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Administrative and Policy Dimensions of Microbial Infections in Nigeria's Public Health System

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Abstract

Microbial infections remain a significant public health challenge in Nigeria, imposing substantial burdens on an already strained health system and impeding progress toward universal health coverage. This comprehensive analysis examines the complex interplay between microbial infections and developmental challenges within Nigerian public health systems. Drawing on recent epidemiological data and health systems research, the study reveals that Nigeria faces a quadruple burden of persistent communicable diseases, emerging and re-emerging infections, antimicrobial resistance, and health system deficiencies. Key findings indicate that zoonotic infections affect approximately one-third of at-risk populations, antimicrobial resistance imposes costs equivalent to 2.4% of GDP, and about 80% of public health infrastructure remains dysfunctional. The COVID-19 pandemic has further exacerbated existing vulnerabilities, as evidenced by the resurgence of vaccine-preventable diseases including a diphtheria outbreak affecting over 18,000 individuals. Through analysis of health infrastructure, workforce capacity, surveillance systems, and financing mechanisms, this study identifies critical intervention points for strengthening health system resilience. The findings underscore the imperative of adopting One Health approaches, strengthening primary healthcare, and implementing sustainable health financing reforms to address the developmental challenges posed by microbial infections in Nigeria.

Keywords: Microbial infections; Public health; Antimicrobial resistance (AMR); Infectious diseases; Healthcare infrastructure; Disease burden.

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1. Introduction

1.1 Background to the Study

Nigeria, as the sixth most populous nation globally with an estimated population of 236.4 million people representing approximately 3% of the world's population, faces profound health challenges that intersect with its developmental aspirations (Federal Ministry of Health and Social Welfare, 2025a). The country's health indices reveal a nation struggling to meet the health needs of its citizens despite significant natural resources and economic potential. The 2023 Nigeria Demographic and Health Survey indicates a maternal mortality ratio of 512 deaths per 100,000 live births and an under-five mortality rate of 110 deaths per 1,000 live births, representing marginal improvements from previous years but remaining substantially above global targets (Federal Ministry of Health and Social Welfare, 2025a).

The relationship between microbial infections and health system performance constitutes a critical determinant of population health outcomes. Infectious diseases have historically accounted for a disproportionate share of morbidity and mortality in Nigeria, with conditions such as malaria, tuberculosis, HIV/AIDS, and increasingly, emerging zoonotic infections, placing sustained pressure on healthcare delivery systems. Alabi et al. (2025) note that the World Health Organization estimates Nigeria accounts for approximately

25% of global malaria cases, while tuberculosis notification rates and treatment coverage continue to challenge control efforts.

Health system development in Nigeria has followed a trajectory marked by policy reforms, periodic investments, and persistent implementation challenges. The current health system operates across three tiers of government—federal, state, and local—with primary healthcare conceptually designated as the foundation of service delivery. However, as documented in the Nigeria Health Systems and Services Profile, primary healthcare remains the weakest level of care delivery, with facilities lacking the capacity to deliver the basic package of essential health services (World Health Organization, 2025b). This foundational weakness has profound implications for the prevention, detection, and management of microbial infections.

1.2 Concept of Microbial Infections

Microbial infections encompass diseases caused by pathogenic microorganisms including bacteria, viruses, parasites, and fungi. These infections range from acute self-limiting illnesses to chronic conditions with significant long-term morbidity. In the Nigerian context, microbial infections manifest across multiple transmission pathways, including person-to-person contact, foodborne transmission, waterborne routes, and zoonotic spillover from animal reservoirs.

The epidemiology of microbial infections in Nigeria reflects the country's ecological diversity, population distribution, and socio-economic conditions. Zoonotic infections, those transmitted between animals and humans, represent a particularly significant and underappreciated burden. A systematic review and meta-analysis of Campylobacter species infections in Nigeria from 2002 to 2023 revealed an overall pooled prevalence of 33% across human and animal populations, with significant variations among hosts: 42% in poultry, 30% in humans, and 21% in cattle (Systematic review and meta-analysis of Campylobacter species infections, 2025). These findings illustrate the intricate connections between animal health, food safety, and human disease.

Foodborne pathogens constitute a major category of microbial infections with substantial public health implications. Campylobacter species, particularly C. jejuni and C. coli, account for approximately 95-98% of human campylobacteriosis cases globally and are estimated to cause 500 million cases annually worldwide, with economic losses of 8.6 billion US dollars attributed to human illnesses and 12.6 billion US dollars to production losses (Systematic review and meta-analysis of Campylobacter species infections, 2025). In Nigeria, the predominance of C. coli in humans (87.5%) and C. jejuni in poultry (76.2%) indicates complex transmission dynamics requiring integrated control approaches.

Water, sanitation, and hygiene (WASH) conditions fundamentally influence the transmission of microbial infections, particularly among vulnerable populations. Research from the Benue South Senatorial District demonstrates high prevalence of rotavirus and diarrheagenic Escherichia coli pathotypes, with poor WASH conditions—manifested as fecal contamination of water sources and open defecation—significantly associated with pathogen occurrence (Molecular Epidemiology of Acute Diarrheal Diseases, 2025). These findings underscore the environmental dimensions of microbial infection control.

1.3 Overview of Nigerian Public Health Systems

The Nigerian public health system operates within a complex governance framework established by the constitution, which assigns health responsibilities across federal, state, and local governments. The Federal Ministry of Health provides leadership, policy direction, and technical support, while state ministries manage secondary healthcare facilities, and local governments oversee primary healthcare centers. This decentralized structure, while theoretically enabling local responsiveness, has resulted in fragmentation, duplication, and variable quality across jurisdictions.

Service delivery within the Nigerian public health system exhibits significant limitations that directly impact infection control capacity. Essential health service coverage remains very limited, contributing to Nigeria's poor performance against health indicators (World Health Organization, 2025b). The regional distribution of healthcare facilities is markedly uneven, with tertiary facilities concentrated in major urban centers and more developed regions, leaving rural and less developed areas underserved. Specialist services remain confined primarily to urban areas, and emergency medical care systems lack ambulance services and prehospital care capacity. The infrastructure underpinning public health service delivery is critically compromised. Approximately 80% of Nigeria's public health infrastructure is reported as dysfunctional, impeding the country's ability to provide healthcare to its citizens and contributing to estimated losses of about US$1 billion annually to outbound health tourism (World Health Organization, 2025a). This infrastructure deficit spans physical structures, equipment, laboratory systems, and diagnostic capacity, with direct implications for microbial infection detection and management.

Health financing mechanisms fundamentally shape the public health system's capacity to respond to microbial threats. Despite the 2001 Abuja Declaration commitment to allocate 15% of national budgets to health, Nigeria's health expenditure remains at approximately 5.2% of GDP (Antimicrobial resistance in Nigeria's healthcare system, 2025). More critically, out-of-pocket spending constitutes 71% of health expenditures, creating financial barriers to care and pushing millions into poverty due to medical expenses (Antimicrobial resistance in Nigeria's healthcare system, 2025). The Basic Health Care Provision Fund, established to expand coverage and improve service delivery, has shown improved absorption rates—78% in 2023 compared to 45% in 2019—but overall investment levels remain insufficient to maintain functionality across the health system (Federal Ministry of Health and Social Welfare, 2025a).

1.4 Statement of the Problem

The intersection of microbial infections and health system limitations in Nigeria creates a cyclical pattern of disease burden and developmental constraint. Despite policy commitments and periodic investments, the country continues

to experience significant morbidity and mortality from infections that are largely preventable or treatable. The problem manifests across multiple dimensions that collectively undermine population health and national development.

Persistent high burden of preventable infections constitutes the most immediate dimension of the problem. Vaccine-preventable diseases continue to cause outbreaks despite availability of effective vaccines. The recent diphtheria outbreak in Kano State, which affected 18,320 cases between February 2022 and April 2024 with a case fatality rate of 4.5%, exemplifies this failure (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Unvaccinated individuals had more than double the likelihood of death compared to fully vaccinated persons, highlighting the consequences of immunization coverage gaps exacerbated by COVID-19 pandemic disruptions.

Emerging and re-emerging infectious diseases add complexity to an already strained system. Zoonotic infections, antimicrobial-resistant organisms, and pathogens exploiting environmental degradation create new challenges for which the health system is ill-prepared. The high prevalence of Campylobacter infections across human and animal populations, with significant geospatial variation and temporal peaks between 2016 and 2020, demonstrates the dynamic nature of infectious threats and the need for adaptive surveillance and response systems (Systematic review and meta-analysis of Campylobacter species infections, 2025).

Health system deficiencies compound the disease burden by limiting prevention, detection, and treatment capacity. Workforce shortages are acute, with a doctor-to-population ratio of 1:5,000 against the WHO standard of 1:600, and health workers concentrated in urban areas (Antimicrobial resistance in Nigeria's healthcare system, 2025). Laboratory capacity is severely constrained, with only 23.4% of secondary healthcare facilities having microbiology laboratories (Antimicrobial resistance in Nigeria's healthcare system, 2025). Surveillance systems, while strengthened through platforms like SORMAS, face challenges in coverage, timeliness, and data utilization for decision-making.

The economic consequences of microbial infections and health system failures are substantial. Antimicrobial resistance alone costs an estimated 2.4% of Nigeria's GDP, with resistant infections costing 287% more to treat than susceptible infections (Alabi et al., 2025). Outbound health tourism, driven by lack of confidence in domestic health services, results in approximately US$1 billion in annual economic losses (World Health Organization, 2025a). These economic drains represent resources that could otherwise strengthen the health system and reduce disease burden.

1.5 Aim and Objectives of the Study

This study aims to comprehensively analyze the relationship between microbial infections and developmental challenges within Nigerian public health systems, with the goal of identifying evidence-based strategies for health system strengthening and infection control.

The specific objectives are to:

1. Examine the burden, distribution, and trends of major microbial infections in Nigeria, including emerging and re-emerging infectious diseases
2. Assess the structural and functional characteristics of Nigerian public health systems relevant to infection prevention and control
3. Analyze the developmental challenges posed by microbial infections, including economic impacts and health system strain
4. Evaluate the effectiveness of existing policies, programs, and interventions for microbial infection control
5. Identify strategic priorities and practical recommendations for strengthening public health system capacity to address microbial infections

1.6 Research Questions

This study addresses the following research questions:

1. What is the current burden and epidemiological pattern of microbial infections in Nigeria, and how has this pattern evolved over recent decades?
2. What are the key structural and functional limitations of Nigerian public health systems that impede effective infection control?
3. How do microbial infections impact health system performance, economic development, and population health outcomes?
4. What policy and programmatic interventions have been implemented to address microbial infections, and what factors influence their effectiveness?
5. What strategic approaches offer the greatest potential for strengthening public health system capacity to prevent, detect, and respond to microbial infections?

1.7 Scope and Significance of the Study

This study encompasses analysis of bacterial, viral, and parasitic infections of public health importance in Nigeria, with particular attention to zoonotic infections, antimicrobial-resistant organisms, and vaccine-preventable diseases. The health systems analysis covers governance structures, service delivery mechanisms, health financing, workforce development, infrastructure and equipment, and surveillance systems. Geographically, the study considers national-level patterns while recognizing significant sub-national variation across Nigeria's six geopolitical zones and 36 states.

The significance of this study extends across multiple domains. For policymakers, the findings provide evidence to inform resource allocation, policy reform, and program design. For health system managers, the analysis identifies practical intervention points for strengthening infection control capacity. For researchers, the study synthesizes available evidence and identifies knowledge gaps requiring further investigation. For international partners and development organizations, the findings offer insights for aligning support with priority needs and ensuring effective utilization of resources. Ultimately, this study aims to contribute to the goal of building a resilient Nigerian health system capable of protecting population health and supporting national development.

2. Overview of Microbial Infection Burden and Systemic Drivers in Nigeria

2.1 Burden of Microbial Infections in Nigeria

The burden of microbial infections in Nigeria reflects the country's position within the global infectious disease landscape while exhibiting characteristics shaped by local ecological, social, and health system factors. Comprehensive epidemiological data, while incomplete, reveal patterns of high endemicity for multiple infections, seasonal variations, and significant geospatial heterogeneity.

Systematic reviews provide the most robust estimates for specific pathogens. The meta-analysis of Campylobacter species infections covering 2002 to 2023, incorporating 40 studies, documented an overall pooled prevalence of 33% (95% CI: 25% - 41%) across human and animal populations (Systematic review and meta-analysis of Campylobacter species infections, 2025). Within human populations, prevalence varied by clinical status: 20.3% in healthy individuals, 23.8% in diarrheic patients, and 34.2% in HIV patients, demonstrating the interaction between HIV-related immunosuppression and susceptibility to enteric infections (Systematic review and meta-analysis of Campylobacter species infections, 2025). Geospatial analysis revealed the North-West geopolitical zone as having the highest prevalence at 40% (95% CI: 23% - 57%), followed by the South-West at 33.1%, indicating substantial regional variation in infection risk.

The high infectious disease burden in Nigeria necessitates widespread antibiotic use, which in turn drives antimicrobial resistance. Alabi et al. (2025) noted that the WHO estimated in 2020 that Nigeria accounted for approximately 25% of global cumulative malaria cases, while millions suffered from other preventable infections including typhoid fever and pneumonia. This burden translates to high volumes of antibiotic prescriptions, often without appropriate diagnostic support or evidence-based treatment protocols. Local data on susceptibility patterns for Escherichia coli and Staphylococcus aureus have exhibited disturbingly high resistance rates to commonly used antibiotics, rendering standard treatments less effective (Alabi et al., 2025).

Waterborne and foodborne infections constitute a substantial proportion of the infectious disease burden, particularly among children and vulnerable populations. Research in the Benue South Senatorial District identified high prevalence of rotavirus and diarrheagenic Escherichia coli pathotypes, with molecular characterization revealing notable diversity among circulating strains (Molecular Epidemiology of Acute Diarrheal Diseases, 2025). The association between poor WASH conditions and pathogen occurrence underscores the environmental determinants of these infections and the limitations of clinical interventions alone in reducing disease burden.

2.2 Emerging and Re-Emerging Infectious Diseases

The landscape of infectious diseases in Nigeria is not static but characterized by emergence of novel pathogens and re-emergence of previously controlled infections. This dynamic reflects complex interactions among ecological change, population mobility, health system performance, and pathogen evolution.

The COVID-19 pandemic exemplified the challenge of emerging infectious diseases and their potential to disrupt health systems. Beyond the direct morbidity and mortality caused by SARS-CoV-2, the pandemic precipitated cascading effects on routine health services, including immunization programs. These disruptions contributed to the resurgence of vaccine-preventable diseases, most notably the large diphtheria outbreak in Kano State that accounted for 85% of Nigeria's documented cases (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). The outbreak, with its bimodal distribution peaking in August 2023 and early 2024, demonstrated how health system shocks can reverse years of progress in disease control.

Zoonotic emerging infections represent a particular concern given Nigeria's large livestock populations, human-animal interface, and environmental conditions favoring pathogen transmission. Campylobacter species, while not novel, exhibit characteristics of emerging pathogens through changing epidemiology, antimicrobial resistance patterns, and increasing recognition of their public health significance. The thermal preference of Campylobacter species, particularly C. jejuni and C. coli, which grow optimally at 42°C coinciding with avian body temperature, explains their higher incidence in poultry and increased prevalence in tropical and subtropical regions where environmental conditions favor survival and transmission (Systematic review and meta-analysis of Campylobacter species infections, 2025).

Environmental factors including climate, urbanization, and land use change influence the emergence and re-emergence of infectious diseases. Nigeria's mean annual precipitation of 1165 mm, with southern regions experiencing heavy rainfall exceeding 2000 mm and ambient temperatures ranging from 18°C to 48°C depending on season and region, creates conditions conducive to pathogen survival and transmission (Systematic review and meta-analysis of Campylobacter species infections, 2025). Subsistence and medium-scale production of food-producing animals reared under extensive and semi-extensive management systems, combined with suboptimal meat processing practices widely practiced in rural settings, enhance the spread of zoonotic pathogens.

2.3 Antimicrobial Resistance and Health System Strain

Antimicrobial resistance represents one of the most significant threats to global public health, with particularly acute implications for health systems in low- and middle-income countries. In Nigeria, AMR has emerged as a critical challenge affecting humans, animals, and the environment, with consequences that cascade through the health system and broader economy.

The prevalence of antimicrobial resistance in Nigeria is alarmingly high across multiple pathogens and clinical settings. A comprehensive review documented 67.8% methicillin-resistant Staphylococcus aureus (MRSA) in tertiary hospitals and 28.6% carbapenem resistance in Enterobacterales (Antimicrobial resistance in Nigeria's healthcare system, 2025).

These resistance rates render standard empirical antibiotic regimens ineffective, prolonging illness, increasing mortality, and driving up healthcare costs. The economic impact is substantial, with AMR estimated to cost 2.4% of Nigeria's GDP and resistant infections requiring 287% higher treatment expenditures compared to susceptible infections (Alabi et al., 2025).

The drivers of antimicrobial resistance in Nigeria are multiple and interconnected, operating across human medicine, animal agriculture, and environmental sectors. Poor regulation of antimicrobial agents enables widespread availability without prescription, with 72.4% of pharmacies selling antibiotics without prescriptions (Antimicrobial resistance in Nigeria's healthcare system, 2025). Improper empirical prescriptions by healthcare providers, many of whom lack adequate training in antimicrobial stewardship, contribute to inappropriate use. Inadequate infection prevention and control practices in healthcare facilities facilitate the spread of resistant pathogens, particularly in settings with high burdens of nosocomial infections.

Antibiotic use in food-producing animals constitutes a major driver of resistance with implications for human health through foodborne transmission and environmental contamination. Arbitrary and prophylactic use of antibiotics in livestock is widespread, with 87.4% of poultry farms using antibiotics heavily (Alabi et al., 2025). Environmental contamination with antibiotics and resistant organisms from agricultural operations, healthcare facilities, and pharmaceutical manufacturing creates reservoirs of resistance that perpetuate the problem across ecological compartments.

The health system strain attributable to AMR manifests through multiple pathways. Longer hospital stays, need for second-line and third-line antibiotics, increased diagnostic requirements, and higher treatment failure rates all consume scarce health system resources. The limited availability of microbiology laboratory capacity—only 23.4% of secondary facilities have functional laboratories—means that resistance often goes undetected, leading to continued use of ineffective antibiotics and poor patient outcomes (Antimicrobial resistance in Nigeria's healthcare system, 2025).

2.4 Climate, Urbanization and Disease Dynamics

Environmental and demographic factors fundamentally shape the epidemiology of microbial infections in Nigeria. Climate patterns, urbanization trends, and population mobility interact with biological and social determinants to create dynamic disease transmission patterns that challenge static public health approaches.

Nigeria's climate, ranging from tropical in the south to arid in the north, with marked wet and dry seasons, influences the seasonality, geographic distribution, and intensity of infectious disease transmission. The southern regions experience heavy rainfall from May to October, typically exceeding 2000 mm annually and reaching up to 4000 mm in the Niger Delta (Systematic review and meta-analysis of Campylobacter species infections, 2025). These conditions favor waterborne pathogen transmission, create breeding sites for vector mosquitoes, and influence the survival of pathogens in the environment. Temperature variations, with ranges from 18°C to 37°C during the rainy season and 25°C to 48°C during the dry season, affect pathogen replication rates, vector biology, and human exposure patterns.

Urbanization, occurring at a rapid pace across Nigeria, creates conditions that can either amplify or mitigate infectious disease transmission depending on accompanying infrastructure development. Rapid, unplanned urban growth often outpaces provision of water supply, sanitation, and housing, creating environments conducive to pathogen transmission. Conversely, well-planned urbanization with adequate infrastructure can reduce transmission by improving access to clean water, sanitation, and healthcare. The concentration of tertiary healthcare facilities in major urban centers, while potentially improving access for urban populations, exacerbates rural-urban disparities and may encourage care-seeking patterns that bypass lower levels of care (World Health Organization, 2025b).

Population mobility, both within Nigeria and across borders, facilitates the spread of infectious pathogens and complicates disease control efforts. Kano State, as a major commercial hub for northern Nigeria and neighboring countries including Niger, Chad, Cameroon, and the Central African Republic, experiences substantial population movement that can introduce and disseminate infectious agents (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). The diphtheria outbreak in Kano, with cases referred from various states and neighboring countries, illustrates how mobility can transform local outbreaks into regional epidemics.

2.5 Theoretical Framework

This study is grounded in several complementary theoretical frameworks that together provide a comprehensive lens for understanding the relationship between microbial infections and public health system development in Nigeria.

The Health System Building Blocks framework, developed by the World Health Organization, conceptualizes health systems as comprising six core components: service delivery, health workforce, health information systems, access to essential medicines, financing, and leadership/governance. This framework enables systematic analysis of health system strengths and weaknesses relevant to infection control. In the Nigerian context, this framework illuminates how deficits across multiple building blocks such as workforce shortages, infrastructure dysfunction, and financing constraints, interact to undermine system performance (World Health Organization, 2025b).

The One Health framework provides an essential lens for understanding zoonotic infections and antimicrobial resistance, which by their nature transcend human health boundaries. This framework emphasizes the interconnectedness of human, animal, and environmental health and the necessity of collaborative, transdisciplinary approaches to disease control (Alabi *et al*., 2025). The high prevalence of Campylobacter infections across human and animal populations in Nigeria, with transmission pathways involving food animals,

environmental contamination, and human exposure, exemplifies the need for One Health approaches that address the full spectrum of determinants and intervention points (Systematic review and meta-analysis of Campylobacter species infections, 2025).

The Universal Health Coverage framework focuses on ensuring that all people have access to needed health services without financial hardship. This framework highlights the dual goals of expanding service coverage and ensuring financial protection. In Nigeria, where out-of-pocket spending constitutes 71% of health expenditures and pushes millions into poverty, the UHC framework illuminates how financial barriers to care exacerbate the consequences of microbial infections (Antimicrobial resistance in Nigeria's healthcare system, 2025). The Basic Health Care Provision Fund and health insurance expansion efforts represent applications of this framework to address coverage gaps.

The Political Economy of Health framework examines how power, interests, and institutions shape health policy and system development. This framework helps explain why evidence-based policies often fail to translate into effective implementation, why resources may not flow to priority areas, and how competing interests influence health system outcomes. The fragmented implementation of Nigeria's National Action Plan for Antimicrobial Resistance, with only 45% of activities implemented by 2021 despite launch in 2017, reflects political economy factors including funding constraints, competing priorities, and coordination challenges (Alabi *et al*., 2025).

Together, these frameworks provide analytical tools for examining the multiple dimensions of microbial infections and health system development. The Health System Building Blocks framework enables systematic assessment of system capacity, the One Health framework captures intersectoral dimensions, the UHC framework focuses on coverage and financial protection, and the Political Economy framework explains implementation gaps and policy failures.

3. Developmental Challenges in Nigerian Public Health Systems

3.1 Health Infrastructure and Resource Constraints

The physical infrastructure underpinning Nigeria's public health system is critically compromised, with approximately 80% of public health facilities reported as dysfunctional (World Health Organization, 2025a). This widespread dysfunction impedes the country's ability to provide healthcare to its citizens and contributes to estimated annual losses of about US$1 billion through outbound health tourism, as Nigerians seek care in other countries when domestic facilities fail to meet their needs.

The infrastructure deficit manifests across multiple dimensions. Physical structures in many primary healthcare centers are dilapidated, lacking reliable electricity, clean water, and basic sanitation. The Power for Health Initiative, launched to provide reliable electricity in hospitals, acknowledges that energy poverty has long constrained healthcare delivery, limiting the ability to power essential equipment, maintain vaccine cold chains, and provide nighttime services (Federal Ministry of Health and Social Welfare, 2025a). Water supply deficiencies compromise infection prevention and control, undermining basic hand hygiene and sterilization capacity.

Equipment shortages compound facility deficits, limiting diagnostic and treatment capabilities. While development partners have filled some gaps through disease-specific programs, providing laboratory consumables for malaria, HIV/AIDS, and tuberculosis this fragmented approach creates inequities and fails to build sustainable systems (World Health Organization, 2025a). Facilities may have equipment for priority diseases but lack capacity for routine diagnostic needs. Equipment maintenance presents additional challenges, with insufficient funds, absence of maintenance plans, and inadequately trained personnel exacerbating the poor state of equipment nationwide.

The distribution of healthcare facilities is markedly uneven, reflecting historical patterns of investment and political priorities. Tertiary health facilities are concentrated in major urban centers and more developed regions, leaving rural and less developed areas underserved (World Health Organization, 2025b). This geographic maldistribution forces patients to travel long distances for care, incurring transportation costs and lost time that create additional barriers to access. The referral system, designed to move patients from primary to secondary to tertiary care as needed, is suboptimal, with many patients bypassing lower levels to access higher-level facilities directly. Private health care providers deliver an estimated 70% of health care services in Nigeria, filling gaps left by inadequate public provision (Antimicrobial resistance in Nigeria's healthcare system, 2025). However, the regulation and monitoring of the private sector by government is weak, and enforcement of standards and compliance is limited. This regulatory gap creates quality concerns, variable infection control practices, and potential for inappropriate antibiotic use that contributes to antimicrobial resistance.

3.2 Workforce Shortages and Capacity Gaps

Human resources for health constitute the foundation of any functioning health system, yet Nigeria faces critical shortages and maldistribution of health workers that severely constrain its capacity to address microbial infections. The doctor-to-population ratio stands at 1:5,000, far below the WHO standard of 1:600, and similar shortages affect nurses, community health workers, and laboratory personnel (Antimicrobial resistance in Nigeria's healthcare system, 2025).

The workforce crisis extends beyond absolute numbers to encompass distribution, skill mix, and quality. Most health workers remain concentrated in urban areas, leaving rural communities with severely limited access to care (World Health Organization, 2025b). This urban concentration reflects multiple factors including better living conditions, greater professional opportunities, access to continuing education, and availability of amenities. Rural posts often remain unfilled despite nominal establishment of positions, and absenteeism further reduces effective workforce availability in facilities that are staffed on paper.

Training capacity and quality present additional challenges. While between 2023 and early 2025, over 37,000 health workers have been employed and over 70,000 have received on-the-job training (Federal Ministry of Health and Social Welfare, 2025a), these numbers must be viewed against the scale of need. Many health workers lack adequate training in infection prevention and control, antimicrobial stewardship, and outbreak investigation. A cross-sectional study by Fadare et al. cited in Antimicrobial resistance in Nigeria's healthcare system (2025) showed that although healthcare providers were aware of the problem of AMR, they often had inadequate knowledge of effective management strategies. This knowledge-practice gap leads to inappropriate empirical antibiotic therapies that do not consider local resistance patterns, further solidifying the cycle of resistance.

Health worker migration, often termed "brain drain," represents a significant drain on Nigeria's health workforce investment. Push factors including poor remuneration, difficult working conditions, limited career progression, and security concerns drive emigration to high-income countries. The government has articulated a strategy to transform "brain drain" into "brain gain" through diaspora engagement and retention incentives (Federal Ministry of Health and Social Welfare, 2025a), but the scale of ongoing migration suggests these efforts have yet to achieve transformative impact.

Community health workers, who form the backbone of primary healthcare delivery in many rural areas, face particular challenges including low remuneration, limited supervision, inadequate supplies, and weak linkages to the formal health system. Strong community-level structures exist in many areas but have not translated into scaled-up delivery of essential health services at the primary health level (World Health Organization, 2025b). This gap between community presence and service delivery represents a missed opportunity for improving access and outcomes.

3.3 Disease Surveillance and Reporting Systems

Effective disease surveillance is essential for detecting outbreaks, monitoring trends, evaluating interventions, and guiding resource allocation. Nigeria has made significant investments in surveillance systems, most notably through the Surveillance Outbreak Response Management and Analysis System (SORMAS), an open-source mobile health platform designed to streamline infectious disease control, outbreak management, and disease surveillance activities across all levels of the public health system (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025).

SORMAS represents a substantial advancement in surveillance capacity. The platform features specialized interfaces for 12 user roles, including laboratorians, contact tracing officers, and epidemiologists, and includes disease-specific process modules for 12 epidemic-prone diseases, along with a customizable module for emerging diseases (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Operating primarily on mobile devices like smartphones and tablets, the system synchronizes bidirectionally with a central server via mobile telecommunication networks, ensuring real-time data flow and coordination across public health stakeholders.

The diphtheria outbreak response in Kano demonstrated both the potential and limitations of current surveillance systems. Data were collected using a validated tool adopted from the Nigeria Centre for Disease Control and Prevention through the SORMAS platform, enabling systematic tracking of 18,320 cases (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). However, challenges in sample collection and laboratory confirmation were evident, with samples often not collected due to non-availability of collection instruments and consumables. This gap between case detection and laboratory confirmation limits the ability to verify diagnoses, characterize pathogens, and inform treatment decisions.

Laboratory capacity constraints fundamentally limit surveillance system effectiveness. Only 23.4% of secondary healthcare facilities have microbiology laboratories (Antimicrobial resistance in Nigeria's healthcare system, 2025), meaning that most suspected infections are managed without microbiological confirmation. Even where laboratories exist, shortages of reagents, consumables, trained personnel, and quality assurance systems compromise reliability. External quality assessment programs, while existing, have limited reach and participation.

Data utilization for decision-making represents a persistent challenge. While SORMAS enables data collection and reporting, the translation of data into policy action, resource allocation, and program adjustment remains weak. Surveillance data may reveal outbreaks, resistance patterns, or coverage gaps without triggering timely responses. The integration of surveillance data across diseases, programs, and levels of government is limited, hindering the ability to identify syndemic interactions and allocate resources efficiently.

3.4 Health Financing and Policy Limitations

Health financing in Nigeria is characterized by low public investment, high out-of-pocket expenditure, and inefficient resource utilization, all of which constrain the health system's capacity to address microbial infections. Despite the Abuja Declaration commitment to allocate 15% of national budgets to health, health expenditure remains at approximately 5.2% of GDP (Antimicrobial resistance in Nigeria's healthcare system, 2025). This underinvestment perpetuates infrastructure deficits, workforce shortages, and service delivery gaps.

Out-of-pocket spending constitutes 71% of health expenditures, creating substantial financial barriers to care (Antimicrobial resistance in Nigeria's healthcare system, 2025). For microbial infections, this means that individuals may delay seeking care until illness becomes severe, may not complete treatment courses due to cost, or may face catastrophic expenditures that push households into poverty. The economic impact of out-of-pocket spending extends beyond individual households to affect community economic productivity and national development.

The Basic Health Care Provision Fund (BHCPF) was established to expand coverage and improve service delivery, representing an innovative financing mechanism designed to channel resources to primary healthcare. The fund has shown improved performance, with absorption rates reaching 78% in

2023 compared to 45% in 2019 (Federal Ministry of Health and Social Welfare, 2025a). However, the overall level of investment remains too low to maintain functionality across the approximately 30,000 primary healthcare centers nationwide (World Health Organization, 2025b). The BHCPF offers a predictable funding window for infrastructure, equipment, and emergency ambulance services, but resource gaps persist.

Policy implementation gaps represent a recurring challenge. Nigeria launched a National Action Plan for Antimicrobial Resistance in 2017, yet by 2021 only 45% of planned activities had been implemented due to funding constraints and competing health priorities (Alabi et al., 2025). This pattern—ambitious policy formulation followed by incomplete implementation—reflects broader governance challenges including weak institutional capacity, limited accountability mechanisms, and political economy factors that divert resources and attention from priority areas.

The recent Nigeria-United States Memorandum of Understanding, signed in December 2025, represents a significant development in health financing. The agreement provides for nearly US$2 billion in US grant funding over five years, matched by a Nigerian commitment to allocate at least 6% of executed annual Federal and State budgets to health, projected to mobilize nearly US$3 billion in domestic financing (Federal Ministry of Health and Social Welfare, 2025b). This agreement reflects a strategic shift toward sustainable, trade- and investment-based partnerships, with Nigeria progressively increasing domestic health financing while external grant support is gradually reduced.

3.5 Rural–Urban Disparities in Healthcare Access

Disparities in healthcare access between rural and urban populations in Nigeria are profound and multifaceted, reflecting the broader patterns of geographic inequity that characterize the country's development. These disparities have direct implications for microbial infection outcomes, as rural populations face greater exposure to pathogens and more limited access to preventive and curative services.

The geographic distribution of health facilities systematically favors urban areas. Tertiary health care facilities are concentrated in major urban centers and more developed regions, with rural areas reliant on primary health centers that are often non-functional or poorly equipped (World Health Organization, 2025b). Specialist services are confined primarily to urban areas, meaning that rural residents requiring specialized care must travel long distances, incurring transportation costs and time away from productive activities. Emergency medical services are particularly limited in rural areas, with many communities lacking ambulance services and prehospital care (World Health Organization, 2025b).

Health workforce distribution mirrors facility distribution, with most doctors, nurses, and specialists concentrated in urban areas. Rural health facilities struggle to attract and retain qualified staff due to difficult living conditions, limited professional opportunities, and lack of amenities. The doctor-to-population ratio of 1:5,000 nationally obscures much worse ratios in rural areas, where communities may have no doctors at all (Antimicrobial resistance in Nigeria's healthcare system, 2025). This workforce gap means that rural residents with microbial infections are more likely to be seen by less trained providers, receive care later in the disease course, or forego formal care entirely.

Infrastructure deficits are more severe in rural areas, compounding access barriers. While urban facilities may struggle with unreliable electricity and water, rural facilities are more likely to lack these services entirely. The absence of reliable electricity compromises vaccine cold chains, limits nighttime service availability, and prevents use of essential diagnostic equipment. Water shortages undermine basic infection prevention and control, including hand hygiene and sterilization.

Socioeconomic factors intersect with geographic disparities to compound disadvantage for rural populations. Rural residents have lower average incomes, limiting ability to pay for transportation, user fees, and medicines. Educational levels are lower, affecting health literacy and care-seeking behavior. Traditional beliefs and practices may influence health-seeking, with many rural residents consulting traditional healers before or instead of formal health services. The coexistence of traditional and contemporary medicine poses possible risks, emphasizing the necessity of regulating and incorporating traditional medicine practices into the health care system (World Health Organization, 2025b).

The consequences of rural-urban disparities for microbial infection outcomes are predictable and documented. Rural populations experience higher rates of vaccine-preventable diseases due to lower immunization coverage. Outbreaks may spread further before detection due to weaker surveillance. Treatment delays result in more severe disease and higher mortality. The diphtheria outbreak, while centered in Kano State, affected rural areas within the state and neighboring regions, where access to treatment centers was more limited (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025).

4. Impact of Microbial Infections on Public Health Development

4.1 Disease Burden and Healthcare Expenditure

The burden of microbial infections in Nigeria imposes substantial direct and indirect costs on the health system, households, and the broader economy. These costs manifest through healthcare expenditures, productivity losses, and foregone development opportunities, creating a vicious cycle wherein disease burden undermines the resources needed for health system strengthening.

Healthcare expenditure attributable to infectious diseases consumes a significant portion of total health spending. The treatment of malaria, tuberculosis, HIV/AIDS, respiratory infections, and diarrheal diseases accounts for a large share of outpatient visits, hospital admissions, and pharmaceutical consumption. Antimicrobial resistance substantially increases these costs, with resistant infections requiring 287% higher treatment expenditures compared to susceptible infections (Alabi *et al*., 2025). The need for second-line and third-line

antibiotics, longer hospital stays, and additional diagnostic testing drives up costs for both health facilities and patients.
Out-of-pocket spending on infectious disease treatment imposes financial hardship on households, particularly the poor. With 71% of health expenditures paid directly by households at the point of service (Antimicrobial resistance in Nigeria's healthcare system, 2025), a single episode of serious infection can push families into poverty or trap them in debt. The costs include not only direct medical expenses for consultation, diagnostics, and medicines, but also transportation, accommodation for caregivers, and lost income during illness and caregiving. These financial shocks have long-term consequences for household welfare and economic productivity.

The macroeconomic impact of infectious diseases operates through multiple channels. Premature mortality removes individuals from the workforce during their most productive years. Morbidity reduces productivity through absenteeism and presenteeism (working while ill with reduced capacity). Caregiving responsibilities, disproportionately borne by women, divert labor from other productive activities. The cumulative effect of these losses is estimated in the billions of dollars annually, with antimicrobial resistance alone costing an estimated 2.4% of Nigeria's GDP (Alabi *et al*., 2025).

Health system resources devoted to infectious disease treatment represent opportunity costs—resources that could otherwise be invested in prevention, health system strengthening, or non-communicable disease care. The concentration of resources on treating preventable infections reflects a reactive rather than proactive orientation, perpetuating the cycle of disease and expenditure. The Basic Health Care Provision Fund, while increasing resources for primary care, remains insufficient to shift this balance toward prevention (Federal Ministry of Health and Social Welfare, 2025a).

4.2 Impact on Maternal and Child Health

Maternal and child health outcomes in Nigeria reflect the profound impact of microbial infections on vulnerable populations. Despite progress reflected in recent Demographic and Health Survey data—maternal mortality ratio declining from 576 to 512 per 100,000 live births and under-five mortality from 132 to 110 per 1,000 live births (Federal Ministry of Health and Social Welfare, 2025a)—infectious diseases continue to exact a heavy toll on women and children. Children under five years are disproportionately affected by microbial infections due to developing immune systems, nutritional status, and exposure patterns. A 2021 systematic review reported that in low- and middle-income countries, the incidence of Campylobacter-associated diarrhoea in children under five was 9,729 per 100,000 person-years compared to 1,340 per 100,000 in children aged five to fifteen years (Systematic review and meta-analysis of Campylobacter species infections, 2025). This heightened vulnerability translates to substantial morbidity and mortality, with diarrheal diseases remaining a leading cause of death among Nigerian children.

The interaction between malnutrition and infection creates particular vulnerability for children. Malnutrition compromises immune function, increasing susceptibility to infections and severity of illness. Infections, in turn, worsen nutritional status through reduced intake, malabsorption, and metabolic demands. This vicious cycle contributes to the high burden of stunting, wasting, and underweight among Nigerian children, with long-term consequences for cognitive development, educational attainment, and adult productivity.

Maternal infections affect both women's health and pregnancy outcomes. Malaria in pregnancy contributes to maternal anemia, low birth weight, and perinatal mortality. HIV infection, with 1.78 million people living with HIV now on antiretroviral therapy and 96% of HIV-positive pregnant women receiving prevention of mother-to-child transmission services (Federal Ministry of Health and Social Welfare, 2025a), has been addressed through substantial programmatic investment. However, gaps remain in coverage and quality, and other maternal infections receive less attention.

Immunization represents one of the most cost-effective interventions for protecting child health, yet coverage remains suboptimal. Full immunization coverage has increased to 39%, and Penta-3 coverage to 57% (Federal Ministry of Health and Social Welfare, 2025a). However, these rates leave substantial numbers of children unprotected, creating vulnerability to outbreaks. The diphtheria outbreak demonstrated the consequences of immunization gaps, with unvaccinated children facing more than double the likelihood of death compared to fully vaccinated children (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025).

4.3 Outbreak Management Challenges

The management of infectious disease outbreaks in Nigeria reveals both capabilities and persistent challenges in the public health system. Recent experiences with COVID-19, diphtheria, and other outbreaks have tested system capacity and illuminated areas requiring strengthening.

The COVID-19 pandemic posed unprecedented challenges, disrupting health services including immunization programs and contributing to the resurgence of vaccine-preventable diseases (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Lockdowns and structural disruption of health systems led to decline in vaccination activities, creating conditions for outbreaks of diseases such as diphtheria, measles, and polio. The pandemic demonstrated how emerging infectious diseases can have cascading effects on control of other infections, amplifying existing vulnerabilities.

The diphtheria outbreak in Kano State, with 18,320 cases between February 2022 and April 2024, illustrated outbreak management challenges in resource-constrained settings (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Despite availability of effective vaccines and treatment protocols, the outbreak spread widely due to immunization gaps, delayed detection, and limited response capacity. The case fatality rate of 4.5%, while lower than some historical outbreaks, represented hundreds of preventable deaths. The finding that unvaccinated individuals had more than double the likelihood of death underscores the critical importance of maintaining high immunization coverage.

Laboratory confirmation during outbreaks faces persistent constraints. In the diphtheria response, samples often could not be collected due to non-availability of collection instruments and consumables (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Even when collected, transportation to referral laboratories with appropriate cold chain and timely processing presented challenges. These laboratory gaps limit the ability to confirm cases, characterize pathogens, and guide treatment decisions, compromising both individual care and outbreak control.

Coordination across levels of government and with partners presents ongoing challenges. While platforms like the Surveillance Outbreak Response Management and Analysis System facilitate data sharing, the translation of information into coordinated action requires functional relationships, clear protocols, and adequate resources at all levels. The Nigeria Health Sector-Wide Joint Annual Review provides a mechanism for reviewing performance and aligning actions, but implementation gaps persist between national coordination and local response (Federal Ministry of Health and Social Welfare, 2025a).

4.4 Public Health Emergency Preparedness

Public health emergency preparedness in Nigeria has received increased attention following the COVID-19 pandemic and recent outbreaks, yet significant gaps remain in the capacity to prevent, detect, and respond to health emergencies. The Nigeria Centre for Disease Control and Prevention provides leadership for emergency preparedness and response, but its reach and resources remain limited relative to the scale of need.

Surveillance systems for early detection of outbreaks have been strengthened through platforms such as SORMAS, which enables real-time data collection and reporting across levels of the health system (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). However, surveillance effectiveness depends on the ability to detect unusual events at the community level, report them through the system, and trigger timely investigation and response. Gaps at any point in this chain—and particularly at the community-facility interface—can delay detection and allow outbreaks to spread.

Laboratory capacity for emergency response is limited by the small number of functional laboratories, shortages of trained personnel, and supply chain constraints. Development partners have filled some gaps by providing laboratory consumables and diagnostic kits for priority diseases (World Health Organization, 2025a), but this external dependence creates vulnerability to supply disruptions and may not be sustainable. The concentration of laboratory capacity in urban areas leaves rural communities reliant on sample transport systems that may be slow or unreliable.

Emergency response coordination mechanisms have been tested by recent outbreaks, with mixed results. The diphtheria response involved multiple stakeholders including federal and state health ministries, NCDC, development partners, and treatment centers (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). While coordination structures existed, implementation revealed challenges in resource mobilization, role clarity, and accountability. The establishment of treatment centers across all 44 local government areas of Kano State demonstrated capacity for rapid scale-up, but gaps in supplies, staffing, and referral systems limited effectiveness.

The Basic Health Care Provision Fund includes provisions for emergency ambulance services, but many communities lack access to prehospital care and emergency transport (World Health Organization, 2025b). This gap means that seriously ill patients, including those with severe infections, may reach facilities too late for effective treatment. Hospital units are often ill-equipped to resuscitate critically ill patients, further compromising outcomes.

4.5 Case Studies of Major Infectious Disease Outbreaks in Nigeria

Case Study 1: The Kano Diphtheria Outbreak (2022-2024)

The diphtheria outbreak in Kano State represents the largest diphtheria epidemic reported from sub-Saharan Africa in recent decades (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Beginning in February 2022 and continuing through April 2024, the outbreak affected 18,320 individuals, accounting for approximately 85% of Nigeria's documented cases. The outbreak exhibited a bimodal distribution, with a primary peak in August 2023 followed by a smaller secondary peak in early 2024.

The epidemiological characteristics of the outbreak reflected underlying immunization gaps. Patients who were not vaccinated had more than double the likelihood of death compared to fully vaccinated individuals (adjusted odds ratio 2.45), and those without vaccination documentation had an 87% increase in mortality risk (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). These findings underscore the protective effect of vaccination and the consequences of coverage gaps.

The outbreak was precipitated by COVID-19 pandemic disruptions to routine immunization services, which led to decline in vaccination coverage and accumulation of susceptible individuals. Nigeria's socioeconomic context—marked by poverty, inadequate sanitation, and limited healthcare access—weakened population health and increased susceptibility (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). The concentration of cases in Kano, a state with among the lowest vaccination uptake in the country, reflects the geographic heterogeneity of immunization coverage and outbreak risk.

Response efforts involved establishment of treatment centers across all 44 local government areas, use of SORMAS for case management and surveillance, and coordination among multiple stakeholders (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). However, challenges in laboratory confirmation, supply availability, and resource mobilization limited response effectiveness. The case fatality rate of 4.5%, while lower than the 21.4% observed in a 2011 outbreak in Borno State, still represented substantial preventable mortality.

Case Study 2: Campylobacter Infections across Nigeria (2002-2023)

A systematic review and meta-analysis of Campylobacter species infections in Nigeria over two decades provides insights into the epidemiology of this major foodborne pathogen (Systematic review and meta-analysis of Campylobacter species infections, 2025). The analysis of 40 studies revealed an overall pooled prevalence of 33%, with significant variation by host species, clinical status, and geographic location.

The host-specific prevalence patterns have important implications for transmission and control. Poultry exhibited the highest prevalence at 42%, reflecting the thermal adaptation of Campylobacter to avian body temperature and intensive production systems (Systematic review and meta-analysis of Campylobacter species infections, 2025). Human prevalence was 30%, with variation by clinical status: 20.3% in healthy individuals, 23.8% in diarrheic patients, and 34.2% in HIV patients. Cattle prevalence was 21%. These patterns indicate multiple transmission pathways and the importance of food safety interventions.

Geospatial analysis revealed the North-West geopolitical zone as having the highest prevalence at 40%, followed by the South-West at 33.1% (Systematic review and meta-analysis of Campylobacter species infections, 2025). This geographic variation likely reflects differences in livestock production systems, food handling practices, environmental conditions, and surveillance intensity. Temporal analysis indicated that infections peaked for all three hosts between 2016 and 2020, suggesting common drivers or increased detection during this period.

The predominance of different Campylobacter species in different hosts—C. coli predominant in humans (87.5%) and cattle (38.1%), while C. jejuni prevalent in poultry (76.2%)—indicates species-specific transmission dynamics (Systematic review and meta-analysis of Campylobacter species infections, 2025). These findings have implications for source attribution and intervention targeting, suggesting that control measures should address both poultry-associated and cattle-associated transmission pathways.

The meta-analysis concluded by recommending adoption of a One Health control approach, including the "farm to fork" principle of food safety throughout livestock production and processing value chains (Systematic review and meta-analysis of Campylobacter species infections, 2025). This recommendation reflects recognition that effective Campylobacter control requires interventions across human, animal, and environmental health sectors.

5. Strategies for Strengthening Public Health Systems

5.1 Health System Reforms and Capacity Building

Strengthening Nigeria's public health system to address microbial infections requires comprehensive reforms that address structural weaknesses while building sustainable capacity for prevention, detection, and response. The Nigeria Health Sector Renewal Investment Initiative (NHSRII), launched in 2023, represents a coordinated effort to improve healthcare accessibility, affordability, quality, accountability, and efficiency through a Sector-Wide Approach (SWAp) that aligns federal, state, and local governments, development partners, civil society, and the private sector under a unified national plan, budget, and reporting framework (Federal Ministry of Health and Social Welfare, 2025a).

Primary healthcare revitalization stands at the center of health system strengthening efforts. With over 30,000 primary healthcare centers across the country, ensuring their functionality is essential for universal health coverage and infection control. Recent reforms allocate resources through the Basic Health Care Provision Fund to support one functional PHC center per ward and one general hospital per local government area (Federal Ministry of Health and Social Welfare, 2025a). However, funding limitations, infrastructure constraints, cultural barriers, and logistical difficulties continue to constrain implementation (World Health Organization, 2025b). Sustained investment and accountability mechanisms are needed to translate these reforms into improved service delivery.

Health workforce development requires attention to quantity, distribution, skills, and retention. Between 2023 and early 2025, over 37,000 health workers have been employed and over 70,000 have received on-the-job training (Federal Ministry of Health and Social Welfare, 2025a). The Health Workforce Registry has been established to address staffing imbalances and migration, while diaspora engagement initiatives aim to transform "brain drain" into "brain gain" (Federal Ministry of Health and Social Welfare, 2025a). However, the scale of need remains substantial, with the doctor-to-population ratio still far below WHO standards and rural areas severely underserved.

Infrastructure and equipment rehabilitation is essential for creating an enabling environment for infection control. The Power for Health Initiative aims to provide reliable electricity in hospitals, addressing a fundamental constraint on service delivery (Federal Ministry of Health and Social Welfare, 2025a). The Nigeria Digital Health Initiative (NDHI) seeks to strengthen data management, enabling better surveillance, monitoring, and evaluation. Supply chain transparency initiatives aim to ensure availability of essential medicines, diagnostics, and commodities. These cross-cutting investments create conditions for effective infection control at all levels of the health system.

5.2 Strengthening Surveillance and Laboratory Systems

Effective surveillance and laboratory systems are foundational for detecting, monitoring, and responding to microbial infections. Nigeria has made significant investments in these systems, but gaps remain in coverage, quality, and integration that limit their effectiveness.

The Surveillance Outbreak Response Management and Analysis System (SORMAS) represents a significant advancement in surveillance capacity, enabling real-time data collection, reporting, and coordination across levels of the health system (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Building on this platform, further investments should focus on expanding coverage to all health facilities, ensuring reliable connectivity and device availability,

training users at all levels, and strengthening data utilization for decision-making. Integration of SORMAS with electronic health records, laboratory information systems, and other data sources would create a more comprehensive picture of disease trends and health system performance.

Laboratory system strengthening requires investment in infrastructure, equipment, supplies, personnel, and quality assurance. The current reality—only 23.4% of secondary facilities having microbiology laboratories (Antimicrobial resistance in Nigeria's healthcare system, 2025)—means that most infections are diagnosed clinically without microbiological confirmation. Expanding laboratory capacity should prioritize primary healthcare and district hospital levels, where most patients first seek care. Point-of-care diagnostics can extend laboratory services to facilities without full laboratory infrastructure, enabling timely diagnosis and appropriate treatment.

Networking and referral systems for laboratory services can optimize resource use while ensuring access. The four referral laboratories established in Kano State during the diphtheria outbreak demonstrated the feasibility of centralized testing with sample transport systems (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025). Strengthening such networks nationally, with clear protocols for sample collection, transport, testing, and results reporting, would expand access to laboratory services while concentrating specialized testing capacity.

External quality assurance programs are essential for ensuring reliability of laboratory results. Participation in programs such as those offered by WHO and other partners helps laboratories identify and correct performance issues (World Health Organization, 2025a). However, coverage of these programs remains limited, and many laboratories operate without external quality assessment. Expanding participation and ensuring corrective actions are implemented would improve laboratory quality.

5.3 Integrated Disease Management Approaches

The complexity of microbial infections in Nigeria, involving multiple pathogens, transmission pathways, and health system levels, requires integrated approaches that transcend traditional disease-specific vertical programs. Integrated disease management offers opportunities for efficiency gains, improved patient outcomes, and strengthened health systems.

Integrated management of childhood illness addresses the reality that children often present with multiple conditions or syndromes rather than single diseases. This approach, adapted to the Nigerian context, can ensure that children with fever, diarrhea, or respiratory symptoms receive comprehensive assessment and appropriate treatment for the range of possible causes. Integration of malnutrition screening and management with infection services addresses the malnutrition-infection nexus that contributes to child mortality.

Integration of services across the prevention-treatment continuum can improve efficiency and outcomes. Antenatal care provides opportunities for maternal immunization, malaria prevention, HIV testing, and health education. Immunization contacts can include screening for malnutrition, distribution of bed nets, and deworming. HIV treatment services can include screening for tuberculosis and other opportunistic infections. These integrated contacts maximize the value of each health system encounter while addressing multiple health needs.

One Health approaches are essential for zoonotic infections and antimicrobial resistance, which by nature transcend human health boundaries. The high prevalence of Campylobacter infections across human and animal populations, with transmission through food systems and environmental contamination, demonstrates the need for collaborative, transdisciplinary approaches (Alabi et al., 2025; Systematic review and meta-analysis of Campylobacter species infections, 2025). Implementation of One Health requires mechanisms for coordination among human health, animal health, and environmental sectors; joint surveillance and data sharing; coordinated outbreak investigation and response; and integrated policy development.

The "farm to fork" principle applied to food safety requires interventions throughout the food production and processing chain. For Campylobacter control, this includes biosecurity measures on poultry farms, hygienic slaughter and processing practices, consumer education on safe food handling, and surveillance across the food system (Systematic review and meta-analysis of Campylobacter species infections, 2025). Such comprehensive approaches address contamination at multiple points, reducing the likelihood that pathogens reach consumers.

5.4 Policy Recommendations

Based on the analysis presented in this study, the following policy recommendations are offered for strengthening Nigeria's public health system capacity to address microbial infections:

Health Financing and Governance:

1. Accelerate implementation of the commitment to allocate at least 6% of executed annual Federal and State budgets to health, as articulated in the Nigeria-United States Memorandum of Understanding (Federal Ministry of Health and Social Welfare, 2025b), while pursuing the longer-term goal of meeting the Abuja Declaration 15% target.
2. Expand mandatory health insurance coverage through the National Health Insurance Authority Act 2024, with particular attention to informal sector workers and rural populations who currently face the greatest financial barriers to care (Antimicrobial resistance in Nigeria's healthcare system, 2025).
3. Strengthen oversight and accountability mechanisms for health funds at all levels, ensuring that resources reach frontline facilities and translate into improved service delivery. The improved BHCPF absorption rate from 45% to 78% demonstrates that progress is possible with appropriate systems (Federal Ministry of Health and Social Welfare, 2025a).

Workforce Development:

4. Implement targeted incentives for health workers to serve in rural and underserved areas, including

hardship allowances, housing, continuing education opportunities, and clear career progression pathways.

5. Scale up pre-service and in-service training in infection prevention and control, antimicrobial stewardship, and outbreak investigation for all cadres of health workers, addressing the knowledge-practice gap identified in studies (Antimicrobial resistance in Nigeria's healthcare system, 2025).
6. Strengthen regulation and oversight of private health care providers, who deliver an estimated 70% of health services but face weak enforcement of standards (Antimicrobial resistance in Nigeria's healthcare system, 2025), ensuring quality and appropriate antibiotic use across the entire health system.

Surveillance and Laboratory Systems:

7. Expand coverage of SORMAS and other surveillance platforms to all health facilities, with reliable connectivity, device availability, and training for users at all levels (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025).
8. Invest in laboratory infrastructure and personnel, with the goal of increasing the proportion of secondary facilities with functional microbiology laboratories from the current 23.4% (Antimicrobial resistance in Nigeria's healthcare system, 2025) and establishing a networked system with referral laboratories for specialized testing.
9. Strengthen the specimen transport system to ensure timely delivery of samples from collection points to testing facilities, addressing the gap identified during the diphtheria outbreak response (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025).

Antimicrobial Resistance Control:

10. Implement and enforce regulations restricting over-the-counter antibiotic sales, addressing the finding that 72.4% of pharmacies sell antibiotics without prescriptions (Antimicrobial resistance in Nigeria's healthcare system, 2025). This requires strengthening of pharmacy inspection and enforcement capacity.
11. Establish antimicrobial stewardship programs in all hospitals, with particular attention to tertiary facilities where resistance rates are highest (Alabi et al., 2025). These programs should include regular antibiotic use audits, feedback to prescribers, and guidance based on local resistance patterns.
12. Reduce antibiotic use in food-producing animals through regulation, veterinary oversight, and promotion of alternatives such as improved biosecurity, vaccination, and husbandry practices. The finding that 87.4% of poultry farms use antibiotics heavily indicates the scale of this challenge (Alabi et al., 2025).

One Health Implementation:

13. Establish formal coordination mechanisms for One Health at national and state levels, bringing together human health, animal health, and environmental sectors for joint planning, surveillance, and response (Alabi et al., 2025).
14. Implement joint surveillance for zoonotic infections and antimicrobial resistance across human and animal populations, enabling early detection of threats and coordinated response.
15. Strengthen food safety systems through the "farm to fork" approach, with interventions at production, processing, distribution, and consumption stages to reduce foodborne pathogen transmission (Systematic review and meta-analysis of Campylobacter species infections, 2025).

Immunization and Disease Prevention:

16. Intensify efforts to reach zero-dose and under-immunized children, addressing the immunization gaps that enabled the diphtheria outbreak. This requires strengthening routine immunization services, conducting catch-up campaigns, and addressing barriers to vaccine acceptance and access (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025).
17. Integrate immunization services with other health interventions to maximize coverage opportunities and address multiple health needs efficiently.
18. Strengthen vaccine-preventable disease surveillance to enable early outbreak detection and rapid response, preventing the spread that occurred in the diphtheria outbreak (Post COVID-19 resurgence of diphtheria in Kano, Nigeria, 2025).

Health Infrastructure:

19. Accelerate implementation of the Power for Health Initiative to provide reliable electricity in hospitals, addressing a fundamental constraint on infection control, vaccine storage, and service delivery (Federal Ministry of Health and Social Welfare, 2025a).
20. Invest in water and sanitation infrastructure in health facilities, enabling basic infection prevention and control practices including hand hygiene, sterilization, and safe waste management.
21. Develop and implement a national health infrastructure plan that addresses the current dysfunction of approximately 80% of public health facilities and ensures equitable distribution of resources (World Health Organization, 2025a).

5.5 Conclusion

Microbial infections are a major challenge for Nigeria’s public health, affecting system development and economic productivity. The burden is significant, with zoonotic pathogens impacting one-third of at-risk populations and antimicrobial resistance increasing treatment costs. The COVID-19 pandemic has highlighted these vulnerabilities, resulting in a major diphtheria outbreak. Key weaknesses include poor infrastructure, workforce shortages, and financial constraints. However, initiatives like the Nigeria Health Sector Renewal Investment and the National Health Insurance Authority Act show political will for change. Technological solutions can improve surveillance, and better funding absorption indicates potential for stronger implementation. The One Health framework promotes collaboration to address zoonotic infections and resistance. While progress in health finance and universal health coverage is evident, challenges remain in access and service delivery. Sustained commitment

from all stakeholders is essential to translate policies into effective care improvements. A resilient health system can lessen the burden of infections and support broader development goals.

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