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Addressing HIV Control and Prevention in Nigeria: Epidemiological Trends, Pathophysiology, and Strategic Public Health Interventions

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GODSPOWER ONUKPOUSI

Department of Public Health, Lead City University, Ibadan, Nigeria

GO, 0009-0001-0139-190X

Correspondence: GODSPOWER ONUKPOUSI, gonukpousi@gmail.com

Abstract

Despite substantial advancements in global antiretroviral scaling, Human Immunodeficiency Virus (HIV) remains a critical public health challenge in Nigeria. Holding the second-largest HIV burden in West and Central Africa, Nigeria possesses an estimated 1.9 million people living with HIV (PLHIV) and an adult prevalence rate of 1.3%. This paper reviews the contemporary epidemiological landscape of HIV in Nigeria, delineates its cellular pathophysiology, evaluates current biomedical and structural interventions—including Pre-Exposure Prophylaxis (PrEP) and Post-Exposure Prophylaxis (PEP)—and highlights systemic barriers such as social stigma and financing constraints. By aligning data-driven interventions with the structural requirements of vulnerable subgroups, Nigeria can bridge implementation gaps and progress toward the UNAIDS 95-95-95 targets.

Keywords: HIV/AIDS, Public Health, Epidemiology, Antiretroviral Therapy, Nigeria, UNAIDS targets

Introduction

In the words of Heraclitus, ‘the only constant in life is change.’ This quote is applicable not only to our life Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) constitute one of the most enduring global health crises, with deep ramifications for health infrastructure, socioeconomic development, and demographic stability. Within sub-Saharan Africa, Nigeria represents a focal point of the epidemic. According to the milestone Nigeria HIV/AIDS Indicator and Impact Survey (NAIIS), the national HIV prevalence stands at approximately 1.3% to 1.4%, representing roughly 1.9 million individuals living with the virus (UNAIDS, 2021).

While coordinated multi-sectoral initiatives have successfully driven down annual new infection rates over the last decade, deep-seated systemic adjustments are still required. The domestic epidemic is shaped by a complex interplay of socioeconomic vulnerabilities, regional healthcare disparities, and cultural norms that directly influence healthcare-seeking behavior. Suboptimal resource allocation and structural obstacles continue to prevent key marginalized sub-populations from consistently accessing preventive and therapeutic services (Bassey & Miteu, 2023).

This review paper aims to provide a rigorous, multi-dimensional analysis of the Nigerian HIV response. Specifically, it intends to:

1. Chart the heterogeneous epidemiological trends across geographic regions and vulnerable demographics.
2. Delineate the molecular and cellular pathophysiology of the infection to contextualize clinical management.
3. Critically evaluate ongoing biomedical prevention strategies (PrEP, PEP) and implementation barriers.
4. Highlight the broader public health and socioeconomic implications while offering evidence-based recommendations to achieve the UNAIDS 95-95-95 targets.

2. Epidemiological Landscape of HIV in Nigeria

Nigeria's HIV epidemic is characterized by structural heterogeneity, displaying extensive variations across geopolitical zones, urban-rural dynamics, and demographic cohorts (Awofala & Ogundele, 2016).

2.1 Regional and Demographic Variations

National aggregate data frequently obscures profound localized variations. Historically, states within the South-South and North-Central geopolitical zones have recorded significantly higher prevalence indices compared to the North-West and North-East zones. Furthermore, gender disparities remain stark; women face a disproportionate burden of the disease, with an adult prevalence of 1.6% compared to 1.0% among men (UNAIDS, 2021). This vulnerability is driven by systemic gender inequality, biological factors, and unequal socio-economic dynamics that limit preventive autonomy among adolescent girls and young women.

2.2 Vulnerable and Key Populations

A significant proportion of new infections occur within concentrated key populations. These subgroups face highly elevated relative risks of infection due to overlapping behavioral, structural, and legal barriers:

- **Female Sex Workers (FSWs):** Driven by low negotiating power for condom use and high partner turnover.
- **Men who have sex with Men (MSM):** Severely impacted by punitive legal frameworks, such as the Same-Sex Marriage Prohibition Act, which drive this demographic underground and restrict healthcare access.
- **People Who Inject Drugs (PWID):** Characterized by high rates of syringe-sharing and minimal access to clean needle-exchange programs.

2.3 Pediatric HIV and Vertical Transmission Challenges

Nigeria accounts for one of the highest global burdens of vertical (mother-to-child) HIV transmission. Gaps in the Prevention of Mother-to-Child Transmission (PMTCT) framework mean that thousands of

infants contract the virus annually during pregnancy, labor, or breastfeeding. Early pediatric diagnosis remains heavily limited by lack of equipment and low maternal retention in antenatal care clinics.

3. Pathophysiology and Clinical Manifestations

3.1 Viral Entry and Replication Cycle

HIV is an enveloped, single-stranded RNA retrovirus that primarily exhibits tropism for host immune cells expressing the surface cluster of differentiation 4 (CD4) receptors. These include CD4+ T lymphocytes, macrophages, monocyte-derived lineages, and follicular dendritic cells.

The replication cascade proceeds through structured molecular phases:

1. **Binding and Fusion:** The viral envelope glycoprotein gp120 binds to the host CD4 receptor and a coreceptor (typically CCR5 or CXCR4), permitting viral entry.
2. **Reverse Transcription:** Once uncoated inside the cytoplasm, the viral enzyme reverse transcriptase converts single-stranded viral RNA into double-stranded complementary DNA (cDNA).
3. **Integration:** The viral enzyme integrase transports the viral DNA into the host nucleus and splices it directly into the host genome, forming a permanent provirus.
4. **Transcription and Assembly:** The host cell machinery is hijacked to transcribe viral mRNA, translating it into polyproteins that are cleaved by HIV protease, generating mature, infectious virions.

[Viral Entry via CD4] ➔ [Reverse Transcription (RNA to DNA)] ➔ [Integration into Host Genome] ➔ [CD4+ T-Cell Decline]

3.2 Immune Deterioration and Progression to AIDS

The pathophysiological hallmark of progressive HIV infection is the quantitative depletion and qualitative impairment of helper CD4+ T lymphocytes. The mechanisms driving this loss include direct viral cytopathicity, syncytium formation, and chronic immune activation leading to accelerated apoptosis (programmed cell death).

A healthy individual exhibits a normal peripheral CD4 count of approximately 500 to 1,500 cells/mcL. Cell-mediated immunity is structurally preserved when counts remain above 350 cells/mcL. However, if replication is left unsuppressed by therapeutics, the CD4 pool drops continuously. When the absolute CD4 count falls below **200 cells/mcL**, the patient is diagnosed with Acquired Immunodeficiency Syndrome (AIDS), indicating severe systemic immunosuppression (Edward, 2023).

3.3 Clinical Manifestations and Opportunistic Co-infections

Following initial viral exposure, a high proportion of patients develop an **Acute Retroviral Syndrome** within 2 to 4 weeks, presenting with non-specific constitutional clinical symptoms: fever, generalized lymphadenopathy, pharyngitis, fatigue, and maculopapular rash (Vaillant & Gulick, 2022). This phase matches a surge in plasma viremia and a temporary drop in CD4 levels.

A prolonged period of clinical latency follows, during which active viral replication continues within secondary lymphoid tissues. Once profound immunosuppression occurs (CD4 count less than 200 cells/mcL), latent pathogens reactivate, leading to severe opportunistic infections and malignancies, summarized below:

CD4 Threshold	Primary Opportunistic Complications	Clinical Manifestations
Less than 500 cells/mcL	Pulmonary Tuberculosis (TB), Recurrent Oral Candidiasis	Chronic cough, night sweats, hemoptysis, white oral plaques
Less than 200 cells/mcL	*Pneumocystis jirovecii* Pneumonia (PCP), Kaposi's Sarcoma	Progressive exertional dyspnea, dry cough, violaceous skin lesions
Less than 100 cells/mcL	Cryptococcal Meningitis, Toxoplasmosis	Severe headache, altered mental status, focal neurological deficits
Less than 50 cells/mcL	Cytomegalovirus (CMV) Retinitis, *Mycobacterium avium* Complex	Blurring or loss of vision, wasting syndrome, persistent fever

4. Diagnostic and Therapeutic Modalities

4.1 Diagnostic Testing Algorithms

Achieving accurate clinical diagnosis relies on multi-tier testing algorithms designed to minimize false-positive and false-negative indices:

- **Rapid Diagnostic Antibody/Antigen Immunoassays:** Utilized as point-of-care screenings in primary health centers due to low cost and rapid turnaround times. These typically detect HIV-1/2 antibodies and the p24 viral antigen.
- **Nucleic Acid Testing (NAT):** Directly quantifies viral RNA. NAT is vital for resolving indeterminate serological profiles, diagnosing neonatal exposures, and identifying acute infections during the early seronegative window phase.

4.2 Antiretroviral Therapy (ART) and Systemic Management

The cornerstone of clinical management is lifelong Antiretroviral Therapy (ART), which deploys combinations of highly active drugs targeting different replication stages (e.g., Dolutegravir-based regimens combining integrase inhibitors with nucleoside reverse transcriptase inhibitors). The clinical objectives of ART are to achieve durable viral suppression, restore CD4+ cell counts, halt disease progression, and eliminate forward transmission via the Undetectable equals Untransmittable ($U=U$) mechanism.

However, clinical retention is vulnerable to distinct structural complications. Long-term therapeutic adherence requires removing institutional barriers such as out-of-pocket medication costs, inconsistent supply chains causing stock-outs, restrictive clinic operating hours, and localized provider bias (Gandhi et al., 2022).

5. Prevention, Control, and Public Health Frameworks

5.1 Biomedical Prevention Strategies

Contemporary public health models emphasize a combined prevention matrix incorporating both post-exposure and pre-exposure protocols:

- **Pre-Exposure Prophylaxis (PrEP):** The daily oral or long-acting injectable delivery of antiretroviral medications to HIV-negative individuals at high relative risk (e.g., serodiscordant couples, key populations). It provides greater than 99% protection against sexual acquisition when adherence is maintained.
- **Post-Exposure Prophylaxis (PEP):** An emergency intervention requiring the initiation of a 28-day antiretroviral course within 72 hours of a potential accidental or occupational viral exposure.

5.2 Digital Health and Public Advocacy

To expand the reach of preventive frameworks, structural innovations like telehealth applications and mobile-health platforms must be scaled up. These tools facilitate confidential symptom monitoring, remote consultation, and automated adherence reminders, bypassing geographical constraints and reducing patient exposure to clinical stigma (Olaniyi, 2019). Public health advocacy remains vital to correct baseline misinformation and normalize routine screening.

6. Discussion: Systemic Barriers to the UNAIDS 95-95-95 Targets

Progress toward the global UNAIDS 95-95-95 targets by 2030 (95% aware of status, 95% of diagnosed individuals on ART, 95% of those on ART virally suppressed) faces distinct structural hurdles in Nigeria:

- **Pervasive Stigma and Human Rights Obstacles:** Social marginalization, fear of community rejection, and structural discrimination within medical settings prevent individuals from seeking testing or disclosing their status. Punitive legal frameworks targeting key populations further restrict health equity.
- **International Financing Reductions:** The Nigerian national response remains heavily reliant on external donor contributions, including the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) and the Global Fund. Abrupt shifts or reductions in international health aid create a critical vulnerability, causing commodity supply disruptions and decreasing condom and PrEP distribution channels.
- **Infrastructure Deficits:** Rural primary healthcare centers frequently lack functional cold-chain systems, data monitoring networks, and trained laboratory staff, creating deep disparities in care quality compared to urban centers.

7. Conclusion and Policy Recommendations

To achieve sustainable epidemic control, the Nigerian public health apparatus must transition from external donor reliance to a resilient, internally financed framework. Based on this review, the following policy interventions are recommended:

1. **Increase Domestic Health Financing:** National and state governments must honor international health compacts by scaling up budgetary allocations to healthcare infrastructure, reducing dependency on external donor streams.
2. **Integrate Vertical Transmission Programs:** Scale up community-based Prevention of Mother-to-Child Transmission (PMTCT) networks, utilizing peer-mentor mothers to improve retention and narrow the pediatric care gap.

3. **Implement De-stigmatization Policies:** Protect patient privacy and pass human-rights-focused healthcare legislation to ensure that key vulnerable sub-populations can access testing, counseling, and treatment safely.
4. **De-centralize Delivery Models:** Expand differentiated service delivery models, multi-month dispensing protocols, and digital health networks into remote geographies to optimize long-term clinical adherence.

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