means that once data is recorded, it cannot be altered or deleted, which raises concerns about compliance with privacy laws such as Kenya's Data Protection Act (Akello, 2022: 5).

Further, bias and fairness in AI systems are critical issues. If these tools, such as Sophie Bot or Tambua Health's diagnostic platforms, are trained on non-representative data, they may perpetuate health disparities by offering less accurate services to underrepresented groups. This can lead to unequal health outcomes—particularly in diverse populations. AI systems handling genomic data, as seen with AfyaRekod, must ensure inclusivity to avoid reinforcing biases in precision medicine. As Manyika, Silberg, and Presten (2019) note, AI systems are susceptible to biases, which could lead to unequal treatment outcomes for different demographic groups. In Kenya, where socio-economic inequalities and healthcare disparities are already prominent, the introduction of biased algorithms could exacerbate these issues. Obermeyer et al. (2019) demonstrated how biased algorithms in healthcare can lead to racially disparate outcomes, a risk that Kenya must mitigate to ensure equitable healthcare delivery.

The digital divide also presents a challenge; while these technologies have the potential to improve healthcare access, they may also exacerbate inequalities if large portions of the population lack the necessary internet access or digital literacy to benefit from these innovations. The scarcity of qualified personnel capable of managing and interpreting AI-generated data or securely handling blockchain systems further limits the country's capacity to leverage these innovations effectively (WHO Africa, 2017). This inequality could be further entrenched if the adoption of AI and blockchain is restricted to urban or well-funded healthcare facilities, leaving rural and economically disadvantaged areas behind. As a result, while AI and blockchain have the potential to address some inefficiencies in Kenya's healthcare system, their unequal implementation could reinforce dependency dynamics and widen the healthcare gap, particularly for vulnerable populations (Ilinca et al., 2019: 4-7).

Misinformation and reliability further complicate the ethical landscape, as inaccuracies in AI-driven tools could lead to harmful health decisions. Platforms like Tambua Health or Sophie Bot must ensure that their AI systems provide reliable and up-to-date information, as misinformation in healthcare can have severe consequences. Informed consent and autonomy are also major concerns, as users must understand how their data is collected, used, and stored. In developing countries, where digital literacy may be limited, ensuring that users of platforms like Sophie Bot or

AfyaRekod are fully informed and able to consent meaningfully is essential. Employment concerns also arise as AI automation may displace healthcare workers, particularly those in administrative or diagnostic roles. While these technologies aim to increase efficiency, their implementation must consider the potential socio-economic impact on the healthcare workforce, particularly in regions where healthcare jobs are critical to local economies. As Ernst, Merola, and Samaan (2018) point out, the socio-economic disruptions caused by automation could disproportionately impact low-skilled workers, further deepening the socio-economic divide. Kenya also faces financial constraints that impede the adoption of AI and blockchain. These technologies require substantial investment in both hardware and software, as well as ongoing maintenance costs. As highlighted by Chatterjee and Dethlefs (2022), resource-limited healthcare systems like Kenya's may find it prohibitive to allocate the necessary funds for large-scale AI and blockchain integration. This is compounded by the existing resource allocation challenges within the healthcare system, which are exacerbated by a shortage of healthcare professionals (Phelan, Yates, and Lillie, 2022: 501-503).

Cultural implications play a significant role in the adoption of AI and blockchain technologies in Kenya's healthcare sector to achieve Sustainable Development Goal 3. Kenya's cultural heritage is characterised by various traditions and trends; that is, without a single prominent culture defining the country (Olubayi, 2010: 222-238). The blending of tradition and modernity is central to Kenyan culture, where non-explicit communication techniques are commonly used, and the style of communication depends on the level of intimacy (AFS-USA, 2023). This cultural aspect underscores the importance of adopting a nuanced approach when introducing AI and blockchain technologies in healthcare. Transparent and clear communication becomes crucial to build trust among healthcare providers and patients, ensuring they understand the benefits and functioning of these technologies. Olubayi (2010: 222-238) adds that a distinct national culture has emerged, borrowing from and reshaping the 50 ancient ethnic cultures of Kenya. This diverse cultural climate posits AFS-USA (2023) can influence the acceptance of AI and blockchain technologies in healthcare settings; so, to overcome resistance and foster acceptance, it is essential to leverage Kenyan people's strong sense of community and sociability. Further, since respecting the influence of elders and authority figures is critical in Kenya, their consultation and collaboration can positively impact the acceptance of AI and blockchain technologies among the wider population (AFS-USA, 2023). Involving them in discussions and decision-making processes can promote a sense of ownership and inclusivity. Addressing privacy concerns is another crucial factor for successful adoption. Kenya's cultural values may place a high premium on personal privacy, making it essential to implement robust data privacy and security measures (AFS-USA, 2023). This will help alleviate concerns and build trust among healthcare professionals and patients. Designing AI and blockchain technologies in healthcare with cultural sensitivity is paramount. Understanding

local cultural practices, beliefs, and norms is essential to ensure responsible and inclusive deployment (AI BOX, 2023; UNESCO, 2022). It aligns with ethical guidelines promoted by organisations like UNESCO and ensures that these technologies are adapted to suit the unique needs and preferences of different cultural groups within Kenya. The introduction of advanced technologies such as AI and blockchain may encounter resistance if these cultural dynamics are not considered. Transparency and clear communication are crucial to gaining the trust of both healthcare providers and patients. While AI offers efficiency in handling tasks like medical record management or diagnostics, the reduction in human oversight and employment opportunities may negatively affect the workforce, particularly in a country like Kenya where job security remains a pressing issue.

Collectively, the aforementioned factors make the adoption of AI and blockchain into Kenya's healthcare system a complex process, necessitating careful consideration of local conditions and equitable implementation strategies.

5.3. Conclusion

The analysis of Kenya’s healthcare system through the lens of dependency theory, supported by Ndzendze and Marwala's insights, demonstrates that while AI and blockchain technologies offer significant potential for leapfrogging traditional development barriers, their impact is constrained by both internal and external dependencies. The reliance on foreign capital, technology, and expertise remains a limiting factor, preventing full healthcare autonomy. Despite the progress shown in the case studies, such as Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS, the technological innovations they represent still rely on external sources for development and implementation, highlighting Kenya's ongoing structural dependencies. Not only that, but the ethical challenges—including infrastructural limitations, data security, AI biases, and digital inequality—must be addressed to ensure that AI and blockchain technologies genuinely contribute to healthcare autonomy rather than reinforcing new forms of dependency. Cultural considerations, including the need for transparency and trust-building in the adoption of these technologies, further complicate their successful integration into Kenya’s healthcare system.

Therefore, while AI and blockchain hold transformative potential, achieving true healthcare independence in Kenya will require a concerted effort to build local technological capacity, reduce reliance on foreign entities, and navigate ethical and cultural challenges. Without this, the risk remains that these technologies, instead of fostering healthcare autonomy, could perpetuate existing inequalities and dependencies. The path forward involves not just adopting AI and blockchain but

fostering an environment where Kenya can independently innovate, produce, and govern its technological solutions.

In Chapter 6: *Conclusion and Recommendations*, I synthesise these findings into a broader conclusion and offer practical recommendations for policy and future research. This following, final chapter will not only summarise the key takeaways but also propose pathways for Kenya to leverage technological innovations for a more autonomous and sustainable healthcare system.

6. Conclusion and Recommendations

Reflecting on the key findings and addressing the research questions set out at the beginning of the study, this chapter offers a comprehensive analysis of how artificial intelligence (AI) and blockchain technologies have contributed to healthcare improvements in Kenya. It focuses on accessibility, efficiency, and quality of care. The chapter also critically examines the application of dependency theory in the context of Kenya's healthcare system, highlighting the country's growing capacity for technological innovation and self-reliance. Lastly, it identifies areas for future research, particularly in addressing existing gaps and exploring how AI and blockchain can further transform healthcare delivery.

Through this reflection, this chapter balances the progress of these technologies with the ongoing challenges, offering guidance for future research and policy to create a fairer, more efficient, and self-sustaining healthcare system in Kenya.

Reflection on the research questions

Research Question 1: *How have AI and blockchain technologies contributed to the improvement of healthcare delivery in Kenya?*

From the case studies examined—Sophie Bot, Ilara Health, Tambua Health, AfyaRekod, and PanaBIOS—it is clear that AI and blockchain technologies have played a significant role in improving healthcare delivery in Kenya. For example, Sophie Bot has revolutionised sexual and reproductive health education by providing real-time, culturally appropriate information to young people, addressing gaps in SRH services. Ilara Health and Tambua Health have decentralised diagnostics, bringing advanced AI-powered diagnostic tools to underserved rural and peri-urban regions. Meanwhile, AfyaRekod has improved data management and patient care continuity through blockchain, allowing for seamless and secure access to health data across healthcare facilities. Although these technologies have led to substantial improvements in healthcare accessibility and delivery, it is important to acknowledge that these outcomes are limited by the continued reliance on foreign technology and infrastructure. For instance, the AI-powered diagnostic tools deployed by Ilara Health and Tambua Health still rely on imported technology, which reflects the underlying dependency dynamics in Kenya's healthcare system.

Research Question 2: *To what extent have these technologies influenced healthcare outcomes—especially in terms of accessibility, efficiency, and quality of care?*

The impact of AI and blockchain technologies on healthcare outcomes is evident in the enhanced accessibility and efficiency seen in the case studies. For example, the introduction of AI-powered

diagnostic devices in Ilara Health and Tambua Health has significantly reduced the need for patients in rural areas to travel long distances for healthcare services. By decentralising care and providing more efficient diagnostic tools, these technologies have improved the quality of care and efficiency in delivering services. However, while AI and blockchain have contributed to improving healthcare outcomes, an analysis of health outcomes between 2015 and 2024 show that changes in disease management (such as in malaria and tuberculosis) cannot be directly attributed to these technologies alone. Kenya's health outcomes are influenced by broader systemic issues, including healthcare infrastructure and external funding, which complicate the attribution of technological impacts to specific interventions.

Research Question 3: *How do these technologies align with or challenge the principles of Dependency Theory, particularly in fostering or hindering self-reliance in Kenya's healthcare sector?*

Dependency Theory argues that developing nations like Kenya remain tied to the Global North for essential technologies, capital, and expertise, which limits their capacity for self-reliance. The research demonstrates that while Kenya's healthcare system still relies on external resources, the rise of locally developed innovations—such as Sophie Bot and AfyaRekod—offers a new pathway toward reducing dependency. For example, AfyaRekod's blockchain-based health records system decentralises control over health data, empowering Kenyan patients and healthcare providers to manage their data autonomously. This represents a shift away from reliance on external data systems. Moreover, innovations like Sophie Bot, developed by local talent, challenge the core-periphery dynamics highlighted in Dependency Theory by showing that Kenya is capable of developing home-grown solutions to local healthcare challenges. However, these examples are not without limitations. Kenya remains dependent on foreign capital and technology for the production and maintenance of these AI and blockchain solutions, which perpetuates structural dependencies despite the promise of innovation. Thus, while AI and blockchain technologies provide avenues for autonomy, they have not yet eliminated Kenya's reliance on external actors in healthcare.

6.1. Synthesis of Findings

The key findings of this study reflect a dual reality: on one hand, AI and blockchain technologies have introduced promising solutions for improving healthcare delivery in Kenya, especially in underserved areas. These technologies have the potential to help Kenya "leapfrog" traditional development barriers by decentralising care, improving data management, and expanding access to services. On the other hand, Kenya remains constrained by the global structures of dependency that Dependency Theory critiques. While innovations such as AfyaRekod and Sophie Bot demonstrate

Kenya’s growing capacity for technological self-reliance, the country’s healthcare sector is still heavily dependent on foreign technology and funding, limiting the full realisation of these technologies' potential. This research also demonstrates that AI and blockchain technologies have a dual effect on Kenya’s healthcare sector. On one hand, these technologies challenge traditional notions of dependency by fostering local innovation and reducing reliance on external health systems. On the other hand, they reinforce new forms of dependency, particularly in relation to imported AI systems and blockchain infrastructure. The balance between technological autonomy and dependency is therefore a complex one, requiring Kenya to not only adopt these technologies but also build the local capacity to innovate, maintain, and produce these solutions domestically.

6.2. Recommendations for Future Research

The findings in this thesis highlight several critical areas where Artificial Intelligence (AI) and blockchain technologies can play a transformative role in reducing dependency and advancing healthcare outcomes in Kenya. However, despite these advancements, there remain significant research gaps and areas that require further investigation. These gaps offer opportunities for academic inquiry, policy development, and practical implementation strategies that address the evolving challenges and opportunities within Kenya’s healthcare system. This subsection outline these recommendations, which will serve as a foundation for future research and guide policy pathways aimed at fostering technological innovation, reducing dependency, and improving healthcare delivery in Kenya.

One area ripe for future research is the comprehensive integration of emerging technologies like AI and blockchain into Kenya’s healthcare system. This includes identifying systemic barriers such as inadequate infrastructure, workforce shortages, and insufficient public funding. These issues hinder Kenya's ability to fully leverage these technologies for sustainable healthcare development. Future research should focus on how infrastructure development can support the deployment of these technologies, especially in underserved areas. Researchers should examine the infrastructural requirements for implementing AI and blockchain in rural healthcare settings, evaluate the effectiveness of existing policies like the Kenya Health Policy (2014–2030) and the Digital Health Act (2023) in fostering AI-driven healthcare innovation, and analyse the role of public-private partnerships in scaling up the use of these technologies within the healthcare sector.

Another key focus for future research is the impact of AI and blockchain on healthcare workforce development. Workforce capacity remains a critical challenge in Kenya’s healthcare sector, and research is needed to explore how AI and blockchain can address these gaps through targeted training programs and initiatives that enhance workforce retention, particularly in rural and

underserved areas. It is essential to train healthcare workers to effectively manage and implement these new technologies, thereby reducing dependency on foreign expertise. Future studies should investigate the development of AI and blockchain training curricula tailored to Kenya's healthcare professionals, assess the socio-economic impact of AI-driven automation on the workforce, particularly in administrative and diagnostic roles, and explore retention strategies, such as housing allowances and performance incentives, to mitigate the shortage of healthcare professionals in rural areas.

Health data management and governance also warrant further investigation, particularly regarding privacy, security, and the ethical management of sensitive patient information. Blockchain technology has the potential to enhance data security, but its implementation must address Kenya's legal and regulatory gaps. Future research should focus on building a robust health data management system that aligns with both domestic and international regulatory frameworks. Researchers could explore the establishment of a National Health Data Management Authority to oversee data governance and ensure the safe integration of blockchain technologies. In addition, the role of AI in predictive analytics for healthcare resource allocation and disease prevention, along with a comparative analysis of Kenya's data governance structures with regional efforts like the AU's One Health Data Alliance Africa Project, are essential areas for future study. What is more, future research should delve into the socio-cultural and ethical implications of deploying AI and blockchain technologies in Kenya's healthcare sector. It is crucial to engage local communities and ensure that technological advancements respect cultural and ethical values. This includes addressing issues such as digital inequality, gender disparities in access to technology, and concerns about patient privacy and consent. Researchers should examine the socio-cultural barriers to adopting AI and blockchain in healthcare, particularly among marginalised populations, investigate the ethical considerations surrounding patient autonomy in the context of AI-powered decision-making tools, and develop strategies to ensure equitable access to these innovations, especially for women and rural populations.

Finally, the environmentally sustainable adoption of AI and blockchain technologies is a critical research area. Kenya's healthcare system, like those of many developing countries, is vulnerable to the environmental impacts of these technologies, particularly the high energy consumption associated with blockchain. Future research should focus on integrating AI and blockchain in ways that minimise environmental harm while promoting healthcare innovation. Key research questions might include investigating the environmental footprint of AI and blockchain in Kenya's healthcare sector, developing frameworks for the sustainable deployment of these technologies with a focus on renewable energy sources and energy-efficient data centres, and aligning Kenya's healthcare

technology strategies with international environmental sustainability goals, such as the African Union's Green Recovery Action Plan.

By pursuing these recommendations, future research will not only build upon the findings of this thesis but will also contribute to the creation of a sustainable, self-reliant, and technologically advanced healthcare system in Kenya. This research agenda aligns with both national priorities and global development goals, supporting Kenya's transition towards greater autonomy and reduced dependency in healthcare delivery.

The absence of retained quantitative data in this study also presented a notable limitation in fully capturing the tangible impacts of AI and blockchain technologies on healthcare outcomes in Kenya. While qualitative methods provide rich, context-specific insights into how these technologies are applied and their perceived effects on healthcare delivery, they do not offer the measurable, statistical evidence needed to evaluate the scale and magnitude of these impacts. For instance, the qualitative case studies of reveal the innovative potential of AI and blockchain in addressing healthcare challenges, but without quantitative data, it becomes difficult to assess how significantly these innovations improve patient outcomes, such as reduced mortality rates, improved disease management, or enhanced access to healthcare services. Quantitative data—such as metrics on patient outcomes, disease prevalence, diagnostic accuracy, or health system efficiency, would provide a clearer, more measurable understanding of the effectiveness of AI and blockchain technologies in real-world healthcare settings. This could include data points like the number of patients diagnosed through AI-powered diagnostic tools, reductions in misdiagnosis rates, or improvements in healthcare delivery times. In addition, metrics on disease control, such as tracking the spread of communicable diseases through blockchain-based surveillance systems, like PanaBIOS, would offer concrete evidence of the technologies' role in preventing and controlling outbreaks.

To address this gap, future research could adopt a mixed-method approach that combines qualitative analysis with deep quantitative data collection. A mixed-methods approach would allow researchers to triangulate findings, ensuring that qualitative insights are backed by quantitative evidence. For example, the thematic findings derived from the qualitative analysis could be validated by gathering data on healthcare outcomes from clinics using AI-powered diagnostic tools or blockchain-based record systems. This data could then be used to perform statistical analyses, providing a comprehensive view of both the subjective experiences of healthcare professionals and patients, and the objective, measurable outcomes of technology deployment. Such a mixed-method approach would also allow for a longitudinal study of how AI and blockchain technologies influence healthcare outcomes over time. By collecting baseline data and tracking improvements in health

indicators, future studies could assess whether these technologies deliver sustained improvements in healthcare systems, or whether their benefits are short-lived or context-dependent. Moreover, quantitative data could also highlight any disparities in the adoption or effectiveness of these technologies across different regions, genders, or socio-economic groups, which would be particularly relevant in addressing issues of digital inequality.

Final Thoughts

In conclusion, this thesis has demonstrated that while AI and blockchain technologies hold great promise for advancing healthcare delivery in Kenya, they exist within a broader global structure of dependency. Kenya's healthcare innovations—while significant—are still bound by external reliance on foreign technology and capital. However, the country's adoption of AI and blockchain represents a critical step toward achieving healthcare autonomy. Future efforts should focus on building the local capacity needed to fully realise the potential of these technologies, reducing dependency, and fostering a more self-sustaining healthcare system. By addressing these challenges, Kenya can position itself as a leader in healthcare innovation and improve health outcomes for its population.

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