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edited by Alessandro Boccanelli
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The African Model

by Gian Stefano Spoto*

Disastrous healthcare systems, counterfeit drugs, excessive use of antibiotics, and much more. UGHJ's lens is focused on Africa, where in many countries the situation is beyond imagination.

But what if this continent were the testing ground for solving many of the problems affecting nations of *imperfect prosperity*? In Senegal, for example, researchers are designing innovative architectural structures for facilities that accommodate pregnant women and their children while also striving to develop holistic healthcare policies.

Isn't *One Health*, the very essence of our magazine, precisely about holistic health policies?

It's natural to think that before implementing these methodological advancements, Africa should first focus on providing basic healthcare services. Especially in rural areas, the concept of healthcare for all – let alone everywhere – is still a distant reality.

One Health also means studying and simultaneously monitoring diseases in both humans and animals. To achieve this, well-organized networks are needed, and some even speculate that controversial cryptocurrencies could serve as a tool to curb the massive stockpiling of medicines.

In such a scenario, how can adequate attention be given to mental health care? In Congo, and across Africa, mental health patients are neglected, often hidden away and isolated without any possibility of external contact or treatment.

And what about individuals with Down syndrome? In many places, they are still seen as a divine punishment and are therefore even more confined within their homes. In Ethiopia, the *Debora* organization is working to break through the barriers of this deeply entrenched stigma. A major event was organized at the end of 2024 following World Down Syndrome Day the previous year.

Unicamillus supports science education and the dissemination of scientific methods in countries where approaches to healthcare remain largely random.

Africa is a priority – an epicenter of urgent challenges that require action. And, as previously mentioned, it also serves as a testing ground for exposing the contradictions and dysfunctions of our own healthcare systems.

* Gian Stefano Spoto, UGHJ Editor-in-chief.

From Zoonoses to One Health, Passing Through Professor Adriano Mantovani

by Arcangelo Gentile*

Abstract
The importance of the awareness that animals, humans, and environment are interconnected and can no longer be approached separately has finally been receiving more and more consideration and is summarized in the term "One Health". A visionary and staunch advocate of the One Health concept can be considered prof. Adriano Mantovani (1926-2012), professor of veterinary infectious diseases at the University of Bologna, that already in the 1950s promoted not only the necessity of interdisciplinary collaboration and unity between human and veterinary medicine, but also the importance of inserting the two medicines in the social and environmental global contests. Without doubt, he can be considered a pioneer of the "One Health".

Keywords
Veterinary public health, One Health, professor Adriano Mantovani.

It is now clear: animals, humans, and the environment are so interconnected that they can no longer be considered separately. This intricate web involves health and disease, climate and natural disasters, human behaviour and social phenomena, local and global economies, wars and the unequal distribution of wealth, and even the lack of basic needs such as education, safe drinking water, food, housing, and healthcare services.

A forerunner of the One Health concept, although limited in scope, is the term *zoonosis*. The credit for coining this term goes to Rudolf Virchow (1821-1902), the first to give scientific value to the shared diseases between humans and animals.

Since ancient times, humans have been aware of the risk of "falling ill" due to animals and the environment, which has influenced prejudices, popular beliefs, and religious dogmas. It was evident in antiquity that epidemics often struck both animals and humans simultaneously, perhaps as a form of divine punishment. With the advent of veterinary medicine and the development of comparative pathology (already in use during Aristotle's time), connections between diseases and professions became apparent. Observations emerged that certain diseases primarily affected individuals who worked closely with animals or their products, or those engaged in specific types of labor – an

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issue that became even more pronounced during the Industrial Age.

With the rise of microbiology, the zoonotic link between certain etiological factors became clear, evolving from the concept of "poisonous agents" to microbial agents. A major breakthrough came with the acceptance that transmission could also occur in the reverse direction, from humans to animals.

Bruno Galli-Valerio (1867-1943), in *Zoonoses. Diseases Transmissible from Animals to Humans* (1894), and Alberto Ascoli (1877-1957), in the *Italian Veterinary Yearbook* (1935), revisited the term zoonosis, giving it nosographic significance. Ascoli classified the most important zoonoses, listing glanders, anthrax, and rabies at the top.

The term *zoonosis* was officially recognized by the World Health Organization (WHO) in 1951, when it provided the first formal definition ("infections in humans... shared in nature by other vertebrate animals") and compiled a list of over 80 diseases transmissible to humans. With zoonoses now well-defined, they paved the way for the advancement of public health. That same year, the WHO established the Veterinary Public Health Unit and the WHO/FAO Joint Expert Group on Zoonoses.

However, to transition from zoonoses to One Health, one crucial element was missing: the relationship between the animal-human duo and the broader environment. This concept aligns with the definition found in *Treccani*: "a complex system of physical, chemical, and biological factors, of living and non-living elements, and of relationships in which all organisms on the planet are immersed", a concept now broadly referred to as the *biosphere*.

It was from this perspective that, in the 1950s, Professor Adriano Mantovani (1926-2012) emerged as a key figure. He was a professor of *Infectious Diseases, Prevention, and Veterinary Health Policies* at the Faculty of Veterinary Medicine in Bologna, Director of the Parasitology Laboratory at the Italian National Institute of Health, and Director of the WHO/FAO Collaborating Center for Veterinary Public Health in Rome. A visionary and staunch advocate of what would later be established as One Health, he is rightfully considered a pioneer – indeed, the father – of veterinary public health.

Firmly convinced of the necessity of interdisciplinary collaboration, Mantovani had a clear vision of the unity between human and veterinary medicine. His approach spanned epidemiology, zoonosis and infectious disease control, urban veterinary hygiene, health education, and even veterinary intervention in emergencies and disasters. In this regard, driven by a strong political sense of participation and social commitment, in 1980 he actively coordinated veterinary services in areas affected by the Irpinia earthquake, laying the groundwork for WHO guidelines in cases of non-epidemic emergencies.

It is true that the One Health concept was simultaneously developing in other parts of the world. However, such a broad and forward-thinking interpretation was found only in this controversial and often debated, yet relentless pioneer: Professor Adriano Mantovani.

Interviews From the Field. From Trauma to Healing: Building a Brighter Future for Mental Health in the Democratic Republic of Congo

by Mattia Albanese, Lorenzo Tarsitani, Ludovica Molina, Michele Nazzaro, Riccardo Serra, Laura Elena Pacifici Noja, Giancarlo Ceccarelli*

Abstract
The healthcare system of the Democratic Republic of Congo (DRC) is a stark reflection of the nation's tumultuous history, characterized by chronic underfunding, insufficient resources, and significant human resource challenges. Mental health services are critically underdeveloped, with a severe lack of trained professionals, pervasive stigma, and systemic weaknesses. The situation is particularly dire in rural areas, where geographic and financial barriers further limit access to care. Prioritizing mental health, investing in training and infrastructure, and combating stigma are essential steps toward building a resilient and equitable healthcare system in the DRC.

Keywords
Mental health, psychiatry, Africa, developing countries, low-resources, healthcare system.

According to the 2024 Asylum Report by the European Union Agency for Asylum (EUAA), approximately 11,000 asylum applications were submitted by citizens of the Democratic Republic of the Congo (DRC) in 2023 across EU countries [1]. Additionally, the Mid-Year Trends 2023 report by UNHCR highlights that, in the first half of 2023, over 1.1 million Congolese citizens were living as refugees and asylum seekers, predominantly in neighboring countries to the DRC [2]. Among this population, literacy rates vary significantly. While a large proportion of refugees

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have limited formal education due to systemic barriers in the DRC, an estimated 15-20% possess secondary or higher education, indicating a substantial underutilization of human capital in host countries. Furthermore, there has been a notable exodus of professionals, including medical doctors, fleeing the challenging political situation and instability. These individuals often face significant difficulties in obtaining recognition for their qualifications and reintegrating into their professions in host countries, further exacerbating personal hardships and contributing to the brain drain from the DRC. However, these professionals provide valuable firsthand testimony of the severe challenges faced by the healthcare system in their home country, shedding light on issues that would otherwise remain largely unknown. This report on the healthcare situation in DRC, specifically in the area of psychiatric care, was inspired by a field interview with Dr. E.L.K., a Congolese psychiatrist who left his homeland due to the ongoing violent conflicts and sought asylum in Europe.

The Democratic Republic of Congo's (DRC) healthcare system mirrors the nation's volatile past. Its fragmented and underfunded structure struggles to overcome profound challenges in healthcare delivery. Although the impact of conflict is immediately evident, it primarily amplifies existing systemic deficiencies, hindering the provision of even fundamental care to the Congolese population (figure 1) [3].

A primary challenge facing the DRC's healthcare system is chronic underfunding. The percentage of Gross Domestic Product (GDP) allocated to healthcare is alarmingly low, failing to meet the Abuja Declaration's 15% target by a significant margin. This severe lack of resources results in dilapidated infrastructure, persistent shortages of essential medicines, and insufficient staffing. Consequently, the system's ability to effectively deliver healthcare is severely compromised. While international aid attempts to address these shortfalls, it can create an undesirable dependency that may not serve the DRC's long-term needs, potentially hindering the development of a self-sufficient and robust healthcare system [4].

The DRC's healthcare system is further hampered by a critical shortage of qualified personnel, including doctors, nurses, and specialists. This human resource crisis is driven by inadequate training, low salaries, and a significant brain drain of healthcare professionals to other countries. The resulting scarcity of skilled workers is particularly acute in rural areas, leaving millions with limited access to basic care. This unequal distribution, with healthcare workers concentrated in urban centers, leaves rural populations underserved and often reliant on traditional healers ill-equipped to manage complex medical needs [4,5].

Geographical and financial obstacles prevent many in the DRC from accessing healthcare. The nation's vast and difficult terrain, combined with poor infrastructure, makes reaching healthcare facilities a logistical ordeal, especially for those in remote regions. This isolation intensifies health inequities and delays timely interventions. Furthermore, poverty creates a substantial barrier, as limited health insurance and high out-of-pocket costs impose devastating financial burdens on families seeking care, exacerbating their economic hardship.

CATEGORY	DESCRIPTION
HEALTHCARE SYSTEM	Fragile, limited infrastructure, particularly in rural areas. Reliance on NGOs and international aid.
EPIDEMIOLOGICAL SITUATION	High burden of infectious diseases (malaria, tuberculosis, HIV/AIDS, etc.). Emerging infectious diseases are also a concern (e.g., Ebola). There is an increasing prevalence of non-communicable diseases such as cardiovascular disease, diabetes, and psychiatric conditions.
DATA CHALLENGES	Data collection and reporting are often incomplete and delayed. Limited resources and infrastructure hinder accurate and timely data gathering.

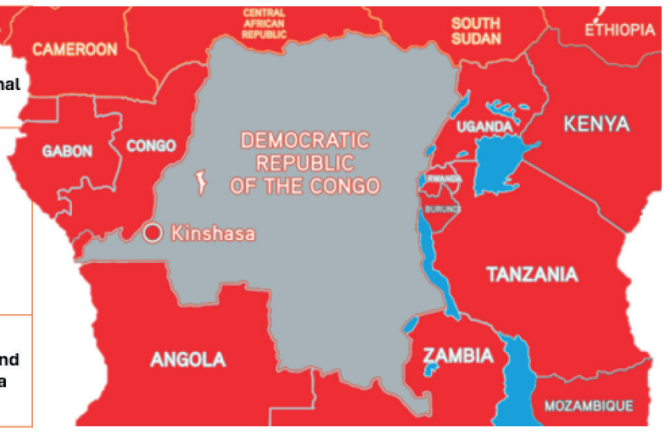

Figure 1. *DRC health data overview.*

The mental health sector in the Democratic Republic of Congo faces immense challenges, reflecting the broader struggles within its healthcare system and the lasting effects of conflict and poverty. Chronic underfunding plagues the DRC's healthcare system as a whole, with mental health receiving minimal resources. Years of conflict and neglect have left the healthcare infrastructure in disrepair. Hospitals and clinics, especially in rural areas, frequently lack essential equipment, medications, and trained staff. Access to healthcare remains highly unequal, with significant disparities between urban and rural populations [6].

Mirroring the broader healthcare system's struggles and the enduring impact of conflict and poverty, mental health services in the Democratic Republic of Congo face immense challenges. A severe shortage of trained professionals, including psychiatrists, psychologists, and psychiatric nurses, plagues the system, particularly in rural areas where most of the population lives. Geographic disparities exacerbate the problem, concentrating mental health services in urban centers and leaving rural communities with minimal or no access to care. This unequal distribution underscores the urgent need for decentralized mental health services.

Financial barriers significantly restrict access to mental healthcare in the DRC. Widespread poverty makes such care unaffordable for a large segment of the population, forcing individuals and families to prioritize basic needs over mental health support. The DRC's healthcare system suffers from chronic underfunding, inadequate infrastructure, and shortages of essential equipment and medications. These systemic weaknesses extend to mental health services, compromising their availability and quality. Furthermore, pervasive stigma and discrimination, often attributing mental illness to spiritual causes or witchcraft, deter individuals from seeking help, perpetuate silence, and reinforce discriminatory practices. The fragmented nature of mental health services and their poor integration into primary healthcare create further barriers to comprehensive care, highlighting the need for a more holistic approach (table 1).

Table 1. *Key challenges and opportunities in the Democratic Republic of Congo's healthcare and mental health systems: a comparative overview highlighting funding gaps, resource disparities, and emerging community-based solutions.*

Indicator	Healthcare System	Mental Health Services
Funding	Significantly below the Abuja Declaration's target of 15% of GDP. Chronic underfunding affects infrastructure, medicines, and staffing.	Extremely limited funding, with mental health receiving minimal resources.
Infrastructure	Dilapidated facilities, especially in rural areas, with frequent shortages of essential medicines and equipment.	Poor infrastructure, lack of specialized facilities, and minimal integration into primary healthcare.
Human Resources	Acute shortage of qualified healthcare professionals, exacerbated by low salaries and brain drain. Urban areas are prioritized over rural regions.	Severe lack of psychiatrists, psychologists, and psychiatric nurses, particularly in rural areas.
Access to Care	Geographical and financial barriers limit access to healthcare, especially in remote regions. High out-of-pocket costs are a significant burden.	Limited access due to financial constraints, geographic disparities, and stigma surrounding mental health.
Geographical Disparities	Healthcare services are concentrated in urban centers, leaving rural populations underserved.	Mental health services are mostly available in urban areas, with rural regions having minimal or no access.
Financial Barriers	Limited health insurance coverage; high out-of-pocket expenses worsen economic hardship for families.	Widespread poverty restricts access to mental healthcare, prioritizing basic needs over mental health support.
Stigma and Cultural Barriers	Some reliance on traditional healers in rural areas due to lack of healthcare access.	Strong stigma associates mental illness with spiritual causes or witchcraft, deterring individuals from seeking care.
International Aid	International funding and humanitarian aid play a crucial role but risk creating dependency.	International organizations support mental health initiatives through training and technical assistance.
Promising Initiatives	Efforts to decentralize healthcare and improve infrastructure are ongoing but face significant obstacles.	Growing emphasis on community-based mental health care and integration into broader health initiatives.

Despite these obstacles, promising efforts and opportunities offer hope. The growing recognition of community-based mental healthcare's importance in serving underserved populations is encouraging. Training community health workers to deliver basic mental health support and integrating mental health into existing community programs can help close the treatment gap. International organizations have a crucial role to play in supporting mental health initiatives by providing training, resources, and technical assistance [7].

Addressing the root causes of mental health challenges, such as poverty, conflict, and gender-based violence, is essential for improving the well-being of the Congolese population. Strengthening mental

health services in the DRC requires a multi-sectoral approach that tackles both immediate needs and long-term systemic challenges. By prioritizing mental health, investing in training and infrastructure, and combating stigma, the DRC can build a more resilient and equitable mental health system.

In Loving Memory of Dr. E.L.K. *Born in the DRC, Dr. E.L.K. dedicated his life to healthcare and community service. After earning his medical degree from the University of Lubumbashi and completing a Master's in Psychiatry in Belgium, he worked tirelessly to improve healthcare systems in Congo and address the psychological impacts of conflict and poverty. Displaced from his homeland, he continued to work in the field of mental health for both his home country and for migrants. His compassionate legacy continues to inspire.*

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The Use of Blockchain and Cryptocurrencies in Humanitarian Aid Management. The Conundrum Between Myth and Reality

by Giulia Tuccio, Mario Di Giulio*

Abstract
Most people consider cryptocurrencies as speculative assets purchased and traded for financial gains. Others consider them a way to avoid the overwhelming power of states, banks and financial institutions. Beyond these opinions, ONGs and UN Organizations are evaluating how to use these means to ensure an effective tool to manage humanitarian aid and overcome the opacities that may leave room for abused and criminal organizations operating in the areas where the ONGs and UN Organizations play their roles.

Keywords
Blockchain, cryptocurrencies, DLT, humanitarian aid, SDG1, SDG2.

1. Introduction

As with any new technological invention, blockchain and its applications have raised many hopes of boosting economies by creating new profitable businesses, eliminating bureaucracies, and tackling difficult issues such as inequality and poverty.

Namely, blockchain as a decentralized system without the need for a centralized government authority has been hailed by many as a return to natural law, in which these people believe humanity has experienced a golden age [1]. For others, perhaps more realistically, DLT [2] technologies could be a means to protect humanity from a future in which state authorities and big corporations are expected to become increasingly intrusive and despotic, ensuring a framework in which everyone can play their role independently.

The same reasoning applies to cryptocurrencies, considered a sort of liberation from the sovereign (and arbitrary) power of the State (and – in this perception – of banks and financial institutions).

The management of humanitarian aid and related concrete

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actions do not appear to be excluded from this scheme.

The purpose of this article is to record some cases in which technologies have played an effective supporting role and others in which their use seems to translate into a sort of window dressing aimed at achieving marketing objectives rather than real needs.

2. The Scenario

In regions affected by natural or humanitarian disasters, access to basic goods and services is often severely constrained. Not to mention access to financial resources.

This challenge is particularly acute in developing countries, where financial infrastructures are underdeveloped or non-existent. Therefore, cryptocurrencies and blockchain technologies have emerged as potential tools to enable financial inclusion and simplify the management of humanitarian aid [3].

Their promise lies in their ability to facilitate direct, transparent, and efficient resource transfers [4], addressing the limitations of traditional aid systems.

Although essential, the humanitarian machine is often criticised for its slowness and bureaucratic inefficiency. Cryptocurrencies, on the other hand, allow fast and direct transactions, offering a level of reactivity that traditional financial systems struggle to achieve and ensuring – at least in theory – efficiency and transparency.

In humanitarian contexts, one of the key advantages of blockchain technology is indeed its intrinsic transparency [5], since each payment is recorded on a distributed ledger, providing a verifiable and immutable record accessible to both donors and beneficiaries.

The benefits are quite obvious.

This feature allows humanitarian organisations and funders to be confident in the concrete allocation of resources, while significantly mitigating the risks of corruption, embezzlement, and misuse of funds – issues that have historically plagued traditional aid distribution mechanisms; what happened in the Gaza Strip [6] is only the latest reprimand.

In addition, blockchain allows funds to be distributed directly to civilians, removing the need for intermediaries [7], such as financial institutions or centralized authorities, which fuel inefficiencies in the distribution process and administrative costs [8]. The peer-to-peer nature of cryptocurrencies makes the transactions not only direct but also almost instantaneous thanks to the use of smartphones, saving a vital resource in times of crisis: time.

It is not surprising, so, that cryptocurrencies have already been widely used to provide humanitarian assistance [9].

3. Case Studies

Of note is the partnership between the UNHCR and the United Nations International Computing Centre (UNICC) in the Stellar Aid Assist 2022–2023 initiative which used blockchain to provide direct cash assistance to Ukrainians displaced by the conflict with Russia. Beneficiaries received funds in digital wallets accessible via their smartphones and could withdraw cash at MoneyGram locations, avoiding transaction fees.

The reduction of collateral costs is combined with a new level of transparency, which represents a top priority for humanitarian agencies to avoid undue delays, along with the traceability of funds.

In this regard, in 2022, the humanitarian organisation

Care International partnered with Binance Charity Foundation to provide financial support to communities in Western Kenya affected by the Covid-19 pandemic. Using the Binance USD (BUSD) stablecoin, Care distributed e-vouchers to members of the Village Savings and Loan Associations, which were then redeemed through trusted local merchants.

Digital tools have therefore proven to be essential for transparent and modern aid delivery. And this belief is also spreading to the private sector.

One example is AIDONIC, which uses blockchain, artificial intelligence and digital payments to bring transparency and visibility to aid from non-profit organisations. Through a GDPR-compliant data management platform and end-to-end payment facilities, the pioneering crypto-to-fund processing system ensures real-time and transparent monitoring, tracking and reporting of the delivery process along the entire supply chain.

Another initiative that has received unanimous support from observers is Building Blocks [10], a blockchain solution led by the World Food Programme (WFP) and based on the Ethereum protocol.

Globally, the humanitarian landscape has become particularly complex, and, without proper operational coordination, the distribution of aid can be uneven. Thus, Building Blocks has been designed to coordinate collective assistance to reach more beneficiaries while making the aid process equitable and convenient. The initiative of the WFP uses blockchain technology to securely distribute aid, prevent it from overlapping, and save millions in bank fees. Accordingly, humanitarian actors assisting the same target group can channel assistance to the same blockchain account, where recipients can access a variety of items allocated by different organisations.

4. Criticalities

Nonetheless, not all that glitters is gold.

There is no shortage of opinions on the actual effectiveness of cryptocurrencies and, more generally, blockchain technologies in improving the management of humanitarian aid.

Some studies have shown that the use – or alleged use – of blockchain systems is proving to be a useful expedient for fundraising, with little benefits and even additional costs [11].

In essence, touting the use and benefits of blockchain could prove to be nothing more than a communication strategy – almost a marketing choice – by some humanitarian organisations to attract the attention and enthusiasm of potential donors attracted by the efficiency and by the traceability that these innovations claim to offer in the aid supply chain.

But those might just be empty promises.

Often, the members or promoters of these organisations themselves do not know how the technology works and simply promote it as a magical, conceptually elusive technology that could produce a wide range of desirable effects without clear explanation.

In fact, the magic disappears immediately when the blockchain used is privately owned and adds distribution layers – often not qualified to deal with potential shortcomings – which burden the allocation of funds, nullifying the benefits of transparency and the possible gain of financial independence for beneficiaries. Traditional distortions that are repeated through a vicious

cycle of ignorance, in which the opacity of technology is exploited to attract funds and perpetuate power structures in society.

Beyond these considerations, cryptocurrencies can certainly constitute valuable tools in the management of humanitarian aid, on one condition: that their distinctive features – transparency and traceability, speed and cost-effectiveness – are not compromised.

On this last note, the unanimously recognised advantage of using cryptocurrencies is the drastic reduction in transaction fees for aid transfers. This means a significant increase in the percentage of money used to directly help people that would otherwise be wasted on administrative and banking costs in traditional international transfers.

Nevertheless, challenges remain.

5. Conclusions

The risks are many and varied as they can either be endemic to the functioning of the blockchain itself or arise from its implementation [12].

Among these are the typical dangers of IT projects, such as network governance – especially if privately owned –, lack of adequate IT support and individual responsibility in case of improper use, implementation costs and cultural resistance to change, and the potential inequitable distribution of benefits due to associated technological requirements.

Perhaps the biggest concern is the handling of private keys [13]. For many humanitarian projects, beneficiaries do not possess a device on which to store their keys – which are often linked to users' biometric data – so organisations need to act as their custodians. While this may be a practical solution, it denies one of the essential traits of blockchain architecture in terms of decentralisation and user autonomy. Consequently, blockchain projects in humanitarian and development contexts should be designed from the beginning to address the issue of personal key management by beneficiaries, and adopt solutions tailored to the specific conditions of each use case.

Another potential threat is that local governments in crisis areas or emerging economies – often corrupt leaders and autocratic regimes – may introduce superstructures, including regulatory ones, to exploit the use of blockchain and cryptocurrencies and, therefore, the financial autonomy of people [14]. This scenario raises the question of how humanitarian actors should proceed and how the existing regulatory ecosystem can be adapted to avoid the misapplication of these promising technologies.

Notwithstanding the above, blockchain and cryptocurrencies have the capability to serve as a potential lifeline for survival, transforming the way humanitarian and development funds are allocated.

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A Modern Paradigm of Teaching Scientific Disciplines to Health Professionals at Unicamillus: Connecting Innovative Education and Global Health Perspectives

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Abstract
Scientific disciplines in general, and physics in particular, are often perceived as a dry and challenging subject, and have a reputation for being difficult to understand and engage with, especially for students new to the field. Traditional teaching methods often focus on equations, abstract concepts, and rigorous problem-solving. In the present paper we report on a modern teaching approach in the context of the Physics and Statistics Integrated Course at the Saint Camillus International University of Health Sciences, based on innovative and creative teaching tools. The adoption of these new teaching methods in scientific disciplines can enhance the education of health professionals, equipping them with critical thinking and problem-solving skills essential for addressing global health challenges.

Keywords
Health science education, innovative teaching, global health.

1. The Physics and Statistics Integrated Course

The Physics and Statistics Integrated Course at the Saint Camillus International University of Health Sciences offers healthcare students a comprehensive foundation in Applied Physics, Medical Statistics, and Informatics. This course provides students with essential skills to understand the physical principles underlying medical technologies, apply statistical methods in clinical research and healthcare data analysis, and utilize informatics tools for evidence-based decision-making, fostering a multidisciplinary approach to modern healthcare practice.

During the course, future health professionals learn the application of the scientific

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method to the biomedical phenomena, and the working principles of the equipment commonly used for diagnostics and therapeutics. Likewise, the students learn how to use Information Technology (IT) and medical statistics tools useful for their profession both as workers, even when interpreting the results of patients' diagnostic tests, and as researchers in the medical sector.

2. The Teaching Tools

The teaching paradigm is a crucial element in the learning process of the students, and, for the professors at Unicamillus, developing a student-customized approach is the core of their work. The teaching tools play a central role, one that cannot be easily replaced by other methods (*e.g.*, such as Artificial Intelligence (AI)): behind a textbook or a university course lies a "Weltanschauung" (worldview), as simply stating a series of notions is very different from truly knowing and applying a science.

This article stems from the teaching experience built by the authors over more than a decade, not only in university classrooms but also in secondary schools – ten years of engagement and interaction with students in these fields. The challenges faced by students involve tackling a subject that is inherently complex, while teachers struggle to identify materials that highlight the connection between purely theoretical concepts and their application in a reality that is familiar to the student.

The teaching approach chosen by the authors begins with the statement of scientific laws, the latter forming the backbone of the learning phase, and unfolds around a carefully selected series of practical examples rooted in the student reality. As Nobel Prize winner Giorgio Parisi said in a recent interview, if you don't understand the roots, you can't understand how the tree works, and it's useless to focus only on the fruits.

Starting from the general Law allows the student to grasp the context behind the phenomenon they are approaching and provides guidance in understanding relationships beyond the physical quantities involved, while the use of practical examples stimulates the deductive reasoning essential in their future work, according to a logic that is developed in the following paragraphs.

Then, the teacher's presentation must not be a juxtaposition of laws and notions, but rather a narration that is articulated through stories, images, and videos, all conveyed in a language that is familiar to the student. Images are actually designed to convey information through an everyday reception tool, helping to simplify complex concepts, and also stimulating interest and attention. Unlike words, which require cognitive processing and interpretation, images engage a communication channel that resonates with the viewer on a more intuitive and emotional level. This ability to evoke immediate responses allows them to communicate in a way that is often more impactful than verbal or written language.

Using also interactive tools to engage the students, such as Mentimeter (an audience engagement online platform that enables the lecturer to boost participation), helps the students not to feel a passive object of the lesson [1].

As the philosopher Umberto Galimberti would say, engaging young students on an emotional level means finding the gateway to reach their intellectual level; if the emotional dimension is ignored,

then you will never reach their minds.

Moreover, visual learning can help include students with different cognitive and learning styles, for example the increasing number of students with Specific Learning Disorders (SLD), making the teaching approach more inclusive and effective.

3. The Student's Cultural and Professional Experience as a Bridge Between Theory and Practice

The idea behind this modern teaching methodology is that the choice of the language plays a central role as the primary tool for conveying complex information. Subjects like physics should not be presented as abstract disciplines detached from the healthcare student's course of study but rather integrated with topics already part of their field of interest. This approach ensures that communication with students is conducted in the language they are familiar with, i.e. medical terminology. For example, the application of mechanics to the functioning of the cardiovascular system or the use of optical physics to explain diagnostic instruments like microscopes can become part of an integrated and effective approach for teaching.

Physics as a discipline occurs in the scholar's study curriculum, since it explains many phenomena occurring in the human body, as well as in the healthcare professional reality when using medical equipment. Using examples related to physiology, anatomy, and medical devices enables students to immediately understand the importance of physical concepts in the surrounding world and in the professional context. This boosts interest and facilitates the learning process, as students are able to identify the immediate applicability of the acquired notions in their future practice. For example, understanding the physical principles behind Magnetic Resonance Imaging (MRI) or ultrasound technology is crucial for correctly using these tools in clinical settings.

Otherwise, many students may perceive scientific subjects as difficult and "distant" from their interests.

If theoretical concepts are introduced through practical examples that are already part of the cultural and professional background, their understanding becomes more intuitive. Active learning, based on experience and direct application, sparks the student's interest, as they no longer see the subject as something far away, making the concepts easier to remember and master.

This approach takes into account that healthcare students already possess a strong and specific body of knowledge and context of reference. Integrating scientific subjects into this context builds on existing knowledge and motivates the student further. They don't have to imagine how to apply an abstract concept to medicine – they immediately see it in action. For example, fluid dynamics can be illustrated through blood circulation in blood vessels, or equilibrium conditions in dynamics can be presented applied to musculoskeletal apparatus as well as thermodynamic principles can be related to macromolecules structure and function and numerous other examples that could be mentioned.

As said, teaching physics through the equipment used in the medical field is another way to closely link theory to practice and using a language that makes interaction more direct. Students can learn the laws of physics by understanding how the devices they will use daily

in their careers work, such as radiology, ultrasound, thermography, or equipment for monitoring vital signs. This approach not only reinforces their understanding of physics but also makes students more confident in using these technologies.

Then, this method addresses two fundamental needs: on one hand, it offers more targeted and focused learning for medical students, and on the other, it promotes a deep understanding of the scientific phenomena underpinning many medical technologies. Additionally, it facilitates a smoother transition from theory to clinical practice, as students already learn how scientific concepts deeply affect their future professional practice.

The examples chosen by the teachers are not only aimed at understanding the subject through experience, but also at paving the way for future healthcare professionals who must use physics and statistics as essential tools for their work. The professional who can use these tools has long since replaced the figure of the doctor who could rely solely on personal experience and intuition.

In conclusion, the approach described is not only valid but strategically very effective, as it creates a direct link between scientific disciplines – a subject commonly perceived as abstract and domain of a few scientists in laboratories – and the professional context in which the student will operate. According to this approach, each lesson can have multiple levels of understanding.

Moreover, students who choose a course that qualifies them for healthcare professions often come from educational backgrounds that do not always include physics and other scientific subjects as a part of their study.

This is especially true at Saint Camillus International University of Health Sciences where students come from a lot of different countries, cultures, and languages, showing how a narrative and intuitive system works better than a more theoretical approach.

This article proposes a teaching paradigm that uses a rigorous yet accessible presentation, even for those who have not previously studied scientific subjects in high school.

4. The Importance of Storytelling in Scientific Comunication

Conventional teaching techniques for scientific disciplines commonly emphasize equations, or theoretical ideas. However, there is a growing body of evidence that suggests the integration of storytelling into academic teaching can significantly enhance the learning experience [2]. Storytelling is a key tool to bridge the gap between abstract concepts and real-world applications, making the material more accessible, relatable, and engaging for students.

Storytelling has long been recognized as one of the most powerful methods of communication. According to Bruner [3], narrative is a fundamental way through which humans make sense of the world. It provides a structure that helps people understand and remember information more effectively. Storytelling stimulates emotional responses and enhances memory retention by connecting the listener's prior knowledge with new content, which is crucial in the learning process. In the context of physics education, storytelling has the potential to transform dry scientific concepts into captivating narratives that not only engage students but also help them understand the relevance and applications of the subject. Research suggests that

storytelling can lead to a deeper understanding and retention of concepts because it allows students to contextualize the material within a coherent framework [4].

Scientific storytelling can take various forms, such as historical narratives, personal anecdotes, case studies, or hypothetical scenarios that illustrate key concepts. This method can make the learning experience more engaging by creating a context that relates the abstract theories of physics to the real world. For example, discussing the historical context in which Isaac Newton formulated his laws of motion can make these principles more vivid and relatable to students. Instead of presenting Newton's laws as mere equations, a lecture can delve into the story of Newton observing the falling apple and reflecting on the forces at play. A similar approach is used to introduce the laws of probability, using the story of Chevalier De Mere, his passion for gambling and the wise advice received by his friend Blaise Pascal.

The use of storytelling can also humanize the subject matter, which is often considered impersonal or intimidating. By sharing stories about the lives of physicists and their struggles, educators can present physics as a dynamic, evolving field driven by curiosity and perseverance, thereby enhancing student engagement and motivation to learn.

As an example, the Snell's law, which describes the relationship between angles of incidence and refraction when a wave passes from one medium to another, can be successfully applied to the "lifeguard problem". Storytelling has the powerful ability to anchor a seemingly difficult concept in students' minds if it is explained through a story with which the students are familiar:

> Imagine a lifeguard standing on a sunny beach, scanning the horizon when suddenly, they spot a swimmer struggling in the water some distance away. The swimmer isn't directly in front but off to the side, in a diagonal direction. The lifeguard knows that every second counts and must make a critical decision: what is the fastest way to reach the swimmer? Running on sand is much slower than swimming in the water, but they can't dive straight in; they need to find the quickest path. This is where Snell's law, a principle usually used to describe how light bends as it passes from air to water, becomes a surprising hero. Just like light takes the path that gets it from one place to another in the least time, the lifeguard must find the exact spot on the shore to enter the water, minimizing the rescue time. By thinking like a beam of light and using Snell's law, the lifeguard can calculate the perfect point where the shift from running to swimming happens, ensuring they reach the struggling swimmer as quickly as possible. (Figure 1)

In this way, the laws of physics don't just explain the universe – they can save lives.

In conclusion, the integration of storytelling in physics lectures proved a promising approach to make science education more engaging, relatable, and effective. It leverages the natural human affinity for narratives to enhance understanding, retention, and enthusiasm for learning. By contextualizing abstract concepts within meaningful stories, educators can bridge the gap between theory and practice, making physics more accessible to students. As the educational

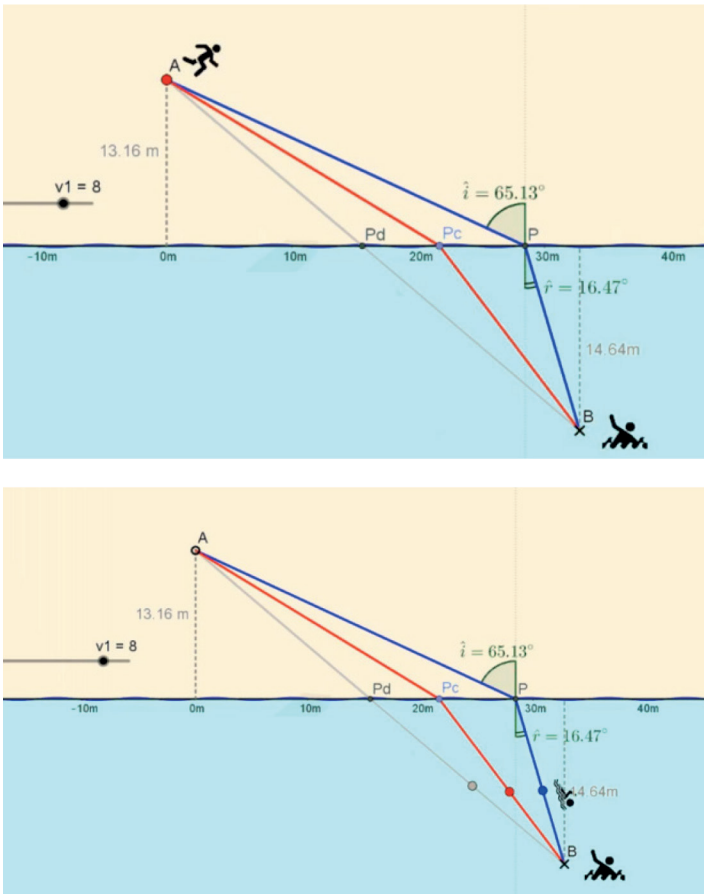

Figure 1. *Using a familiar story can help students grasp challenging concepts as storytelling has a strong ability to make the information memorable. For instance, the Snell's Law can effectively be used to solve the "lifeguard problem" by demonstrating how angles of incidence and refraction are related when a wave moves from one medium to another.*

landscape continues to evolve, adopting innovative methods like storytelling will be crucial in inspiring the next generation of scientists and thinkers.

5. Applied Physics

The word physics derives from the Greek "τὰ φυσικά", meaning "natural realities". True to its name, over its four centuries of existence, physics has provided a description of natural phenomena. At their core, phenomena in life sciences are explained by the theories of physics, and every operating room shows how science and medicine are inseparable, offering the teacher countless practical examples. Frequency of the heartbeat, systemic arterial and venous blood pressure, pulmonary blood pressure, oxygen saturation and body temperature are typical physical quantities monitored routinely in patients in the operating room, as well as the electrical potentials at the skin's surface, correlated with the physiological states of the heart (ECG), and the Bispectral Index (BIS), which monitors brain activity and provides an estimate of a patient's depth of anesthesia (Figure 2).

Our perception of reality is a mere physical process: sensory perceptions are nothing but electrical stimuli (all five sens-

es), and for example, movement in the static magnetic field of MRI scanners modifies them (metallic taste, phosphenes, tinnitus, tactile perceptions).

Moreover, citing again Professor Giorgio Parisi, physics is becoming wider and wider, and it contains many areas of knowledge that did not exist in the past or were not part of physics.

According to this view, the authors have given a more modern approach to the course of applied physics by introducing the basics of life science, which studies the physical principles governing living organisms, and medical physics: modern health technologies are presented, discussing the physical principles behind medical imaging (*e.g.*, X-rays, MRI, CT scans), radiation therapy, ultrasound, and biomedical sensors.

6. Medical Statistics

Medical sciences largely rely on statistics for the collection, analysis, and interpretation of data. Statistics are essential for verifying scientific hypotheses and validating new discoveries. We can easily say that statistics play a key role in everyday physician decision-making: the diagnostic process is a pathway through different probabilities.

A basic knowledge of the underlying principles empowers the medical student of today, and the doctor of tomorrow, to read medical literature with a mind of their own, able to judge upon the credibility of a research, of a new drug, of a proposed surgical technique, and even to embrace a career where creating medical knowledge is an option on top of just consuming it. An example of involving students in descriptive statistics was to propose short surveys covering family, everyday life, or media reports aimed at both the professional and the citizen, such as those prepared for the Covid-19 reporting [5]. Similarly, in order to introduce the concept of multivariate analysis, workshops were held to discuss interaction and confounding in the analysis of health determinants.

7. Computer Science and the Interdisciplinary Approach

Medical technologies have profoundly transformed diagnosis, treatment, and patient management, making medicine more precise and efficient. To place the students into this rapidly evolving context, enabling them to manage new technologies, the integrated course has been structured in a manner that involves an interdisciplinary approach, with physics, statistics, and computer science concepts seen as interconnected rather than separate disciplines.

An important focus in computer science is understanding how analog signals are transformed into digital signals, essential for using advanced medical technologies. In classes, practical teaching aids connect theoretical ideas by incorporating hands-on displays using stethoscopes, sphygmomanometers, oxymeters and thermometers, available in analog and/or digital designs. The use of these devices in class keeps the students' attention engaged, as they use these instruments for the first time in their lives, and they are eager to try them and to know how they work.

In this way, students better understand how signal sampling and quantisation concepts work since they have just seen in-action devices that monitor vital patient data such as temperature and blood pressure. Hence, the distinction between analog (that is, actually, the real world that follows the physics laws) and digital (that is what a computer can han-

Figure 2. *Physical quantities monitored routinely in patients in the operating room.*

dle) goes beyond theoretical computer science and directly influences diagnosis and patient care. Through statistical methods, noise in physiological signals can be minimized. For instance, filtering techniques remove artefacts from heart rate or blood pressure signals, allowing for cleaner data that reflects a patient's true condition. Moreover, probabilistic models and statistical inference allow AI systems to extract insights from sampled data, estimate unknown parameters, and calculate the likelihood of specific outcomes.

8. Conclusions

The three teaching subjects entrusted to the authors of this essay, *i.e.* physics, statistics, and computer science, are characterised by a set of successive steps of abstraction that the student must carry out in order to properly understand the topics discussed in class. This is true for physics, since the students, in their first year, have great difficulty in superimposing what is studied in physics, even in mechanics, directly with the reality of the world around us. And it is even more true for both statistics, which deals with quantities and measurements that are not immediately traceable to concrete facts and properties for a young student, and for computer science, which makes virtualisation and abstraction its strong points.

In this framework narration through examples and storytelling become the most effective teaching tools, since through them the teacher leads the students to be aware not merely of the solutions presented to them, but of the motivations that led researchers and technicians to find those solutions, making them become not only subjects of the presentation but active part and even main character of the process taking place in class.

Furthermore, the proposed interdisciplinary approach among computer science, physics, and statistics shows students how these fields work together to use diagnostic and therapeutic tools. Physics provides the theoretical foundation to understand biological signals' functioning and the

properties of materials in medical devices. Statistics assists in understanding data, allowing the transformation of this data into useful clinical observations. Computer science manages signals, physics explains their operation, and statistics aids in reaching credible conclusions to support clinical decisions based on solid scientific evidence.

By means of this method, students gain a deep knowledge of technology in healthcare, and approach the medical profession with a thorough, interdisciplinary perspective. This equips them with advanced critical thinking and problem-solving skills, enabling them to adapt to diverse medical contexts, and address complex global health challenges, particularly in resource-constrained settings where innovative and interdisciplinary approaches are most needed. In developing countries, this approach could bridge knowledge gaps, empower local healthcare systems, and improve health outcomes by fostering new generations of well-prepared practitioners.

9. Aknowledgments

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Promoting Mother-Child Health in Rural Sub-Saharan West Africa: A Sustainable Architectural Approach to Culturally Tailored Care

by Cecilia Ceccarelli, Francesco Branda, Marta Giovanetti, Mattia Albanese, Laura Elena Pacifici Noja, Fabio Scarpa, Massimo Ciccozzi, Giancarlo Ceccarelli*

Abstract

Maternal healthcare in rural Sub-Saharan West Africa faces significant challenges, including inadequate access to facilities, cultural barriers, and socio-economic constraints that jeopardize the well-being of pregnant women and their newborns. This paper explores the intersection of these challenges and presents a sustainable architectural approach aimed at enhancing maternity care. By focusing on culturally sensitive design principles, the proposed architectural solutions prioritize the needs and values of local communities while promoting safe pregnancy practices. The integration of traditional building techniques and local materials not only addresses environmental sustainability but also fosters a sense of ownership and acceptance among users. Furthermore, the design incorporates essential elements such as natural ventilation, passive cooling, and accessible healthcare facilities, which are crucial for improving maternal health outcomes. This research emphasizes the importance of creating spaces that are not only functional but also responsive to the cultural and social dynamics present in rural Sub-Saharan West Africa. Ultimately, this study advocates for a holistic approach to maternity care that combines architectural innovation with community engagement to promote healthier and safer pregnancies in the region.

Keywords

West Africa, Senegal, pregnancy, maternity, architectural design, clinic, infectious disease, tradition, culturally sensitive.

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1. An Overview of the Geoeconomic, Political, and Health Dynamics in Sub-Saharan West Africa

Benn loxo du taccu – One hand does not clap.

(Wolof proverbs, Senegal)

The Sub-Saharan West African region, which includes countries such as Senegal, The Gambia, Guinea, Côte d'Ivoire, Ghana, Togo, and Benin, presents a complex interplay of geoeconomic, political, and health dynamics that significantly influence the experiences and opportunities of its populations. Economically, the region is characterized by a diverse array of economies ranging from resource-rich nations to those heavily reliant on agriculture and services. Countries like Côte d'Ivoire and Ghana are endowed with abundant natural resources, including minerals, oil, and gas, while agriculture employs a significant portion of the population and contributes to food security through key exports such as cocoa, cashews, and palm oil [1]. Regional economic integration efforts, notably those led by the Economic Community of West African States (ECOWAS), aim to foster trade and collaboration among member nations; however, challenges such as infrastructural deficits, limited access to financing, and varying regulatory environments continue to obstruct economic growth and stability, impacting foreign direct investment opportunities [2]. Politically, the region displays a mix of democratic governance and instability, with countries like Ghana and Senegal making strides toward consolidating democratic processes, while others grapple with issues of governance, corruption, and political unrest. Electoral contests can be contentious, occasionally resulting in civil conflicts that complicate development initiatives [3, 4]. The region also faces significant security challenges, particularly from extremist groups such as Boko Haram and affiliated organizations, which threaten stability in countries like Nigeria, Niger, and Burkina Faso and have repercussions for neighboring states [5]. This intersection of security challenges, governance, and socio-economic development creates a nuanced political landscape. In terms of health, Sub-Saharan West African countries experience a high burden of infectious diseases, alongside pressing maternal and child health issues and a rising prevalence of non-communicable diseases. Infectious diseases such as malaria, HIV/AIDS, tuberculosis, and viral hepatitis remain widespread, causing significant morbidity and mortality [6-8]. Despite progress made in addressing these health challenges, healthcare access and infrastructure deficiencies persist, especially in rural and underserved regions. The area's maternal mortality rates remain among the highest globally, driven by factors such as inadequate access to quality maternal healthcare, skilled birth attendants, and emergency obstetric care, with cultural beliefs and socio-economic constraints further complicating efforts to improve health outcomes [9-17]. The Covid-19 pandemic has intensified the vulnerabilities of health systems in these nations, underscoring the need for resilient public health responses and revealing existing healthcare disparities [18]. To navigate the interconnected challenges of geoeconomic development, political stability, and health outcomes, collaborative strategies involving governments, regional organizations, and international partners are essential. As

the region attempts to realize its developmental aspirations within the frameworks of globalization and local contexts, addressing these multifaceted dimensions will be critical for sustainable development in Sub-Saharan West Africa, ultimately enhancing the overall well-being of its populations.

2. Maternal Health in Sub-Saharan West African Countries

Maternal health remains a critical public health issue in Sub-Saharan West Africa, particularly in the Gulf of Guinea region. Despite significant progress in global health, maternal mortality rates in this area remain among the highest in the world. Various multifactorial elements contribute to this persistent challenge, including healthcare access, socioeconomic factors, cultural practices, and the prevalence of infectious diseases [19-23].

Access to Prenatal and Postnatal Care

Maternal health in Sub-Saharan Africa continues to pose a significant public health challenge, driven by a complex interplay of socioeconomic disparities, inefficiencies within health systems, and deep-rooted cultural influences. Despite international efforts and commitments to enhance maternal health, the region grapples with some of the highest maternal mortality rates globally. This reality highlights a critical need to improve access to both prenatal and postnatal care, which are essential for safeguarding the health of mothers and their newborns [20, 22, 24].

Prenatal care encompasses vital medical check-ups and necessary interventions throughout pregnancy, playing a crucial role in minimizing both maternal and neonatal morbidity and mortality. Access to quality prenatal services facilitates early detection and management of potential complications that may arise during pregnancy. Furthermore, consistent prenatal care serves as a platform for educating expectant mothers about maternal health, thereby promoting healthy behaviors that can significantly impact outcomes for both mother and child. Similarly, postnatal care is of paramount importance, as it enables healthcare providers to closely monitor maternal recovery and the health of newborns. This period is critical not only for addressing potential complications such as postpartum depression but also for guiding mothers on proper infant feeding practices and the overall care of their newborns [20, 22, 24-27].

The current landscape of maternal healthcare in Sub-Saharan Africa is marred by multiple hindrances that impede access to these essential services. Geographical barriers play a significant role, particularly in rural regions where healthcare facilities are often situated at considerable distances. Poor transportation infrastructure exacerbates this challenge, making it difficult for women to obtain timely care, which is especially dangerous during emergencies. Economic factors further complicate access; many women face high costs related to healthcare services, including transportation fees and hospital charges. The opportunity cost of time spent seeking care can be particularly burdensome for low-income families, leading some to delay or forgo necessary prenatal and postnatal services altogether [24-27]. Socioeconomic disparities play a crucial role in maternal health outcomes. Women from low-income backgrounds

often face greater obstacles in accessing quality healthcare services. Financial constraints impact not only the ability to pay for services but also the opportunity cost associated with seeking care, particularly in low-resource settings where women may be responsible for household duties. Educational attainment is another critical factor, as women with higher levels of education tend to seek healthcare services more proactively and are generally more knowledgeable about reproductive health [28-31].

Moreover, many health systems throughout the region struggle due to inadequate funding, which results in understaffed facilities and a lack of essential medical supplies. The persistent shortage of skilled healthcare workers – such as midwives and obstetricians – compounds these challenges, severely compromising the quality of maternal healthcare services available to women. Cultural beliefs and social practices surrounding childbirth also influence women's decisions about healthcare. In some communities, there is a preference for traditional birth attendants over formal healthcare settings, which may discourage women from seeking modern medical care even when it is necessary. Additionally, limited health education poses a barrier that cannot be overlooked. Many women remain unaware of the importance and benefits of prenatal and postnatal care, which discourages them from utilizing the available healthcare resources. Targeted education campaigns are essential in changing perceptions about maternal health and empowering women and communities to seek necessary care [32].

Cultural Practices and Beliefs

Maternal health in Sub-Saharan West African Countries is significantly influenced by cultural practices and beliefs, which shape women's experiences during pregnancy, childbirth, and the postpartum period [33]. Understanding these cultural dynamics is crucial for developing effective maternal health programs and interventions that respect and integrate local practices while promoting safe and evidence-based healthcare. Cultural practices related to maternal health often reflect a society's values, norms, and historical experiences. In many Sub-Saharan African communities, traditional beliefs about childbirth are deeply rooted and can differ significantly from biomedical perspectives. These cultural beliefs can dictate not only the choice of care provider but also the types of practices adopted during prenatal and postnatal care [33-36].

In regions where formal healthcare services are scarce or perceived as inadequate, traditional birth attendants (TBAs) often play a central role in maternal healthcare. Many women prefer to deliver with TBAs due to longstanding cultural practices, their familiarity with the community, and their perceived understanding of traditional healing methods. TBAs are usually deeply trusted figures, and their presence provides a sense of comfort and continuity during childbirth, reinforcing the social fabric of the community. However, while TBAs can be invaluable resources, their training and the quality of care they provide can vary widely. In some cases, reliance on traditional practices may divert women from seeking medical assistance during emergencies or complications, which can have detrimental health consequences. Therefore, integrating TBAs into formal healthcare

systems through training and collaboration could enhance maternal health outcomes while respecting cultural preferences [37-38].

Cultural beliefs surrounding pregnancy and childbirth can significantly influence maternal health behaviors. In many cultures, pregnancy is viewed not just as a medical condition but also as a significant social event with spiritual implications. Certain traditional practices, such as dietary restrictions, rituals for protection against evil spirits, and rites of passage, inform women's behaviors during pregnancy. These practices can promote emotional well-being and community support; however, they may also hinder appropriate medical care if they encourage avoidance of healthcare facilities.

Moreover, there are specific cultural taboos and practices related to postpartum care, which can impact maternal recovery and bonding with the infant. Practices like engaging in specific cleansing rituals or confinement periods often determine a woman's postpartum behavior, including breastfeeding practices. Such customs can sometimes lead to a lack of understanding of the importance of professional follow-up care, potentially exposing mothers and newborns to preventable health issues [39-41].

Gender dynamics also play a critical role in shaping maternal health within Sub-Saharan African contexts. In many communities, women may have limited autonomy in health decision-making, often relying on male family members or elders to make significant choices regarding their health care. These dynamics can pose substantial barriers to accessing timely prenatal and postnatal services, as women may face opposition when seeking care [42, 43].

Cultural norms often define the expected roles of women and men within families, influencing how maternal health services are utilized. For instance, if seeking maternal health services requires traveling long distances or incurring costs, women may be deterred from doing so if their families hold traditional views that prioritize men's roles in decision-making. Therefore, addressing these gender norms and empowering women through education and advocacy are vital components for improving access to maternal healthcare.

Maternal Mortality in Sub-Saharan West African Countries

According to the World Health Organization (WHO), the estimated maternal mortality ratio (MMR) for Sub-Saharan Africa was approximately 542 deaths per 100,000 live births in 2017, with the Gulf of Guinea exhibiting ratios that often exceed this average [9, 10]. For instance, in Nigeria, one of the most populated countries in the region, the maternal mortality ratio is estimated to be around 917 deaths per 100,000 live births, making it one of the highest globally. Other countries, such as Guinea (724), Côte d'Ivoire (645), and The Gambia (432), also report significant maternal mortality figures. In contrast, countries like Ghana and Senegal, while still facing challenges, have achieved lower maternal mortality ratios, estimated at 308 and 315, respectively. An in-depth analysis indicates not only the critical health risk faced by women during pregnancy and childbirth but also highlight the disparities within the region. Factors contributing to such elevated MMRs include inadequate access to skilled healthcare personnel,

particularly during childbirth, and insufficient healthcare infrastructure [9-17].

Role of Infectious Diseases

Maternal health in Sub-Saharan Africa is profoundly impacted by the burden of infectious diseases, which contribute significantly to maternal morbidity and mortality rates. The interplay between reproductive health and infectious disease dynamics presents complex challenges that require targeted interventions and comprehensive strategies to improve overall maternal health outcomes in the region [6-8]. Infectious diseases, including neglected tropical diseases (NTDs), human immunodeficiency virus (HIV), tuberculosis (TB), and sexually transmitted infections (STIs), present formidable obstacles to achieving sustainable improvements in maternal health. These diseases can affect women's health before, during, and after pregnancy, indicating the need for integrated health services that address both maternal and infectious disease care.

Maternal health in Sub-Saharan Africa is intricately linked to the burden of NTDs, a diverse group of infectious diseases that disproportionately affect impoverished populations in tropical and subtropical regions. These diseases, which include malaria, schistosomiasis, lymphatic filariasis, and onchocerciasis, present substantial challenges to maternal health by contributing to morbidity, mortality, and complications during pregnancy [6, 8, 44, 45].

NTDs significantly impact maternal health by exacerbating existing vulnerabilities among pregnant women. Malaria, for instance, remains a leading cause of morbidity and mortality for pregnant women in Sub-Saharan Africa. Due to physiological changes during pregnancy, women are more susceptible to severe malaria, which can lead to complications such as anemia, low birth weight, and preterm delivery. The consequences of malaria in pregnancy are profound, as they not only affect the health of the mother but also have long-term implications for neonatal health. The WHO recommends preventive measures such as intermittent preventive treatment in pregnancy (IPTp) and the use of insecticide-treated nets (ITNs) to mitigate the impact of malaria on maternal health. However, access to these interventions remains inconsistent, particularly in rural areas [6, 8, 44-47].

Schistosomiasis, another common NTD in the region, can negatively impact maternal health as well. Infection during pregnancy is associated with adverse outcomes, including anemia and increased risk of premature birth. Moreover, the disease may contribute to increased susceptibility to other infections, further complicating maternal care. Addressing schistosomiasis through preventive measures, such as community health education and access to treatment, is essential for improving maternal health outcomes. Lymphatic filariasis and onchocerciasis can also pose significant risks to maternal and infant health. Lymphatic filariasis can lead to lymphedema and hydrocele, causing significant physical and psychological distress. Women suffering from these debilitating symptoms may face difficulties in accessing care or maintaining health during pregnancy, leading to poorer outcomes. Onchocerciasis, known to cause river blindness, can have indirect effects by reducing the availability of healthcare resources in affected communities, thus limiting access to essential maternal healthcare services [6, 8, 47, 48].

The intersections between NTDs and maternal health further highlight the importance of integrated healthcare approaches. Successful strategies must encompass not only the control and prevention of NTDs but also comprehensive maternal health services. This involves ensuring that pregnant women receive appropriate screenings, treatment, and preventive medications while effectively managing the broader health determinants that influence both maternal and neonatal outcomes.

Tuberculosis is another infectious disease of significant concern for maternal health in the region. Pregnant women with TB are at risk of severe morbidity, including respiratory complications and worsening nutritional status, which can lead to adverse effects on both maternal and fetal health. Co-infection with HIV and TB further complicates treatment and care, necessitating integrated service delivery that addresses both conditions simultaneously. Routine screening for TB in pregnant women, particularly in high-prevalence areas, should be prioritized to reduce maternal and neonatal risks [49-51].

Sexually Transmitted Infections (STIs), including syphilis and gonorrhea, can have serious implications for maternal health and pregnancy outcomes. These infections can lead to complications such as pelvic inflammatory disease, maternal sepsis, miscarriage, and preterm labor. Furthermore, STIs can facilitate the transmission of HIV [52, 53]. In fact, the HIV epidemic poses significant challenges to maternal health in Sub-Saharan Africa. Women of reproductive age bear a disproportionate burden of HIV infection, and maternal health outcomes are adversely affected by the disease. HIV-infected women are at increased risk for obstetric complications, including maternal mortality. Antiretroviral therapy (ART) has improved life expectancy and health outcomes for HIV-positive women, but barriers to accessing testing, treatment, and care persist, contributing to preventable complications during pregnancy and childbirth. Moreover, the risk of mother-to-child transmission (MTCT) of HIV remains a critical concern during pregnancy, childbirth, and breastfeeding if adequate interventions are not employed. Comprehensive prenatal care must include routine HIV screening and linkage to care, thereby improving maternal and infant health outcomes. Public health initiatives that promote regular screening, treatment, and education about safe sex practices are critical for reducing the incidence of STIs and their associated maternal health risks [54-56].

The intersection of maternal health and infectious diseases is influenced by various challenges. Inadequate healthcare infrastructure, coupled with limited access to essential services, hampers the ability to provide comprehensive care to pregnant women. Many women in rural areas face significant geographical barriers to accessing healthcare facilities, leading to underutilization of vital services including antenatal care, diagnostic testing, and treatment for infections. Additionally, the lack of skilled healthcare workers, particularly in remote regions, compounds these issues, resulting in inadequate screening, education, and care for infectious diseases [57].

Cultural beliefs and practices can also impact the recognition and management of infectious diseases among pregnant women. Stigma surrounding HIV and other infectious dis-

eases may discourage women from seeking testing or treatment and can lead to delayed presentations and poor health outcomes. Comprehensive community engagement and education initiatives are essential for addressing these cultural barriers and promoting understanding of the importance of maternal health and infectious disease prevention.

3. Strategies for Improvement of Maternal and Infant Health in Sub-Saharan West Africa: A Comprehensive and Culturally-Informed Approach

Addressing the multifaceted challenges of maternal health in Sub-Saharan West Africa necessitates a comprehensive strategy that encompasses the strengthening of healthcare systems, community education and engagement, integration of services, and advocacy for supportive policies. Enhancing healthcare systems is essential and involves training skilled healthcare providers, upgrading facilities, and ensuring the availability of essential medications and supplies. Community engagement through educational programs is critical to raising awareness of maternal health issues and promoting positive health-seeking behaviors. Moreover, the integration of maternal health services with programs addressing infectious diseases, nutrition, and reproductive health is vital for providing holistic care. Policy advocacy plays a significant role in this multifaceted approach by prioritizing maternal health funding and resource allocation while mobilizing stakeholders at local, national, and international levels to support initiatives aimed at improving maternal outcomes [58-60].

Incorporating cultural practices into health programs offers an additional avenue for enhancing maternal health. By recognizing and respecting traditional beliefs, health initiatives can foster greater acceptance and utilization of healthcare services within communities. Engaging community leaders and implementing culturally sensitive educational initiatives can promote positive health behaviors that harmonize with both traditional practices and modern medical guidelines. For instance, integrating cultural celebrations surrounding childbirth with educational initiatives on prenatal and postnatal care can create an empowering environment for women, bridging the gap between cultural recognition and medical care [59, 61].

Another critical strategy in the management of maternal and infant health is the strategic design of rural maternity centers. These centers can be developed with targeted, sustainable architectural interventions that are culturally appropriate and responsive to the local context. By offering accessible and adequately equipped facilities, these maternity centers can significantly enhance maternal healthcare by meeting women's needs in a familiar and supportive environment, thereby increasing the utilization of healthcare services [61, 62].

4. The Role of Architectural Design in Creating Spaces and Facilities for Culturally Sensitive and Healthy Pregnancy Care

Architectural design plays a crucial role in shaping healthcare environments, particularly in the context of maternal and infant health. Designing spaces that cater specifically to the needs of pregnant women can significantly influence their overall well-being and health outcomes. Culturally sensitive architectural design not only

respects and reflects the cultural values of the community but also fosters an environment that promotes healthy behaviors during pregnancy [61-64]. Pregnancy is a critical period that requires both physical and emotional support. Facilities designed with the specific needs of expectant mothers in mind can enhance the experience of prenatal care. For example, waiting areas and consultation rooms should be designed to be welcoming, comfortable, and culturally appropriate. Incorporating natural light, soothing colors, and spaces for privacy can alleviate anxiety and promote relaxation, essential factors that can affect maternal health positively. Additionally, integrating culturally relevant design elements – such as traditional motifs, local materials, and communal gathering spaces – can enhance the acceptance and utilization of healthcare services by expecting mothers. Community engagement in the design process ensures that the facility reflects the local culture and traditions, creating a sense of ownership and belonging among users. Furthermore, the physical layout of clinics and maternity centers is vital for facilitating a seamless flow of patients while maintaining privacy. Design features such as separate pathways for different types of patients, dedicated areas for prenatal education, and spaces that encourage companionship, like family waiting areas, can support a positive healthcare experience. Sustainability is another critical aspect of architectural design in healthcare. Utilizing environmentally friendly materials and energy-efficient systems not only minimizes the ecological footprint but also contributes to the health of patients and staff. Green spaces and gardens can be integrated into the design to provide therapeutic environments that promote mental well-being [63, 64].

Design Concept

Considering the multifaceted challenges of maternal healthcare, the proposed architectural approach aims to create a healthcare facility that effectively addresses these needs while prioritizing individual and public health within a safe, welcoming, and sustainable environment that is seamlessly integrated into the surrounding natural landscape (figure 1).

In the designer's vision and intentions, and ideally within the collective imagination of the community, including users and their families, the maternity center represents a harmonious blend of heritage and innovation, serving as a welcoming and protective environment. Sustainability and harmony with the surroundings are prioritized in this design, enabling the facility to meet both present and future medical challenges within the context of global health. This architecture serves a vital healthcare function while seamlessly integrating into the natural landscape, maintaining a zero-impact footprint.

Layout and Zoning

The maternity center is thoughtfully organized into several key zones to ensure optimal functionality and facilitate ease of movement throughout the facility [64]. Each area is designed to support specific functions while enhancing the overall patient experience (figure 2). Upon entering, visitors are welcomed by a spacious reception and waiting area that exudes warmth and friendliness. This space features comfortable seating arrangements, natural ventilation, and an abundance

Figure 1. *A visual sketch of the project illustrates the layout, form, and spatial relationships between the building and its environment, emphasizing the structure's integration with its surroundings and its responsiveness to user needs. Furthermore, it effectively conveys the architectural design and conceptual framework of the healthcare facility.*

of natural light, contributing to a calming atmosphere. The inclusion of local artwork and decorative elements enriches the cultural resonance of the environment. Strategically located private consultation rooms provide patients with the privacy they need while ensuring easy access to medical care. Each room is outfitted with modern medical facilities and designed with patient comfort in mind. Large windows allow for ample natural light and ventilation, creating a pleasant setting for both patients and healthcare providers.

The labor and delivery rooms are specifically designed to offer a safe, comfortable, and supportive environment for childbirth. Each spacious room is equipped with state-of-the-art medical equipment, while soothing colors and natural materials create a calming atmosphere that helps reduce stress and anxiety for expectant mothers. Adjacent to the labor and delivery suites is a dedicated neonatal care unit, equipped with incubators, phototherapy units, and other essential medical apparatus. This unit is designed to ensure quick and efficient transfer of newborns in need of specialized care, easily accessible from the delivery rooms. A single isolation room, equipped with a dedicated ventilation system, is incorporated into the design to prevent the spread of infectious diseases. Utilizing the "wind tower" technique, this room features a higher ceiling and elevated windows that promote effective air circulation, maintaining a clean and healthy environment. Postpartum recovery rooms provide a comfortable space for mothers to recuperate after childbirth. Designed to foster a homelike environment, these rooms offer space for family members to stay and support the new mother. Natural light, ventilation, and soothing decor contribute to a relaxing and healing atmosphere. Additionally, medical and nursing staff offices are strategically located to support the efficient operation of the center. These functional and comfortable spaces are equipped with modern office equipment and benefit from ample natural light. The relaxation and study area for healthcare staff will include an internal window with a glass partition for direct observation of the neonatal intensive

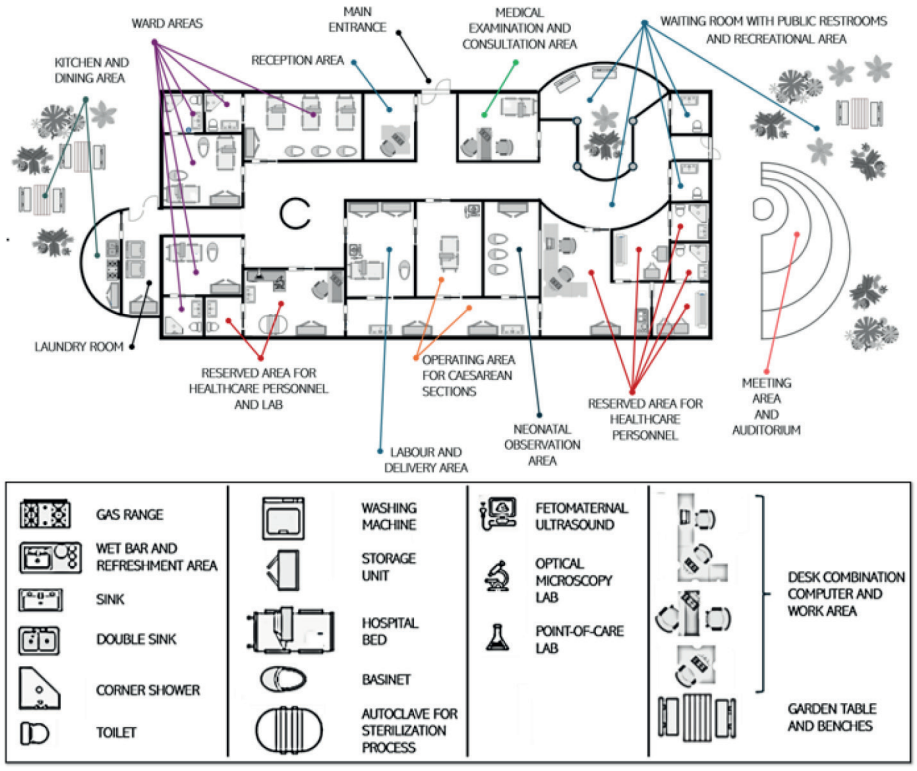

Figure 2. *Proposed architectural layout of the maternity center, including the functional purposes of the various spaces.*

care area. A multi-functional training and education area is dedicated to the continuous education of healthcare providers and to inform patients on maternal and neonatal health. This flexible space is equipped with modern teaching aids and is designed to facilitate interactive learning sessions, workshops, and community meetings. The center also features beautifully landscaped gardens and courtyards, creating tranquil outdoor spaces for patients, families, and staff. These areas foster relaxation and well-being, complete with shaded seating, walking paths, and spaces designed for outdoor activities and events.

Architectural Solutions to Facilitate Clinical Pathways

The design of the maternity center focuses not only on providing the essential spaces for optimal care for women and newborns during pregnancy and childbirth but also rigorously applies the latest public health research to develop rational and functional care pathways [63, 66]. This involves the establishment of distinct areas for hospitalized patients and outpatients, differentiated pathways based on the severity of clinical conditions, and specific health concerns (figure 3).

The design of patient rooms and care environments are focused on maximizing visibility and accessibility for healthcare providers.

Incorporating large windows and open sightlines allows staff to monitor patients effectively while minimizing unnecessary movement throughout the facility. This not only enhances safety and response times but also sup-

ports collaborative care models where multidisciplinary teams can work together seamlessly. Moreover, the layout of nursing stations and support areas is strategically placed to optimize workflow. By sitting in these spaces near patient rooms, nurses can quickly respond to patient needs and coordinate care without unnecessary delays. The incorporation of flexible workspaces and areas for collaboration further enhances teamwork and fosters a culture of communication among staff.

Finally, when possible, the integration of technology within architectural design is another critical aspect of facilitating clinical pathways. Spaces can be equipped with advanced medical technology and information systems that allow for efficient data sharing and communication among healthcare professionals. This ensures that critical patient information is readily available at the point of care, enabling informed decision-making and timely interventions.

Technical Solutions to Promote Infection Prevention and Control

Hygiene standards have been maximized by adapting the building's infrastructure to facilitate clean and contaminated pathways, along with a designated isolation space for pregnant women with communicable diseases [63, 67-75]. A single isolation room is provided, equipped with a dedicated ventilation system to mitigate the transmission

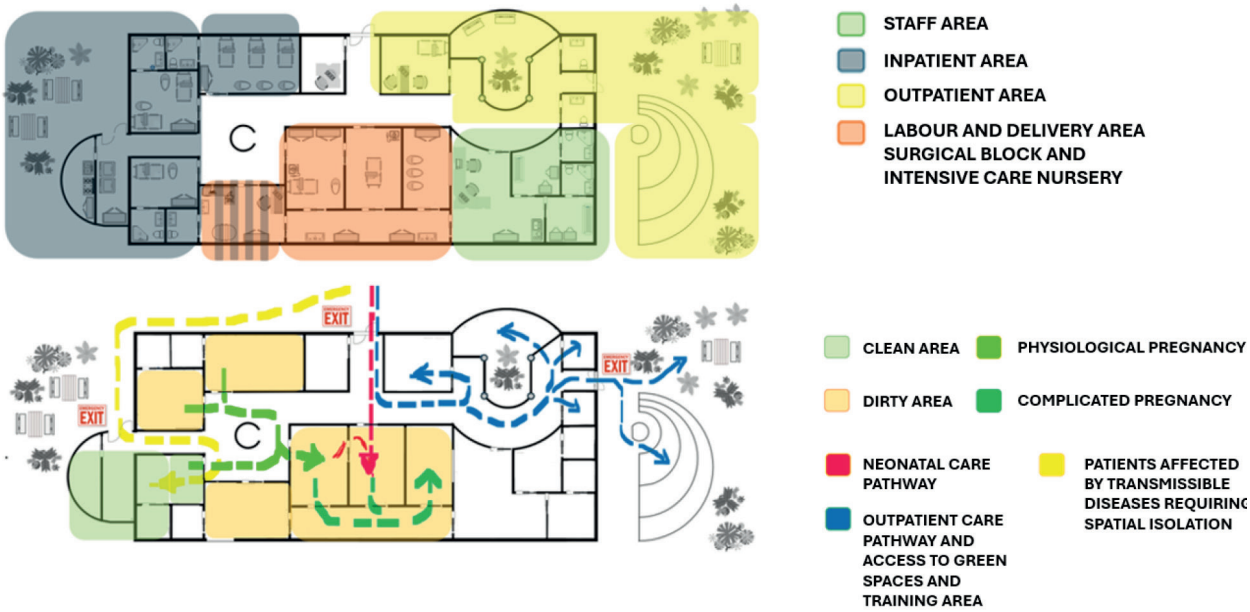

Figure 3. *Architectural design plays a crucial role in enhancing the efficiency and effectiveness of clinical pathways within healthcare facilities. One of the primary architectural solutions is the creation of distinct zones within a healthcare facility that correspond to different stages of care. For instance, a well-defined triage area at the entrance helps to quickly assess patients and direct them to appropriate treatment zones, thereby streamlining the patient intake process. This prevents bottlenecks and ensures that individuals receive timely medical attention.*

of infectious diseases. This isolation room utilizes the "wind tower" technique, featuring a higher ceiling and elevated windows, which facilitate effective air circulation and maintain a healthy environment (figure 4) [67, 68].

The integration of courtyard designs establishes coherent ventilation pathways and enhances infection control by promoting natural airflow within space. These courtyard areas serve as ecological interchange zones, creating an integrated ventilation channel that supports natural ventilation throughout the hospital building (figure 4).

Technical Solutions for Addressing Climate Challenges and Energy Autonomy

While architectural solutions that support hygiene and optimized clinical pathways are primary objectives of this design, sustainable features are equally vital to the overall concept. The project incorporates passive ventilation strategies to enhance natural airflow, reducing reliance on mechanical cooling systems. Additionally, the use of local materials minimizes the environmental impact of construction and supports local economies. Techniques such as passive ventilation, natural heating, and the integration of green spaces also contribute to energy efficiency and reduced environmental impact (figure 5) [76-82].

The roofing system will be constructed using wood planks in conjunction with a waterproof membrane fabricated from recycled tires; this sustainable design not only provides a reliable waterproof barrier but also enhances passive ventilation capabilities. The layered structure created by the overlapping tiles allows for air circulation beneath the roof, promoting natural airflow that can help regulate indoor temperatures. This passive ventilation aids in maintaining a cooler environment, particularly in warm climates, by facilitating the dissipation of heat. As a result, the roofing system not only contributes to sustainable building practices but also plays a crucial role in preserving freshness and comfort within the space, minimizing the reliance on mechanical cooling systems. Moreover, roof design accommodates the possible installation of solar panels to meet the energy needs of the center, ensuring autonomy from the unreliable energy supply often experienced in rural areas [83-84]. The center will include gardens that provide outdoor spaces for patients, families, and staff. These areas are thoughtfully designed to promote relaxation and well-being, featuring shaded seating areas and spaces for community events (figure 6).

An outdoor multifunctional auditorium will be dedicated to educating patients on sexual and reproductive health, facilitating interactive learning sessions, theater performances, and community meetings. A removable shade structure crafted from local fabric, supported by poles, will provide a practical and versatile solution for protecting attendees from sun and inclement weather during events.

Use of Materials and Construction Process

Utilizing locally sourced materials and artisanal craftsmanship enables architects to integrate traditional building materials, construction techniques, and design features that align with the cultural identity of the community. Additionally, these approaches

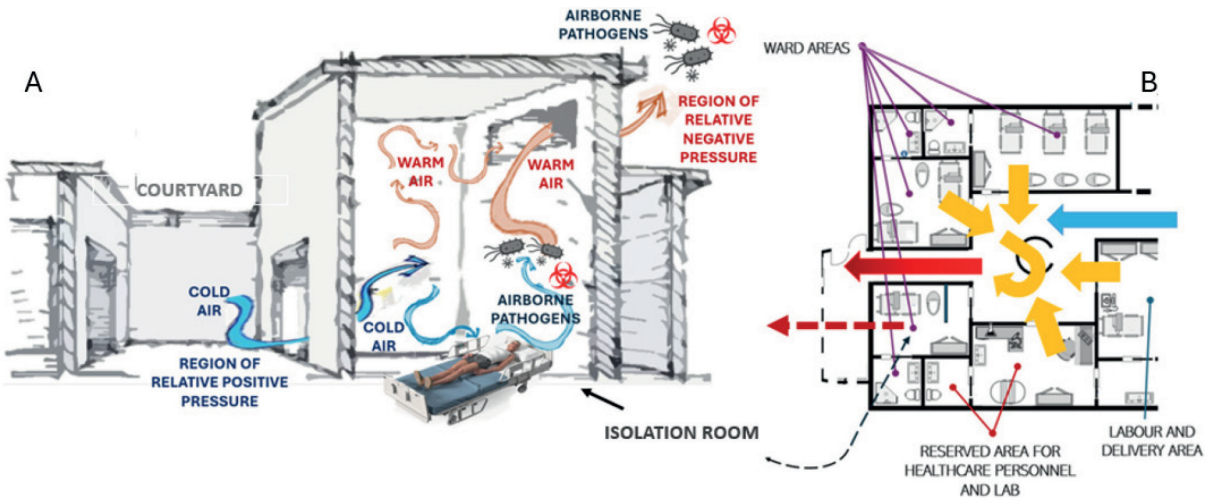

Figure 4. *Architectural strategy for infection prevention and control. Passive ventilation systems, such as wind towers, can ventilate spaces and reduce the burden of airborne pathogens by utilizing regional pressure differences and the stack effect. The design approach (open-end corridor and court-yard) increases ventilation rate (air change per hour) thereby reducing the risk of infection significantly (Modified from: Emmanuel U et al. J Environ Health Sci Eng. 2020, doi: 10.1007/s40201-020-00580-y and Mahon H et al. Energy, 2022, doi. 10.1016/j.energy.2022.125118) [67, 68].*

are economically sustainable. Furthermore, the use of local materials and craftsmanship fosters a cultural harmony with the heritage, traditions, and aesthetic preferences of the community that will use the healthcare facility.

Within this project, the primary structure of the hospital will be constructed using earthen bricks, coated with a layer of red clay that serves as plaster for both the external and internal surfaces. Internal flooring will feature standard tiles, while the cement and shell-tiled floors in the covered courtyard areas will be constructed using disposable formwork. The exposed areas of the courtyards will be treated with small, crushed stones to facilitate drainage. The choice of standard tiles for internal spaces stems from the need for smooth, easy-to-clean surfaces, which must be professionally installed, particularly in operating rooms, with minimal joint spacing of approximately 2 mm.

The roofing system will consist of rosewood planks combined with a waterproof membrane made from recycled tires, created by cutting the tires into coplanar pieces that overlap. Windows will feature frames constructed from rosewood beams, with wild bamboo canes inserted into the frames to provide partial light shielding while allowing for necessary air circulation. Sliding doors will utilize wooden planks and will be mounted on an external track trolley system, composed of an iron tube and specialized metal components.

Bamboo vulgaris will be employed to construct the columns supporting the fabric canopies over both the auditorium and courtyard areas. For the larger courtyard, three bamboo canes will be bundled and secured together, while all columns will

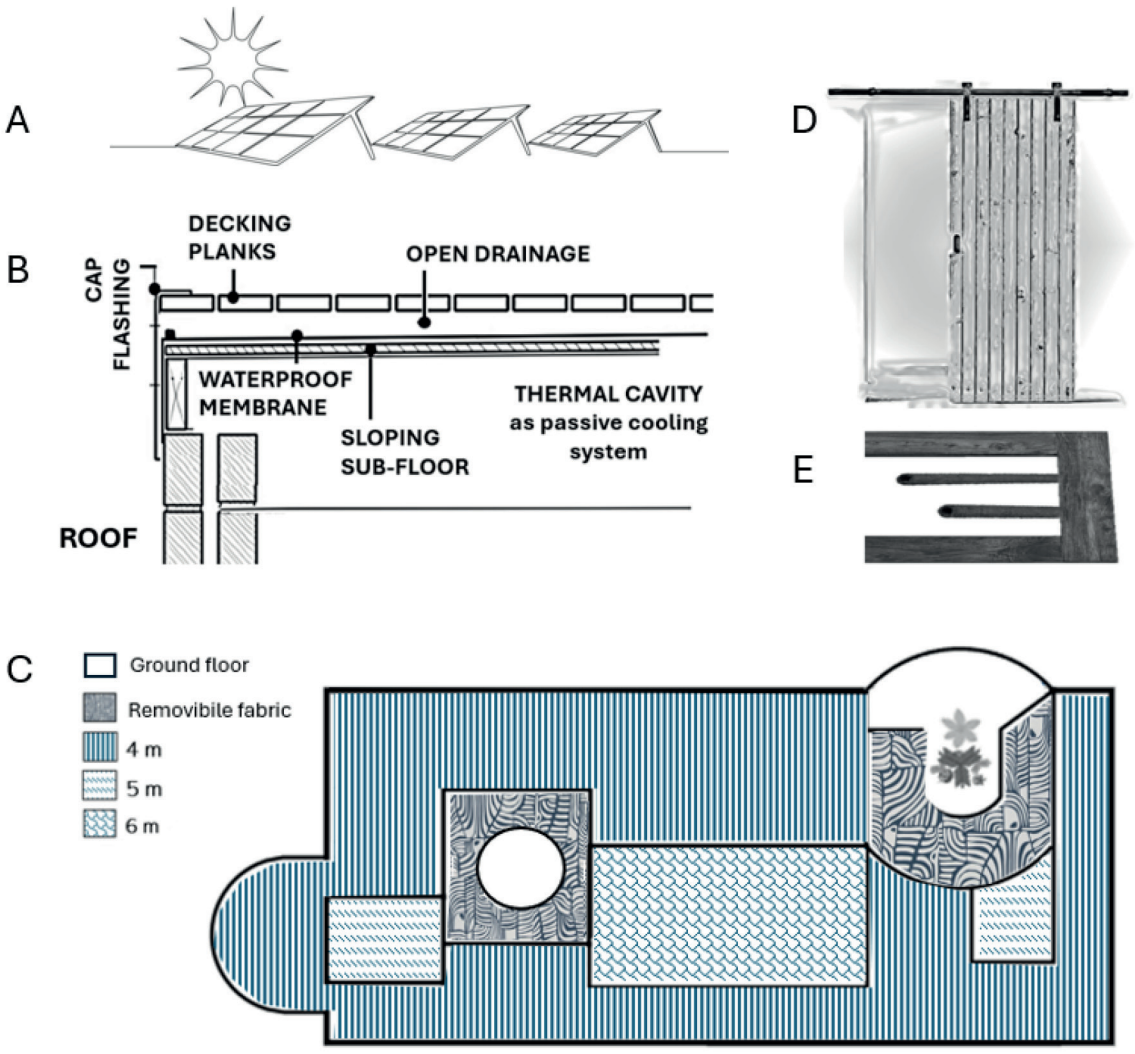

Figure 5. *Construction Technical Details. A) Provision for the installation of solar panels on the roof, B) construction technical details for the roof, C) elevation of the building's roofs, D) Construction Technical Details for doors – The sliding doors will be crafted from high-quality wood to ensure durability and aesthetic appeal. These doors will feature an ergonomic design that allows for quick and easy access, reducing the need for contact with handles and thereby minimizing the risk of environmental microbial contamination within the healthcare space. The doors will be installed using an external track and trolley system, allowing for smooth and efficient operation. The track will be securely mounted to the wall, and the trolley system will consist of robust metal components designed to support the weight of the doors while allowing for effortless sliding, E) The windows will feature frames made from wooden planks, providing a sturdy structure. Dividers will be constructed using bamboo slats, which will allow for natural light and ventilation while offering partial light shielding. This combination of materials will enhance the windows' aesthetic appeal and contribute to the overall sustainability of the building design.*

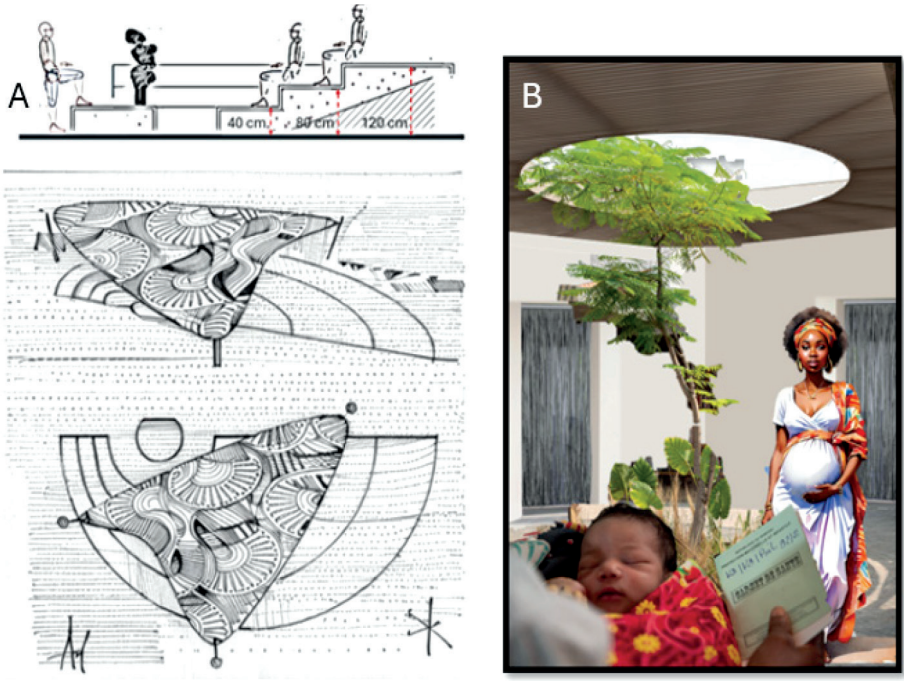

Figure 6. *Spaces for Relaxation, Training, and Social Interaction. A) Auditorium Open Space: The area features a removable sail cover crafted from traditional fabric, supported by three poles, providing shelter for the meeting space from weather. B) Rendering of Courtyard: This courtyard is strategically located near the patient rooms and is dedicated to relaxation and socialization, creating a tranquil environment for both patients and their families.*

be anchored in the ground for stability. Hooks attached to the walls will support the curtains in the smaller courtyard, with a metal ring inserted at the center of the curtain to create an opening for natural light and ventilation. Steps for the auditorium will be crafted from red clay. Tall trees will be planted within the courtyard and waiting area to provide shade and reduce ambient heat, with a medium-sized tree designated for the courtyard adjacent to the inpatient ward.

Minimized construction costs allow for the evaluation of allocating a portion of the budget to an autonomous energy supply system, which includes solar panels. This setup will provide reliable and sustainable energy for lighting, medical equipment, and other essential functions [85-87].

Culturally Responsive Architectural Design: Embracing Local Traditions

Drawing inspiration from West Africa's rich architectural heritage, the design incorporates elements such as open courtyards, impluviums, verandas and towers that promote natural ventilation (figure 7 and figure 6B) [88-89].

The integration of traditional forms, materials, and techniques ensures cultural relevance while enhancing the building's sustainability and environmental performance. The center is designed to harmoniously blend with its surrounding environment, creating a welcoming and protective atmosphere reminiscent of an embrace or a maternal womb (figure 8).

Culturally responsive architectural design plays a pivotal role in community acceptance; it involves creating structures that not only meet functional needs but also honor and reflect the cultural traditions and values of the local community [90-92]. This approach

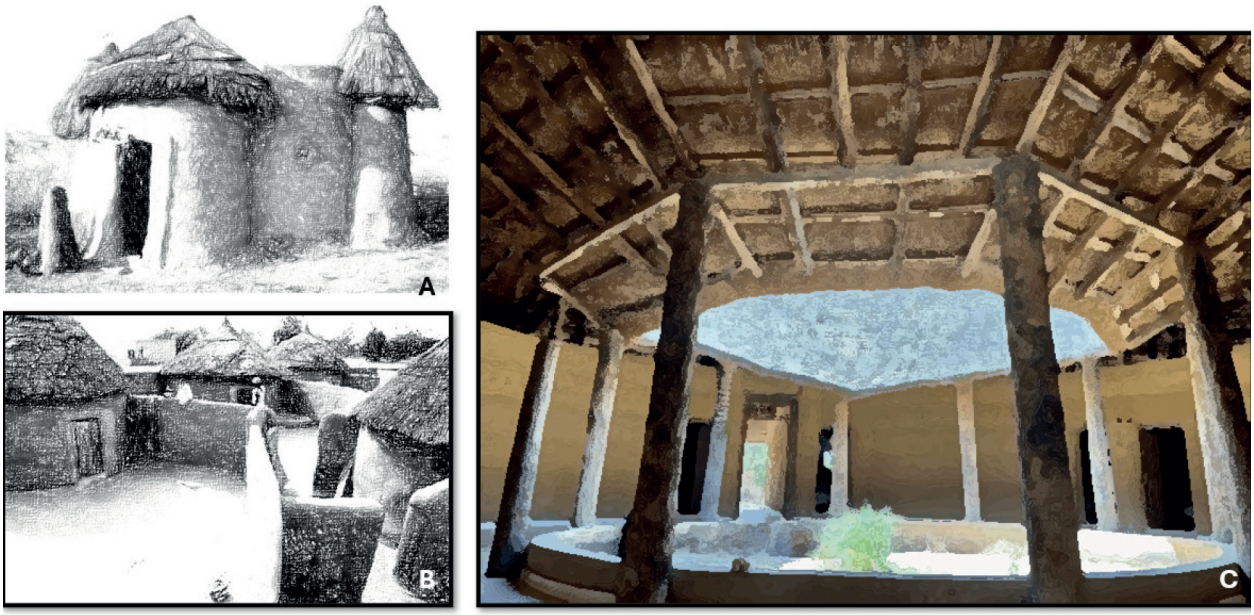

Figure 7. *Charcoal sketches and watercolors depicting examples of West Africa's traditional architectural heritage. Vernacular and traditional housing in Sub-Saharan Africa has evolved over generations to meet the challenges posed by extreme climatic conditions. These indigenous structures often embody deeply rooted cultural values and provide insights into sustainable living. By effectively utilizing natural materials and innovative design, they create comfortable and resilient homes. Exploring these traditional architectural forms reveals valuable lessons in climate-responsive design, which are crucial for the advancement of sustainable architecture in the region. A) An example of vernacular and low-tech architecture is the Tata Somba or Takyenta tower-style mud houses in Koutammakou, Togo. These structures are composed of rammed earth and typically consist of about eight interlinked buildings, all surrounded by mud walls. B) A settlement of mud huts with contiguous central courtyards in Burkina Faso. C) The traditional Jola house in Senegal's Casamance region is a circular structure that exemplifies sustainable architecture. Characterized by mud brick walls and a central courtyard, or impluvium, it features a sloped roof that collects rainwater in a cistern for drinking. This design employs evaporative cooling, where evaporating water cools the indoor air while the thatched roof shields the thick walls from solar heat. Similar impluvial architectural styles are also present in the Igbo, Yoruba, and Edo cultures of southern Nigeria, utilizing sun-dried mud bricks and thatch.*

is particularly important in regions with rich cultural heritages, as it fosters a sense of identity and belonging among residents while promoting social cohesion. To achieve this, architects must engage in thorough research and dialogue with local communities to understand their history, customs, and aesthetic preferences. This collaborative process allows architects to incorporate traditional materials, construction techniques, and design elements that resonate with the local culture. For instance, the use of indigenous materials and craftsmanship can enhance the authenticity of a building while supporting

Figure 8. *An ideal graphic sketch of a section of the building that illustrates the intersection between the healthcare-related areas and the welcoming spaces, inspired by traditional West African architectural models such as open courtyards, impluviums, and verandas. A synthesis of heritage and innovation in healthcare architecture fosters a welcoming, protective environment. Prioritizing sustainability and environmental balance, this design paradigm addresses current and future medical challenges within a global health framework, focusing on comprehensive care for vulnerable populations. The architecture seamlessly integrates with the natural landscape, achieving a zero-impact footprint while effectively serving its healthcare function.*

local economies. Moreover, culturally responsive design can address environmental sustainability by utilizing traditional practices that are inherently eco-friendly.

Conclusion

The state of maternal health in West Africa is a complex interplay of various determinants, including access to care, socioeconomic factors, infectious diseases, and cultural beliefs. As countries in this region strive to make progress toward achieving the Sustainable Development Goals focused on reducing maternal mortality, it is imperative to adopt a multifaceted approach that addresses the underlying issues. Through concerted efforts in healthcare improvement, education, community engagement, and policy advocacy, it is possible to enhance maternal health outcomes and save the lives of countless women and their newborns. A multifaceted approach that includes strengthening healthcare systems, promoting community engagement, integrating services, advocating for supportive policies, and strategically designing culturally appropriate maternity centers is essential for enhancing maternal and infant health in Sub-Saharan West Africa.

Cultural practices and beliefs are fundamental determinants of maternal health in Sub-Saharan Africa. By understanding and respecting the cultural contexts that influence maternal health behaviors, health practitioners and policymakers can create more effective interventions. Pro-

moting dialogue and collaboration between traditional and formal healthcare systems will enhance maternal health outcomes, empowering women to access the care they need while honoring their cultural identities. In this way, addressing maternal health becomes not just a biomedical challenge, but a holistic one that incorporates the social, cultural, and economic dimensions of women's lives.

The role of architectural design in creating culturally sensitive spaces dedicated to healthy pregnancy care is essential. Emphasizing comfort, privacy, cultural relevance, and sustainability within healthcare environments can significantly improve the experiences and health outcomes of pregnant women. As maternal health continues to be a pressing concern, investing in thoughtful architectural design is imperative for fostering health-promoting environments that meet the diverse needs of women throughout their pregnancy journey.

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The Role of Antibiotic Resistance in African Developing Countries

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Abstract
Antibiotic resistance poses a significant public health challenge in African developing countries, driven by multifaceted factors including the overuse and misuse of antibiotics, inadequate regulation, counterfeit medicines, poor healthcare infrastructure, and the overuse of antibiotics in agriculture. This paper explores the key drivers of antibiotic resistance in the African context, highlighting the role of self-medication, weak governance, and diagnostic challenges. It also examines the impact of urbanization, environmental contamination, and human-animal interactions on the spread of resistant bacteria. To address this crisis, the paper proposes comprehensive strategies, including strengthening policy frameworks, enhancing antibiotic stewardship, expanding public education, improving surveillance systems, and reducing agricultural misuse. Emphasis is placed on the need for international collaboration, sustainable financing, and community engagement to combat resistance effectively. This paper underscores the importance of integrating "One Health" principles and fostering innovation in diagnostics and treatments to mitigate antibiotic resistance and protect public health in Africa.

Keywords
Antibiotic resistance, infectious disease, nosocomial infections, surveillance on bacterial infections, One Health, antibiotics use in agriculture.

1. Introduction

Antibiotic resistance is one of the most pressing global health challenges, with devastating impacts on public health and economies worldwide. However, the burden is particularly acute in African developing countries, where weak healthcare systems, poverty, and a high prevalence of infectious diseases exacerbate the issue (World Health Organization [WHO], 2021; O'Neill, 2016). This phenomenon occurs when bacteria develop mechanisms to survive antibiotics,

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rendering treatments ineffective and leading to increased mortality rates, prolonged illness, and economic losses (Ventola, 2015).

The high burden of infectious diseases such as tuberculosis, malaria, and HIV/AIDS drives the overuse and misuse of antibiotics, further fueling resistance (Laxminarayan *et al.*, 2013). Compounded by systemic challenges such as counterfeit drugs, inadequate public awareness, and agricultural misuse, antibiotic resistance poses a severe threat to health security in Africa. This paper examines the drivers, impacts, and strategies to mitigate antibiotic resistance in African developing countries.

2. Key Drivers of Antibiotic Resistance in Africa

2.1. *Overuse and Misuse of Antibiotics*

The widespread overuse and misuse of antibiotics remain among the most critical drivers of antibiotic resistance in Africa. Factors contributing to this issue include self-medication, over-the-counter antibiotic sales, and overprescription in healthcare settings.

- **Self-Medication and Over-the-Counter Sales**
  In many African countries, weak regulatory frameworks allow the sale of antibiotics without prescriptions. Studies in Nigeria and Ghana reveal that antibiotics are often purchased from informal markets or pharmacies, with no oversight from qualified healthcare providers (Okeke *et al.*, 2005; Bebell & Muiru, 2014). Individuals commonly use antibiotics for viral infections, such as colds or flu, for which these drugs are ineffective, inadvertently fostering resistance (WHO, 2021).
- **Overprescription in Clinical Settings**
  Healthcare providers often prescribe antibiotics unnecessarily, influenced by diagnostic uncertainty, patient expectations, or inadequate training. For example, research in Tanzania found that 50% of patients with respiratory infections received antibiotics, despite the majority of these cases being viral (Essack *et al.*, 2017). Overprescription in hospitals and clinics amplifies the exposure of bacteria to antibiotics, accelerating resistance development (Laxminarayan *et al.*, 2013).

2.2. *Poor Regulation and the Prevalence of Counterfeit Medicines*

Africa faces significant challenges with counterfeit and substandard medicines. A report from the WHO estimates that 10% of medicines in low- and middle-income countries are falsified, with Africa disproportionately affected (Newton *et al.*, 2006). Counterfeit antibiotics often contain insufficient active ingredients, exposing bacteria to subtherapeutic doses that fail to kill them but encourage resistance (Newton *et al.*, 2006; Nwokike *et al.*, 2009).

Efforts to curb counterfeit drugs are hindered by weak governance and insufficient resources for regulatory agencies. For example, in Nigeria, only 30% of pharmaceutical imports are adequately monitored, creating a significant vulnerability in the supply chain (WHO, 2021).

2.3. *Lack of Awareness and Education*

A lack of public and professional awareness exacerbates

the misuse of antibiotics. Surveys in countries such as Uganda and Kenya show widespread misconceptions, including the belief that antibiotics are effective against all infections, including viral ones (Byarugaba, 2004; Mendelson *et al.*, 2016).

At the community level, limited health literacy often results in non-adherence to prescribed antibiotic regimens, with patients discontinuing treatment once symptoms improve. This incomplete usage promotes the survival of partially resistant bacterial strains, further propagating resistance (Essack *et al.*, 2017). Additionally, healthcare workers in resource-limited settings may lack updated training on antimicrobial stewardship, perpetuating inappropriate prescription practices.

2.4. *Inadequate Healthcare Infrastructure and Surveillance*

The lack of robust healthcare infrastructure and surveillance systems is a significant barrier to managing antibiotic resistance in Africa. Most countries lack comprehensive systems to monitor resistance trends, limiting their ability to implement effective interventions (African Union, 2020).

- **Diagnostic Challenges**
  Inadequate laboratory capacity leads to reliance on empirical treatment, where antibiotics are prescribed without confirming bacterial infections. For example, in rural areas of Ethiopia, over 70% of antibiotics are prescribed based solely on symptoms rather than diagnostic tests (Okeke *et al.*, 2005).
- **Data Gaps**
  Without accurate data on resistance patterns, healthcare providers are often unaware of which antibiotics are effective, leading to the continued use of obsolete drugs. Furthermore, national strategies are difficult to design without reliable resistance surveillance data (Bebell & Muiru, 2014).

2.5. *Overuse in Agriculture*

Antibiotics are extensively used in livestock farming in Africa, both to treat infections and as growth promoters. This practice creates a reservoir of resistant bacteria in animals, which can transfer to humans through food consumption, direct contact, or environmental contamination (Van Boeckel *et al.*, 2017).

In Kenya and Uganda, studies have shown that poultry and cattle farms frequently use antibiotics without veterinary oversight, often at subtherapeutic doses (Mitema *et al.*, 2001). This misuse increases the likelihood of resistant bacterial strains, such as *Salmonella* and *Escherichia coli*, entering the human food chain. Additionally, agricultural runoff containing antibiotic residues contaminates water supplies, further amplifying the spread of resistance (Laxminarayan *et al.*, 2013).

2.6. *Urbanization and Population Density*

Rapid urbanization and high population density in many African cities exacerbate the spread of antibiotic-resistant infections. Overcrowded living conditions, inadequate sanitation, and poor waste management contribute to the transmission of resistant bacteria (WHO, 2021).

- **Healthcare-Associated Infections**
  Hospitals and clinics in densely populated areas often face resource constraints, resulting in insufficient infection control

measures. This fosters the spread of resistant pathogens, particularly in settings with high antibiotic use, such as intensive care units (Mendelson *et al.*, 2016).

– **Environmental Contamination**
  Urban waste often contains antibiotic residues and resistant bacteria from hospitals, agricultural runoff, and untreated sewage. These pollutants contaminate water sources, creating an ecological environment that promotes resistance (Okeke *et al.*, 2005).

2.7. *Human and Animal Migration*

Human and animal migration facilitates the cross-border spread of resistant bacteria. For instance, nomadic pastoralism in East Africa often involves livestock movement across national boundaries, increasing the risk of introducing resistant strains into new regions (Mitema *et al.*, 2001). Similarly, international travel and trade can disseminate resistance genes globally, complicating containment efforts (Van Boeckel *et al.*, 2017).

2.8. *Weak Governance and Policy Implementation*

Although many African countries have adopted national action plans on antimicrobial resistance, implementation remains weak due to limited funding, insufficient coordination, and competing health priorities (African Union, 2020). For example, in several nations, regulatory bodies lack the authority or resources to enforce restrictions on over-the-counter antibiotic sales or monitor agricultural antibiotic use effectively (Essack *et al.*, 2017).

Impact on Public Health

1. **Increased Morbidity and Mortality**
   Resistant infections are harder to treat and result in higher morbidity and mortality rates. Diseases like multidrug-resistant tuberculosis (MDR-TB) are particularly challenging, requiring expensive, prolonged treatments with lower success rates (WHO, 2021; Mendelson *et al.*, 2016). MDR-TB is prevalent in countries like South Africa and Nigeria, posing a significant public health threat (Keshavjee & Farmer, 2012). Infections such as neonatal sepsis, a leading cause of death among newborns, are increasingly caused by antibiotic-resistant bacteria, complicating treatment and increasing fatality rates (Zaidi *et al.*, 2005; Bebell & Muiru, 2014).
2. **Healthcare System Strain**
   Resistant infections necessitate longer hospital stays and the use of second- or third-line antibiotics, placing an unsustainable burden on healthcare systems. In resource-limited settings, this often leads to suboptimal care and preventable deaths (Okeke *et al.*, 2005; Ventola, 2015).
3. **Impact on Maternal and Child Health**
   Pregnant women and children are particularly vulnerable to the effects of antibiotic resistance. Maternal infections during childbirth and conditions like urinary tract infections are becoming harder to treat, increasing maternal and infant mortality (Zaidi *et al.*, 2005; WHO, 2021).

Economic Impact

1. **Increased Healthcare Costs**
   Treating resistant infections often involves expensive second-line therapies that strain household incomes and national healthcare budgets (Mendelson *et al.*, 2016; O'Neill, 2016). For example, treating MDR-TB can cost up to 20 times more than treating drug-sensitive TB, with many patients unable to afford the treatment (Keshavjee & Farmer, 2012).
2. **Productivity Loss**
   Antibiotic resistance disproportionately affects working-age adults, reducing productivity and household incomes. In agriculture-dependent communities, the loss of labor due to illness exacerbates poverty (Okeke *et al.*, 2005; Ventola, 2015).
3. **Impact on Global Trade and Tourism**
   Countries with high resistance rates may face trade restrictions, especially for agricultural products, and reduced tourism due to healthcare concerns (O'Neill, 2016; Laxminarayan *et al.*, 2013).

3. Strategies to Combat Antibiotic Resistance in Africa

Tackling antibiotic resistance in Africa requires a multifaceted approach involving strong governance, community engagement, healthcare reforms, and international cooperation. Below is an expanded discussion of key strategies to combat antibiotic resistance, tailored to the region's unique challenges.

3.1. *Strengthening Policy and Governance*

– **Development and Enforcement of National Action Plans (NAPs):**
  Many African countries have adopted National Action Plans (NAPs) for antimicrobial resistance (AMR) in alignment with the WHO's Global Action Plan. However, implementation is often hindered by funding and operational challenges. Governments must prioritize AMR by allocating sufficient resources, enforcing existing regulations, and integrating AMR strategies into broader public health agendas (WHO, 2021).
– **Regulation of Antibiotic Sales and Use:**
  Strict enforcement of laws prohibiting the over-the-counter sale of antibiotics is essential. Policies requiring prescriptions for antibiotic purchases can reduce self-medication and misuse. For example, South Africa has implemented stricter pharmacy regulations that have successfully curtailed over-the-counter antibiotic sales (Mendelson *et al.*, 2016).

3.2. *Enhancing Antibiotic Stewardship Programs (ASPs)*

Antibiotic Stewardship Programs in healthcare facilities aim to ensure the appropriate use of antibiotics to minimize resistance. Effective ASPs can include:

– **Training Healthcare Professionals:**
  Regular training on the rational use of antibiotics for healthcare providers is critical. Training should focus on evidence-based prescribing practices, the dangers of overprescription, and the importance of adhering to treatment guidelines (Bebell & Muiru, 2014).
– **Establishing Prescription Audits:**

Hospitals and clinics should implement prescription audits to monitor antibiotic use and ensure compliance with guidelines. Facilities with such programs, like those piloted in Kenya, have reported significant reductions in antibiotic misuse (Essack *et al.*, 2017).

– **Promoting Diagnostic Testing:**
Improving access to diagnostic tools can help distinguish between bacterial and viral infections, reducing unnecessary antibiotic prescriptions. Portable and cost-effective rapid diagnostic tests (RDTs) are particularly valuable in rural areas with limited laboratory capacity (Okeke *et al.*, 2005).

3.3. *Public Education and Awareness Campaigns*

Educating the public about the dangers of antibiotic resistance and the importance of proper antibiotic use is crucial.

– **Mass Media Campaigns:**
Governments and NGOs can use radio, television, and social media to disseminate educational messages. Campaigns like the "Antibiotics Off the Menu" initiative in South Africa have successfully raised awareness about resistance risks (Mendelson *et al.*, 2016).
– **Community Health Workers:**
Training community health workers to educate rural populations on antibiotic use can bridge the gap in areas with limited access to formal healthcare services.
– **School Curricula:**
Incorporating AMR education into school curricula ensures long-term awareness by instilling good practices in younger generations (WHO, 2021).

3.4. *Expanding Surveillance Systems*

Reliable data on AMR is essential for designing effective interventions.

– **National Surveillance Networks:**
African nations must strengthen national surveillance networks to track antibiotic resistance trends. Programs like the Global Antimicrobial Resistance Surveillance System (GLASS) have begun to provide valuable data, but coverage must expand, especially in rural and underserved areas (WHO, 2021).
– **Integration of Human, Animal, and Environmental Surveillance (One Health):**
The "One Health" approach integrates surveillance across human, animal, and environmental sectors.
For example, monitoring antibiotic use in livestock, coupled with resistance testing in foodborne pathogens, can provide insights into cross-sector resistance trends (Van Boeckel *et al.*, 2017).

3.5. *Reducing Agricultural Antibiotic Use*

Agricultural antibiotic misuse is a significant driver of resistance in Africa, requiring targeted interventions.

– **Phasing Out Growth Promoters:**
Policies banning the use of antibiotics as growth promoters in livestock should be enforced. For instance, the European Union's ban on antibiotic growth promoters has inspired similar efforts globally, which African nations could emulate (Laxminarayan *et al.*, 2013).
– **Promoting Veterinary Oversight:**

Ensuring that antibiotics are administered to animals only under veterinary supervision can reduce misuse. This requires expanding veterinary services in rural areas and providing training on antibiotic stewardship to veterinarians and farmers.

– **Alternative Practices:** Encouraging alternative farming practices, such as improved hygiene, vaccination programs, and probiotic use, can reduce the need for antibiotics in livestock production (Van Boeckel *et al.*, 2017).

3.6. *Improving Sanitation and Hygiene*

Improved sanitation and hygiene can limit the spread of resistant bacteria in communities.

– **Access to Clean Water:** Investments in water, sanitation, and hygiene (WASH) infrastructure are crucial. Access to clean water can reduce the incidence of infections, thereby decreasing antibiotic demand (Essack *et al.*, 2017).
– **Hospital Infection Control:** Strengthening infection prevention and control (IPC) measures in healthcare settings, such as hand hygiene protocols, proper sterilization of equipment, and isolation of infected patients, can reduce healthcare-associated infections and antibiotic use (Mendelson *et al.*, 2016).

3.7. *Fostering Research and Development (R&D)*

Investing in local research is essential for addressing the unique drivers of resistance in Africa.

– **New Antibiotics and Alternatives:** Supporting African universities and research institutions to develop new antibiotics or alternative therapies, such as bacteriophages and immunotherapies, is critical. Partnerships with international organizations can provide funding and technical expertise (Laxminarayan *et al.*, 2013).
– **Traditional Medicine:** Exploring the antimicrobial potential of traditional African medicinal plants can provide novel treatment options while reducing reliance on conventional antibiotics (Bebell & Muiru, 2014).

3.8. *International Collaboration*

Antibiotic resistance is a global problem that requires coordinated international efforts.

– **Regional Cooperation:** African nations can collaborate through organizations like the African Union and the Africa Centres for Disease Control and Prevention (Africa CDC) to share surveillance data, harmonize regulations, and implement cross-border interventions (African Union, 2020).
– **Global Partnerships:** Engaging with global initiatives, such as the Fleming Fund and the Access to Medicine Foundation, can provide technical and financial support for combating resistance in Africa (WHO, 2021).
– **Technology Transfer:** Developed countries can support African nations by transferring diagnostic technologies, sharing expertise, and facilitating affordable access to essential antibiotics and alternatives.

3.9. *Sustainable Financing for AMR Interventions*

Sustained funding is crucial to ensure the long-term success of AMR initiatives.

- **Public-Private Partnerships:** Collaboration between governments and private sector stakeholders can mobilize resources for AMR initiatives, such as improving laboratory capacity and funding awareness campaigns.
- **Global Health Funds:** Leveraging funds from organizations like the Global Fund to Fight AIDS, Tuberculosis, and Malaria can support integrated AMR efforts, especially in resource-limited settings.

3.10. *Addressing Socioeconomic Inequalities*

Poverty and inequality exacerbate the drivers of antibiotic resistance in Africa.

- **Universal Healthcare Access:** Expanding access to affordable healthcare reduces self-medication and reliance on informal markets for antibiotics (Okeke *et al.*, 2005).
- **Community Empowerment:** Empowering communities through education, capacity-building, and economic development can address the root causes of antibiotic misuse and resistance.

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