



Epidemiology and Public Health Implications of *Streptococcus pneumoniae* Infections among High-Risk Populations in Nigeria: A Narrative Review

Editor's Pick

This review highlights the persistent burden of *Streptococcus pneumoniae* among high-risk populations in Nigeria and identifies critical gaps in surveillance, diagnostics, and vaccine coverage. Strengthening surveillance systems and expanding equitable access to diagnostics and vaccination are essential to reducing pneumococcal disease and associated mortality.

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Abstract

Streptococcus pneumoniae remains an important cause of morbidity and mortality globally, with a disproportionate burden among populations at increased risk of severe disease. These include age-defined groups, such as children under 5 years old and older adults, as well as immunocompromised populations, including people living with HIV/AIDS, individuals with

malignancies, and those receiving immunosuppressive therapies. Additional clinical and social factors, including sickle cell disease, diabetes, malnutrition, limited healthcare access, and suboptimal vaccination coverage, may further increase vulnerability to pneumococcal disease. In Nigeria, these interacting vulnerabilities occur within a health system characterised by diagnostic limitations, inequitable access to care, and persistent gaps in pneumococcal disease surveillance and prevention.

This narrative review synthesises available evidence on the epidemiology, risk factors, clinical manifestations, diagnosis, antimicrobial resistance, prevention, and public health implications of *S. pneumoniae* infections among high-risk populations in Nigeria, with particular attention to age-defined groups, immunocompromised populations, and individuals with underlying conditions associated with increased susceptibility to severe pneumococcal disease.

To mitigate this burden, Nigeria must integrate pneumococcal monitoring into the National Integrated Disease Surveillance and Response (IDSR) framework. Key priorities include expanding molecular diagnostic capabilities and monitoring the coverage and efficacy of pneumococcal vaccines. Improving pneumococcal disease control in Nigeria requires stronger surveillance and laboratory capacity, alongside equitable vaccination and better antimicrobial stewardship. Contemporary national data are also needed to guide future vaccine policy.

Key Points

1. Pneumococcal disease remains an important cause of preventable morbidity and mortality in Nigeria, particularly among young children, older adults, immunocompromised people, and those with conditions that increase susceptibility to severe disease.
2. This narrative review synthesised available evidence on *Streptococcus pneumoniae* infections among high-risk populations in Nigeria, examining epidemiology, risk factors, clinical manifestations, diagnosis, antimicrobial resistance, vaccination, surveillance, and public health implications.
3. Improving pneumococcal disease control in Nigeria requires stronger surveillance and laboratory capacity, alongside equitable vaccination and better antimicrobial stewardship. Contemporary national data are also needed to guide future vaccine policy.

INTRODUCTION

Background

Children under 5 years old represent an age-defined high-risk population, whereas immunocompromised populations include individuals with impaired immune function due to conditions such as HIV infection, malignancy, or immunosuppressive therapy.^{1,2} Despite advancements in effective vaccines and antibiotics, the disease burden remains high in low- and middle-income countries (LMIC) due to fragile health systems, limited diagnostic capacity, and suboptimal vaccine uptake.³ In Nigeria, pneumonia continues to be a primary driver of mortality among paediatric populations and an age-defined high-risk population.^{4,5} Northern states, such

as Nasarawa, have documented particularly high mortality rates, emphasising the need for localised interventions.

In Nigeria, *Streptococcus pneumoniae* is an important cause of morbidity and mortality among populations at increased risk of pneumococcal infection or severe disease.^{6,7} These populations are heterogeneous and should not be considered synonymous with immunocompromised populations.^{8,9} Age-related risk groups include children under 5 years old and older adults, while immunocompromised populations include people living with HIV/AIDS, individuals with malignancies, and patients receiving immunosuppressive therapies. Other clinical conditions, such as sickle cell disease and diabetes, as well as malnutrition, may

independently increase susceptibility to invasive pneumococcal disease (IPD).¹⁰⁻¹² The burden may be further amplified by delayed diagnosis, limited healthcare access, inadequate vaccination coverage, and antimicrobial resistance (AMR).¹³⁻¹⁵

Globally, pneumococcal infections are a major public health threat; however, their impact is more severe in LMICs where infrastructure is often inadequate.^{2,16} In Nigeria, this is complicated by socioeconomic constraints, poor health-seeking behaviour, and gaps in surveillance, leading to a systematic underestimation of the true burden.^{9,17} Understanding the epidemiology and clinical outcomes in immunocompromised patients is critical for guiding prevention strategies.¹⁸ This review synthesises evidence regarding the epidemiology, risk factors, and management of pneumococcal infections in Nigeria to inform policies that strengthen healthcare delivery for vulnerable populations.

Problem Statement

Among children, pneumonia is a leading cause of death. Although manageable with basic health measures, its control remains elusive in many regions due to its link to poverty. It is most prevalent where infrastructure is deficient and treatment is unaffordable.^{10,19} Furthermore, unsatisfactory care-seeking behaviour and limited access to quality care remain limiting factors. The global impact on the elderly is also profound, with deaths among those aged 70 years and older increasing from 600,000 in 1990 to over one million in 2019.²⁰

Studies highlight limitations regarding the diagnosis and treatment of pneumococcal disease in resource-limited settings.^{13,14} A primary concern is the reliance on empirical diagnoses based solely on clinical symptoms, leading to antibiotic misuse and accelerated resistance.¹⁵ Other hurdles include inadequate laboratory capacity, delayed sample processing, low sensitivity of traditional cultures, and limited access to molecular diagnostics like PCR. Despite the introduction of pneumococcal conjugate vaccines (PCV), *S. pneumoniae* remains a primary cause of mortality in LMICs.³ The

lack of real-time data on prevalence and serotype distribution hampers effective public health responses.

PATHOGENESIS AND RISK FACTORS

S. pneumoniae is a Gram-positive, encapsulated coccus that colonises the human nasopharynx, particularly in children.^{2,21} Progression from asymptomatic colonisation to invasive disease depends on bacterial virulence and host susceptibility.^{9,17} The polysaccharide capsule is the primary virulence determinant, enabling the bacterium to evade the immune system by inhibiting phagocytosis. Other factors include pneumolysin, surface proteins, and autolysins, which facilitate adherence and tissue invasion.¹

The bacterium causes a spectrum of illnesses ranging from non-invasive (otitis media) to life-threatening IPD, including pneumonia, meningitis, and bacteraemia. These severe forms contribute disproportionately to mortality in LMICs. Host factors such as malnutrition, prevalent in Nigeria, compromise both innate and adaptive immunity.^{16,22,23} Similarly, comorbidities like HIV, sickle cell disease, and diabetes significantly elevate the risk of IPD.^{7,12,24} HIV infection represents an important immunological risk factor for IPD because impaired cellular and humoral immune responses increase susceptibility to severe bacterial infections. In Nigeria, the relevance of HIV-related immunocompromisation to pneumococcal disease reflects the substantial number of people living with HIV and persistent gaps in treatment outcomes. The nationally representative 2018 Nigeria HIV/AIDS Indicator and Impact Survey estimated HIV prevalence at 1.4% among adults aged 15–49 years, corresponding to approximately 1.9 million people living with HIV, while viral suppression among people living with HIV aged 15–49 years was 42.3%. These findings underscore the importance of HIV prevention, effective antiretroviral treatment, and sustained viral suppression as components of strategies to reduce the risk of IPD among people living with HIV in Nigeria.²⁴

Environmental determinants also play a pivotal role. Overcrowded living conditions, poor ventilation, and exposure to indoor air pollution from biomass fuels facilitate the spread of respiratory droplets.^{13,17} When combined with limited access to healthcare, the risk of complications and death becomes exceptionally high.

EPIDEMIOLOGY AND BURDEN OF PNEUMOCOCCAL DISEASE

The epidemiology of pneumococcal disease in Nigeria should be interpreted across several high-risk population groups rather than as a single immunocompromised population. Children under 5 years old and older adults experience increased risk related primarily to age-associated susceptibility, whereas people living with HIV/AIDS, individuals with malignancies, and patients receiving immunosuppressive therapies have increased risk associated with impaired immune function. Additional conditions, including sickle cell disease, diabetes, and malnutrition, may further modify susceptibility and disease severity. Accordingly, the evidence presented below is organised around these distinct but overlapping risk categories. Globally, *S. pneumoniae* is responsible for over one million deaths annually.^{2,10} While child mortality declined between 2000–2010, pneumonia and diarrhoeal diseases remain primary causes of avoidable death, accounting for 30% of paediatric deaths worldwide.^{22,23} Africa has the second-highest incidence of paediatric pneumonia (0.33 episodes per child per year). Nigeria bears a massive share of this burden: in 2018, an estimated 162,000 Nigerian children under 5 years of age died from pneumonia, equivalent to approximately 443 deaths per day or 18 deaths every hour. This estimate represents all-cause pneumonia mortality and should not be interpreted as pneumococcal-attributable mortality.⁴

Specifically, 19% of child deaths in Nigeria in 2018 were attributed to pneumonia.^{4,25} Nigeria ranks third globally for deaths in children under 5 years old caused by acute respiratory infections.^{5,26} Furthermore, the rate of pneumonia mortality decline (8%)

is alarmingly slow compared to measles (93%) or malaria (48%).⁴

Pneumonia is also a massive challenge for patients who are HIV-positive, with incidence rates between 3.9–20.0 cases per 100 person-years.^{12,24} Beyond paediatrics, the elderly face a significant threat, as the disease often manifests as bacteraemia or meningitis with high case-fatality rates.^{21,27} Globally, it causes over 300,000 deaths annually among adults aged 70 years and older.^{10,11,28} Nigeria's burden is exacerbated by weak health infrastructure and historically poor vaccination coverage.²⁹

Selected epidemiological evidence on *S. pneumoniae* infections and carriage in Nigeria is summarised in [Supplementary Table 1](#).

ECONOMIC BURDEN AND POLICY CONSIDERATIONS

The economic burden of pneumonia and pneumococcal disease extends to both healthcare providers and households. In the USA, the annual economic burden of IPD among adults aged 50 years or over was estimated at 1.8 billion USD, while the annual cost of pneumonia in Europe has been estimated at approximately 10 billion EUR, comprising 6.2 billion EUR in direct costs and 3.6 billion EUR in indirect costs.^{2,6} In Nigeria, evidence on the economic burden remains limited. A study among children younger than 5 years of age receiving care in two hospitals in Kano reported median provider costs of 17 USD for outpatient care and 272 USD for inpatient care, while the median household cost was 51 USD.⁶ These findings highlight the financial burden of pneumonia and pneumococcal disease on healthcare systems and households. Sustained investment in vaccination, cold-chain infrastructure, laboratory capacity, and disease surveillance is therefore important for strengthening pneumococcal disease prevention and control in Nigeria.

CLINICAL MANIFESTATIONS

Clinical presentation varies, especially among immunocompromised patients where symptoms may be atypical.^{8,25} Common symptoms include fever, cough, and dyspnoea, but in patients with neutropenia, fever may be the only sign.³⁰ Progression can lead to complications such as bacteraemia, meningitis, and acute respiratory distress syndrome.^{8,30} Overlapping symptoms with other infections create a high risk of misclassification, leading to delayed treatment or antibiotic overuse.^{15,20}

Diagnosis

Diagnosis begins with history, physical examination, and imaging.^{25,31} In resource-limited settings, laboratory confirmation is often unavailable. Laboratory methods include Gram staining, biochemical identification, culture, and PCR. While culture is the 'gold standard', it suffers from low sensitivity and delays.^{12,13,28} PCR may provide superior outcomes, but requires validation.^{13,18,23}

Sputum is frequently contaminated, complicating isolation.^{18,28} Most facilities use disc diffusion for susceptibility testing, which is less accurate than the broth micro dilution for determining minimum inhibitory concentration. See [Supplementary Table 2](#) for a summary of challenges and limitations of diagnosis in Nigeria, while key diagnostic and surveillance challenges affecting pneumococcal disease detection and characterisation in Nigeria are summarised in [Supplementary Table 3](#).

AMR

Rational antibiotic use is vital to slow AMR. In Nigeria, widespread over-the-counter access and empirical prescribing contribute significantly to resistance.^{15,24,32} Diminishing effectiveness of first-line treatments is a growing concern, leading to increased costs and mortality.^{15,33} Addressing this requires stewardship: enforcing regulations, training clinicians, and improving diagnostics to allow for targeted therapy. It is recommended that national guidelines must reflect changing local susceptibility

patterns.^{33,34} See [Supplementary Table 4](#) for a summary of studies on antimicrobial susceptibility and resistance patterns of *S. pneumoniae* reported in Nigeria.

Surveillance and Laboratory Strengthening

Prevention is dependent on timely, high-quality surveillance to inform vaccine selection and treatment protocols.^{27,34,35} Investment in infrastructure, specifically culture and PCR capacity, is essential. In Nigeria, investing in sentinel sites, particularly in high-burden states like Nasarawa, is needed to guide local policy. Integrating surveillance into the Integrated Disease Surveillance and Response (IDSR) system can increase efficiency and support real-time decision-making from local to national levels.

Health Systems and Community Interventions

Addressing social determinants, improving air quality, and reducing malnutrition are vital.^{13,28} Strengthening primary healthcare, including access to antenatal care and HIV prophylaxis, reduces infection risk.²⁸ Community engagement is crucial for increasing vaccine acceptance and encouraging prompt care-seeking behaviour. Messaging must be tailored to address cultural beliefs and logistical barriers like travel costs.

Preventive and Control Strategies

Prevention relies on vaccination, early diagnosis, and stewardship. Nigeria introduced PCV10 into its routine schedule in late 2014, with national scale-up by 2016.^{29,36} However, coverage is inequitable; while countries like Burkina Faso achieve >75%, Nigeria's full coverage was reported at only 24.2%.³⁷ The WHO and United Nations Children's Fund (UNICEF) estimated PCV3 coverage among 1-year-olds in Nigeria at 60% in 2023, indicating persistent gaps in completion of the three-dose PCV schedule.³⁸ Pneumococcal vaccination strategies for older adults and other high-risk groups differ across jurisdictions. Although international guidelines recommend pneumococcal vaccination for specified high-risk adults, Nigeria-specific recommendations and implementation

strategies should be interpreted within the context of national policy, vaccine availability, epidemiological evidence, and programme feasibility.³⁹ Nigeria lacks the robust surveillance systems seen in South Africa to monitor vaccine impact.²⁹ See [Supplementary Table 5](#) for a summary of pneumococcal vaccination coverage and prevention initiatives in Nigeria.

DISCUSSION

This review highlights the underappreciated burden of pneumococcal disease in Nigeria. Despite PCV introduction, there remain systemic challenges in surveillance and diagnosis that perpetuate preventable morbidity and mortality among high-risk populations, including young children, older adults, immunocompromised individuals, and people with underlying conditions associated with increased susceptibility to severe pneumococcal disease.^{23,30} The lack of disaggregated data in regions like Nasarawa State creates uncertainty regarding circulating serotypes, limiting evidence-based policy refinement.^{12,29}

Diagnostic challenges may lead to misclassification of the causative pathogen of pneumococcal disease and may fuel AMR. Also, resistance to penicillin and macrolides is well-documented across Africa.^{33,37} Following pneumococcal conjugate vaccine introduction, serotype replacement has been documented in some settings, with non-vaccine serotypes contributing to residual pneumococcal disease.⁴⁰ Available Nigerian serotype data indicate the presence of pneumococcal serotypes not necessarily covered by current vaccine formulations; however, the available evidence is insufficient to establish a national need to transition from PCV10 to PCV13.

Expansion to a broader-valency vaccine could be considered as a potential policy option, contingent on contemporary national serotype surveillance, assessment of vaccine-preventable disease burden, programme feasibility, vaccine supply, and cost-effectiveness. Recently, the WHO/UNICEF estimated national PCV3 coverage at 60% in 2023, indicating that a substantial

proportion of children did not complete the recommended three-dose PCV schedule and may remain insufficiently protected against vaccine-preventable pneumococcal disease.³⁶ Strengthening the response requires targeted investments in laboratory capacity and equitable vaccine delivery.

CONCLUSION

S. pneumoniae remains an important cause of preventable morbidity and mortality among high-risk populations in Nigeria, including young children, older adults, immunocompromised individuals, and people with underlying conditions associated with increased susceptibility to severe disease. Progress of pneumococcal disease control may be undermined by low coverage, lack of resources, and the absence of a comprehensive surveillance network. This review and study analysis identifies three priorities:

- Surveillance integration: monitoring and tracking of pneumococcal disease must be integrated into the national IDSR system.
- Laboratory strengthening: sustainable financing is needed for diagnostic networks and investment in newer and more sensitive pneumococcal diagnostic methods.
- Policy learning: Nigeria should adopt regional success stories, like South Africa's data-driven monitoring.

CALL TO ACTION

Policymakers and funders must prioritise pneumococcal disease within the WHO's Universal Health Coverage agenda. Expanding vaccine access, embedding surveillance in the health system, and fostering collaboration between the government and academia are essential steps. Without this commitment, Nigeria will continue to face preventable deaths and escalating treatment costs. These strategies can reduce disease burden and build a more resilient health system.

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