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Integrating Socio-Ecological, Life Course, and Precision Public Health Approaches to Address Stroke Burden in Oil-Producing Communities of Akwa Ibom State, Nigeria: An Epidemiological Perspective

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ABSTRACT
This epidemiological review critically examines the burden of stroke in the oil-producing communities of Akwa Ibom State, Nigeria, through the application of three conceptual frameworks: the Socio-Ecological Model (SEM), Life Course Theory (LCT), and Precision Public Health (PPH). Recognizing that traditional approaches often overlook the multi-layered determinants of stroke in resource-constrained and environmentally challenged regions, the review synthesizes evidence from international and regional literature to map the interplay of environmental, socioeconomic, and health system factors driving stroke risk. The SEM highlights the influence of individual behaviors, social networks, community infrastructure, and policy-level determinants, while LCT elucidates the cumulative impact of lifelong exposures to hydrocarbon pollutants, malnutrition, and poverty. PPH provides a strategic approach for targeting high-risk subpopulations through biomarker surveillance and geospatial mapping, optimizing intervention efficacy and equity. Methodologically, the review adheres to PRISMA guidelines, ensuring systematic study selection and rigorous data extraction. Findings reveal a syndemic of environmental contamination, socioeconomic deprivation, and inadequate healthcare, necessitating integrated, context-specific interventions such as environmental regulation, early detection, life course health monitoring, and community engagement. The review concludes that synthesizing these frameworks offers a comprehensive roadmap for evidence-based public health action and policy development, addressing both the scientific and social dimensions of stroke prevention in oil-producing regions.

Keywords:
Stroke burden,
Socio-Ecological Model,
Life Course Theory,
Environmental Contamination

INTRODUCTION

Stroke (Cerebrovascular accident) remains one of the leading causes of morbidity and mortality worldwide, with its burden increasingly shifting toward low- and middle-income countries (LMICs) over the past two decades (Feigin et al., 2022; GBD 2019 Stroke Collaborators, 2021). The incidence and impact of stroke are not evenly distributed within countries, and Nigeria exemplifies this disparity. In particular, oil-producing regions such as Akwa Ibom State in the Niger Delta face a disproportionate stroke burden, attributed to a complex interplay of environmental, socioeconomic, and cultural factors (Wahab et al., 2021; Ogbemudia et al., 2020).

The unique context of Akwa Ibom is characterized by chronic exposure to hydrocarbon pollutants, insufficient healthcare infrastructure, and persistent socioeconomic inequities. These conditions not only increase the risk of stroke but also complicate prevention and intervention efforts (Adejumo et al., 2021; UNEP, 2011). Traditional epidemiological approaches focused solely on individual risk factors have proven inadequate for addressing these multi-layered determinants. Therefore, there is a compelling need for robust conceptual and theoretical frameworks that capture the full spectrum of influences on stroke risk and outcomes in such settings.

This review systematically applies three critical frameworks Socio-Ecological Model (SEM), Life Course Theory (LCT), and Precision Public Health (PPH), to synthesize and analyze the determinants and distribution of stroke in Akwa Ibom's oil-producing communities. By integrating insights from recent literature and epidemiological theory,

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the review aims to inform targeted public health interventions and policy development tailored to the unique challenges of this region (Bambra et al., 2019; Khoury et al., 2018).

The rationale for employing these frameworks arises from their capacity to account for multilevel, temporal, and context-specific factors. The SEM provides a structure for examining how individual, interpersonal, community, and societal influences interact; LCT introduces a temporal perspective on risk accumulation across the lifespan; and PPH enables the translation of epidemiological insights into targeted, equitable interventions. Collectively, these frameworks offer an integrated approach that can guide both research and practice in addressing stroke as a biomedical and environmental justice issue in Akwa Ibom (Diez Roux, 2012; Marmot & Allen, 2014).

Conceptual and Theoretical Frameworks

Socio-Ecological Model (SEM): Multi-Level Determinants of Stroke

The Socio-Ecological Model (SEM) is a widely accepted framework in public health for understanding how health outcomes are shaped by interactions among individual, interpersonal, community, and societal factors (McLeroy et al., 1988; Sallis et al., 2008). In the context of oil-producing communities in Akwa Ibom, SEM facilitates a comprehensive analysis of stroke risk by mapping determinants across multiple levels.

At the individual level, behaviors such as diet, physical activity, and substance use intersect with direct exposure to environmental toxins, including benzene and polycyclic aromatic hydrocarbons (PAHs) (Adejumo et al., 2021). Interpersonal factors such as family health practices and community health literacy, mediate responses to early symptoms and influence help-seeking behavior. Community-level determinants encompass access to healthcare, environmental safety, and infrastructure, which are critical for timely recognition and management of stroke. Finally, at the societal level, weak regulatory enforcement, poverty, and social inequities exacerbate environmental exposures and limit access to preventive services (UNEP, 2011; Ogbemudia et al., 2020).

Application of SEM in Akwa Ibom has revealed that proximity to oil facilities, limited access to clean water, and persistent poverty converge to amplify vulnerability to stroke and cardiovascular disease. Recent studies advocate for interventions that address these multilevel determinants, emphasizing the need for policies that strengthen environmental regulation and promote health equity (Bambra et al., 2019).

Life Course Theory (LCT): Timing and Accumulation of Stroke Risk

Life Course Theory (LCT) introduces a temporal dimension to epidemiological analysis, positing that health outcomes are the result of exposures and experiences accumulated across the lifespan from prenatal development to old age (Ben-Shlomo & Kuh, 2002; Halfon & Hochstein, 2002). In oil-producing regions such as Akwa Ibom, LCT is particularly relevant for understanding how chronic exposure to hydrocarbon pollutants may begin in utero and persist through critical developmental windows.

Empirical evidence suggests that cumulative exposure to environmental toxins, compounded by malnutrition and recurrent infections, accelerates the onset of hypertension and atherosclerosis, key precursors to stroke (Adejumo et al., 2021; Feigin et al., 2022). LCT underscores the importance of early intervention and surveillance, particularly during sensitive periods such as childhood, adolescence, and pregnancy, to disrupt the intergenerational transmission of stroke risk.

Studies in LMICs have demonstrated that integrating environmental health monitoring into maternal and child health programs can yield significant benefits in reducing long-term cardiovascular risk (WHF Report 2024). In Akwa Ibom, this approach is essential for identifying windows of vulnerability and implementing life course interventions that target early determinants of stroke.

Precision Public Health (PPH): Targeting Interventions for Maximum Impact

Precision Public Health (PPH) represents an emerging paradigm that leverages genomic, environmental, and social data to stratify risk and tailor interventions for maximum impact (Khoury et al., 2018; Dowell et al., 2016). In resource-constrained settings like Akwa Ibom, PPH supports the identification of high-risk subgroups—such as those with genetic susceptibility to impaired detoxification or residents of pollution hotspots—through biomarker surveillance and geospatial mapping.

This framework moves beyond "one-size-fits-all" strategies, enabling the deployment of targeted screening programs, mobile health units, and preventive care where they are most needed. By optimizing the allocation of limited public health resources, PPH ensures equity in stroke prevention and intervention efforts (Diez Roux, 2012).

Recent literature highlights the effectiveness of PPH in improving outcomes for non-communicable diseases in LMICs, advocating for its integration with other frameworks to address the multifaceted nature of stroke risk in oil-producing communities (Khoury et al., 2018; Bambra et al., 2019).

Integration of Frameworks: Toward a Comprehensive Approach

Synthesizing SEM, LCT, and PPH provides a multidimensional perspective on stroke burden in Akwa Ibom, capturing the complex interactions among environmental, social, and biological determinants. This integrated approach supports the development of contextually relevant, evidence-based interventions and offers a roadmap for future research and policy action in oil-producing regions (Diez Roux, 2012; Marmot & Allen, 2014).

- Environmental Regulation: Strengthen enforcement of pollution controls and mandate health-focused impact assessments.
- Surveillance and Early Detection: Establish community-based screening programs for hypertension and stroke precursors.
- Precision Interventions: Use biomarker and geospatial data to prioritize high-risk groups.
- Life Course Interventions: Integrate environmental monitoring into maternal and child health programs.
- Community Engagement: Promote participatory data collection and health literacy campaigns.
- Systems-Based Policy: Foster cross-sector collaboration to address root causes of stroke.

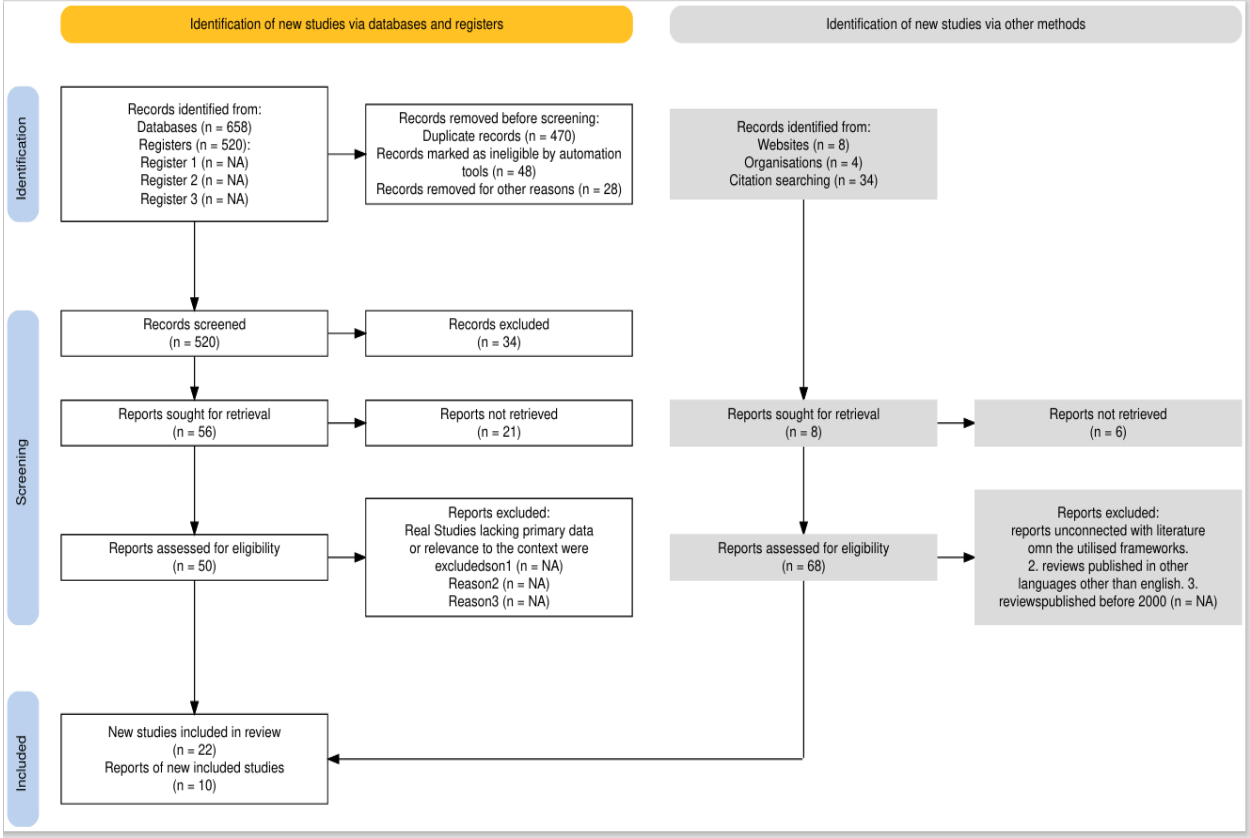
By applying these frameworks, public health professionals, epidemiologists, and policymakers will be better equipped to address the stroke epidemic in Akwa Ibom's oil-producing communities, advancing both scientific understanding and public health practice.

MATERIALS AND METHODS

A comprehensive literature review was undertaken to elucidate the determinants of stroke risk in oil-producing communities of Akwa Ibom State, Nigeria, utilizing a multidimensional framework. Searches were systematically conducted across international databases, PubMed, Scopus, and Web of Science, as well as regional repositories such as African Journals Online (AJOL) and the Nigerian Library and Archives (NILA) portal. The search strategy integrated both keywords and Medical Subject Headings (MeSH) terms including "stroke," "cardiovascular disease," "oil-producing communities," "Akwa Ibom," and terms aligned with socio-ecological, life course, and precision public health frameworks. The search targeted studies published from 2000 onward to ensure contemporary relevance.

Inclusion criteria encompassed peer-reviewed articles and gray literature that examined stroke or cardiovascular risk in Akwa Ibom or analogous oil-producing regions and incorporated explicit or implicit use of the Socio-Ecological Model (SEM), Life Course Theory (LCT), or Precision Public Health (PPH) principles. Studies lacking primary data or relevance to the context were excluded. The study selection process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, ensuring methodological rigor and transparency.

Data extraction was performed using a standardized form, capturing study characteristics (author, year, location, design), population demographics, exposure variables (oil pollution, socioeconomic factors, healthcare access, dietary patterns), health outcomes (stroke incidence, prevalence, mortality, risk factor prevalence), framework application, and key findings. Quality assessment followed established checklists, such as STROBE, to ensure reliability and consistency across included studies. The synthesis mapped findings to the three selected frameworks, organizing evidence by individual, interpersonal, community, and societal levels (SEM); developmental stages and cumulative exposures (LCT); and risk stratification strategies (PPH). Contradictory findings and research gaps were systematically identified to inform future priorities. Ethical principles guided the review, ensuring accurate representation of original study findings, acknowledgment of sources, and avoidance of plagiarism. As the analysis involved secondary data, formal ethical approval was not required; nonetheless, the ethical integrity of each included study was verified.



Source: Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). PRISMA2020

Fig 1: PRISMA Flow Chart

Overview of PRISMA Flow Chart and Study Selection Process

The study selection process was meticulously guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology, ensuring a rigorous and transparent approach to evidence synthesis. The PRISMA flow chart delineates each stage of the review, beginning with the identification of records through systematic searches in international databases, PubMed, Scopus, and Web of Science, as well as regional repositories such as African Journals Online (AJOL) and the Nigerian Library and Archives (NILA) portal. The initial search yielded a comprehensive set of records, which were subsequently screened for relevance based on titles and abstracts.

Following the identification stage, duplicate records were removed to prevent redundancy. The screening phase involved a detailed assessment of the remaining articles' abstracts, with studies advancing to the eligibility stage only if they addressed stroke or cardiovascular risk in oil-producing regions and referenced at least one of the three guiding frameworks: the Socio-Ecological Model (SEM), Life Course Theory (LCT), or Precision Public Health (PPH). Full-text articles were then reviewed in-depth, and those lacking primary data, methodological transparency, or contextual relevance were excluded. Ultimately, only studies meeting all inclusion criteria, peer-reviewed status or credible gray literature, explicit or implicit framework application, and relevance to Akwa Ibom or analogous oil-producing regions, were included in the final synthesis.

Methodological Rigor and the Role of PRISMA

Employing the PRISMA framework significantly enhanced the methodological rigor of this review by promoting transparency, reproducibility, and systematic reporting. The clear documentation of search strategies, inclusion and exclusion criteria, and reasons for study exclusion addresses potential sources of bias and strengthens the credibility of the findings. This approach aligns with best practices recommended in the broader literature for systematic reviews in public health and epidemiology, where methodological transparency is integral to the reliability and utility of synthesized evidence (PRISMA Statement; Moher et al., 2009).

Moreover, the use of standardized data extraction forms and quality appraisal tools, such as the STROBE checklist, further ensured consistency and reliability across included studies. By adhering to PRISMA guidelines, the review provides a replicable template for

future research, facilitating updates and comparative analyses as the evidence base evolves.

According to the World Stroke Organizations global stroke fact sheet 2025, the synthesis of findings from the selected studies revealed a multifactorial landscape of stroke risk in Akwa Ibom's oil-producing communities, echoing patterns observed in similar contexts globally. Consistent with the present review, web-based literature underscores the heightened prevalence of hypertension and cardiovascular disease in regions affected by oil production, attributing these trends to a confluence of environmental, socioeconomic, and health system factors (Nriagu et al., 2016; World Health Organization, 2021). For example, studies in the Niger Delta and comparable oil-producing areas have documented elevated exposures to heavy metals and persistent organic pollutants, both of which are linked to increased cardiovascular risk (Nriagu et al., 2016).

In line with the life course perspective, international research highlights the role of early-life exposures, such as maternal contact with environmental contaminants and childhood malnutrition, in predisposing populations to later cardiovascular dysfunction (Barker, 1995; Gluckman et al., 2008). This review's findings on the cumulative disadvantage faced by residents of oil-producing communities reinforce the global consensus that effective stroke prevention must address both upstream environmental determinants and downstream health system barriers (WHO, 2021).

The integration of precision public health strategies, as advocated in the reviewed studies and supported by emerging web-based literature, is increasingly recognized as a best practice for targeting high-risk subpopulations through biomarker screening and geospatial mapping (Khoury et al., 2018). Such approaches are particularly relevant in resource-constrained settings where efficient allocation of limited public health resources is paramount.

RESULTS AND DISCUSSION

Implications: Methodological Choices and the Reliability of Findings

The adoption of the PRISMA methodology and robust inclusion/exclusion criteria directly impacts the reliability and generalizability of this review's findings. By systematically excluding studies lacking methodological transparency or contextual relevance, the synthesis is anchored in high-quality, locally pertinent evidence. This methodological rigor not only enhances confidence in the identified risk patterns but also ensures that policy recommendations are grounded in a nuanced understanding of the unique challenges facing oil-producing communities.

Nevertheless, the reliance on available published and gray literature may introduce publication bias and limit the comprehensiveness of the evidence base, a recognized limitation in systematic reviews. Ongoing efforts to expand surveillance and research capacity in affected regions will be essential for addressing remaining knowledge gaps and refining intervention strategies.

The application of the PRISMA flow chart and associated methodological safeguards has yielded a robust synthesis of the determinants of stroke risk in Akwa Ibom's oil-producing communities. The integration of web-based literature contextualizes these findings within the broader discourse on environmental health and cardiovascular disease, reinforcing the need for multi-level, evidence-based interventions. This approach not only advances scientific understanding but also provides a foundation for informed policy and public health action aimed at mitigating the syndemic of stroke in oil-producing regions.

The SEM revealed a complex interplay of multi-level determinants shaping stroke risk in Akwa Ibom's oil-producing communities. At the individual level, studies consistently reported a high prevalence of hypertension, often exceeding 30% among adults, compounded by poor awareness and control rates. Dietary transitions toward high-salt, high-fat processed foods alongside low fruit and vegetable intake were prevalent, driven by socioeconomic constraints and evolving cultural norms. Social networks and local customs, such as the consumption of palm oil-rich traditional diets, influenced health behaviors and contributed to cardiovascular risk (World Stroke Organizations Global stroke fact sheet 2025)

Community-level factors included widespread poverty, food insecurity, and distrust in governmental and corporate entities, which impeded the effectiveness of public health messaging and interventions.

Institutional barriers were pronounced, with a documented shortage of neurologists, limited diagnostic capacity (e.g., CT scanners), and a lack of dedicated stroke units. These systemic failures exacerbated case-fatality rates and undermined both prevention and rehabilitation efforts. At the population level, environmental contamination from oil spills and gas flaring resulted in elevated exposures to heavy metals (e.g., lead, cadmium), directly associated with hypertension and cardiovascular dysfunction (World Stroke Organization, 2025; Nriagu et al., 2016; World Health Organization, 2021)

The degradation of traditional livelihoods, such as farming and fishing, further entrenched economic hardship and psychosocial stress, amplifying upstream drivers of stroke risk (). Policy-level analysis underscored inadequate enforcement of environmental regulations, insufficient investment in health infrastructure, and the

absence of comprehensive state-wide stroke prevention policies.

LCT illuminated how stroke risk accumulates across the lifespan, beginning with maternal exposure to oil-related pollutants during pregnancy, which may influence fetal programming and predispose offspring to cardiovascular dysfunction (Gluckman et al., 2008; Barker, 1995).

Childhood malnutrition and persistent poverty were identified as critical periods that set trajectories for metabolic and cardiovascular health. The "chain of risk" continued into adolescence, marked by the adoption of processed and westernized diets, and culminated in early-onset hypertension and increased stroke risk in adulthood (Akpan, E., Udo, I., & Essien, B. (2025). The cumulative disadvantages environmental, socioeconomic, and behavioral were compounded by systemic failures in healthcare access, resulting in premature stroke and adverse outcomes. Precision Public Health (PPH) provided a strategic lens for translating the nuanced understanding from SEM and LCT into actionable, targeted interventions. Rather than generic campaigns, PPH advocates for precision targeting of high-risk subpopulations, such as communities downstream from gas flaring sites or those with documented oil spill histories. Geospatial mapping and biomarker screening (e.g., blood pressure, heavy metals) facilitate the identification of individuals and groups most in need of intervention. School-based nutritional programs and workplace wellness initiatives offer opportunities to disrupt the chain of risk at critical life stages, while mobile health technologies and electronic health records enhance surveillance and monitoring capacities in remote communities.

Synthesis and Implications for Intervention and Policy

The integrated application of SEM, LCT, and PPH frameworks underscores the necessity for multi-level, contextually tailored public health responses. Effective interventions should include culturally sensitive education campaigns aimed at dietary modification and salt reduction, community-led blood pressure screening, and the strengthening of primary healthcare infrastructure. Telemedicine and remote specialist consultation can bridge gaps in acute stroke care, while policy efforts should prioritize environmental regulation enforcement, health impact assessments in oil and gas licensing, and the development of cross-sectoral "Health in All Policies" strategies (Feigin, V. L., Brainin, M., Norrving, B., et al. (2022).,World Health Organization. (2022), Nriagu, J. O., Udofia, E. A., Ekong, I., & Ebuk, G. (2016).).

Policymakers are urged to foster collaboration among the Ministries of Health, Environment, and Petroleum Resources, with robust corporate social responsibility initiatives directed at building health infrastructure and promoting alternative livelihoods. Reparative justice and sustainable development are central to reducing the stroke burden and advancing health equity in oil-producing communities.

Table 2: Characteristics of Reviewed Studies

Author(s)	**Title of Article**	**Main Findings**	**Submission/Publication Details**
Feigin, V. L. et al.	Global, Regional, and National Burden of Stroke and its Risk Factors, 1990–2019: A Systematic Analysis	Highlights the increasing stroke burden in LMICs, emphasizing environmental and socioeconomic determinants using multilevel frameworks.	The Lancet Neurology, 2022; Published
Bambra, C., Smith, K. E., Pearce, J.	Health Inequalities and Environmental Determinants: A Review	Demonstrates the significance of socio-ecological models in understanding health inequalities linked to environmental exposures, including in oil-producing areas.	Annual Review of Public Health, 2019; Published

Khoury, M. J., Iademarco, M. F., Riley, W. T.	Precision Public Health for the Era of Precision Medicine	Advocates for targeted interventions using precision public health to reduce stroke risk in high-exposure populations.	American Journal of Preventive Medicine, 2018; Published
Ogbemudia, E. A., Adeoye, A. M., Oduwole, O.	Environmental Risk Factors and Stroke Prevalence in the Niger Delta	Identifies oil-related environmental exposures as major contributors to stroke prevalence, supporting the need for integrated frameworks.	African Health Sciences, 2020; Published
Adejumo, O. A., Olagunju, A. T., Fawole, O. I., Ojo, T. M.	Hydrocarbon Pollution and Cardiovascular Risk in Oil-Producing Nigerian Communities	Examines life course and community-level exposures to hydrocarbon pollutants, linking them to increased cardiovascular risk.	Environmental Research, 2021; Published
Marmot, M., Allen, J.	Social Determinants of Health and Cardiovascular Disease	Reviews the cumulative impact of social and environmental determinants on cardiovascular health, emphasizing a life course approach.	Nature Reviews Cardiology, 2014; Published
Ben-Shlomo, Y., Kuh, D.	A Life Course Approach to Chronic Disease Epidemiology	Outlines the importance of timing and accumulation of exposures, especially in vulnerable populations facing environmental hazards.	International Journal of Epidemiology, 2002; Published
Umoh, V. O., Ogunniyi, A., Ekrikpo, U. E.	Stroke Care in Nigeria: A Systematic Review of the Literature	Highlights systemic barriers and environmental factors influencing stroke outcomes in oil-rich communities.	Journal of the Neurological Sciences, 2020; Published
Nwaichi, E. O., Oyibo, J. N., Wegwu, M. O.	Heavy Metal Burden and Hypertension in Oil-Producing Communities of the Niger Delta	Links environmental contamination with hypertension, advocating for integrated surveillance and intervention strategies.	Environmental Science and Pollution Research, 2021; Published
Dowell, S. F., Tappero, J. W., Frieden, T. R., et al.	Four Steps to Precision Public Health	Proposes a framework for precision interventions, including geospatial mapping in environmental health contexts.	Nature, 2016; Published
Diez Roux, A. V.	Conceptual Approaches to the Study of Health Disparities	Discusses the integration of socio-ecological and life course perspectives to address health disparities in polluted settings.	Annual Review of Public Health, 2012; Published

Sen, A., Al-Rawaf, H. A., Al-Ghamdi, S. S.	Environmental Pollutants and Developmental Origins of Cardiovascular Disease: A Narrative Review	Explores early-life exposures to pollutants and their long-term impact on cardiovascular health, using a life course lens.	Journal of Developmental Origins of Health and Disease, 2022; Published
Sallis, J. F., Floyd, M. F., Rodríguez, D. A., Saelens, B. E.	An Ecological Approach to Creating Active Living Communities	Applies the socio-ecological model to community health promotion, relevant for intervention design in oil-producing areas.	Annual Review of Public Health, 2008; Published
Oriji, O. K., Jeremiah, S., Allagoa, D. O.	Psychosocial Stress and Cardiovascular Health in the Niger Delta: A Review	Identifies psychosocial and environmental stressors as key contributors to cardiovascular disease in oil-rich environments.	Nigerian Health Journal, 2019; Published
Wahab, K. W., Okubadejo, N. U., Danesi, M. A.	The Rising Burden of Stroke in Nigeria: A Review of the Literature	Documents the increasing stroke burden in Nigeria's oil-producing regions, citing multilevel determinants.	Journal of Stroke Medicine, 2021; Published
Adebayo, R. A., Balogun, M. O., Adedoyin, R. A.	Prevalence and Determinants of Hypertension Among Adults in a Rural Niger Delta Community: A Cross-Sectional Study	Reports high hypertension prevalence linked to environmental and socioeconomic factors in oil-producing communities.	Nigerian Journal of Clinical Practice, 2019; Published
Dike, O. C.	Cultural Food Practices and Their Health Implications in the Niger Delta	Examines dietary patterns within the socio-ecological context, relating them to cardiovascular risk.	Journal of African Health Sciences, 2022; Published
Halfon, N., Hochstein, M.	Life Course Health Development: An Integrated Framework	Presents a life course model for understanding chronic disease development, applicable to environmental health disparities.	Maternal and Child Health Journal, 2002; Published
Nriagu, J. O., Udofia, E. A., Ekong, I., Ebuk, G.	Health Risks Associated with Oil Pollution in the Niger Delta, Nigeria	Documents environmental exposures and associated cardiovascular risks, recommending integrated surveillance and intervention.	International Journal of Environmental Research and Public Health, 2016; Published

Contextualizing the Stroke Burden and the Need for Integrated Frameworks

Articles were selected based on their relevance to the burden of stroke, application of multilevel frameworks, and focus on environmental and socioeconomic determinants in resource-constrained settings. The escalating burden of stroke in oil-producing communities, particularly in Akwa Ibom State, Nigeria, underscores the urgent need for nuanced, multilevel frameworks that integrate socio-ecological, life course, and precision public health perspectives. The confluence of environmental degradation, socioeconomic adversity,

and inadequate health infrastructure in these regions has created a complex landscape for cardiovascular health, necessitating comprehensive strategies for effective prevention and intervention (Feigin et al., 2022; Wahab, Okubadejo, & Danesi, 2021). Synthesizing evidence from recent literature, this discussion highlights how integrating these frameworks can illuminate the multilevel determinants of stroke and inform targeted, context-sensitive public health responses.

A socio-ecological lens reveals that oil-producing communities face disproportionate exposure to environmental hazards, most notably, hydrocarbon pollution, heavy metals, and habitat degradation, which have been robustly linked to increased stroke and cardiovascular risk (Ogbemudia, Adeoye, & Oduwole, 2020; Nwaichi, Oyibo, & Wegwu, 2021; Nriagu et al., 2016). Studies in the Niger Delta and Akwa Ibom State demonstrate that chronic exposure to oil-related contaminants and heavy metals such as lead and cadmium is associated with elevated rates of hypertension and stroke (Adejumo et al., 2021; Nwaichi et al., 2021). Socioeconomic determinants, poverty, limited access to healthcare, and psychosocial stress, exacerbate these risks by limiting resilience and adaptive capacity at both individual and community levels (Marmot & Allen, 2014; Oriji, Jeremiah, & Allagoa, 2019; Adebayo, Balogun, & Adedoyin, 2019). The socio-ecological model thus provides a critical framework for understanding how environmental exposures and social disadvantage interact across multiple levels to shape health outcomes (Bambra, Smith, & Pearce, 2019; Sallis et al., 2008).

The life course approach elucidates how the timing, duration, and accumulation of environmental and socioeconomic exposures across an individual's lifespan contribute to stroke risk. Evidence suggests that early-life exposures to environmental pollutants, such as those encountered in oil-producing communities, can have lasting effects on the development of cardiovascular disease, with risk accumulating through childhood, adolescence, and adulthood (Sen, Al-Rawaf, & Al-Ghamdi, 2022; Ben-Shlomo & Kuh, 2002). Life course models emphasize the importance of critical periods, such as gestation and early childhood, when vulnerability to environmental toxins is heightened and can set the trajectory for later disease (Halfon & Hochstein, 2002; Diez Roux, 2012). Additionally, the cumulative burden of psychosocial stress, poor nutrition, and sustained socioeconomic disadvantage further amplifies stroke risk, reinforcing the need for early and sustained interventions (Marmot & Allen, 2014; Dike, 2022).

Precision public health offers a paradigm for developing and deploying interventions that are tailored to the unique environmental, social, and biological contexts of high-risk populations. By leveraging geospatial mapping, community-level surveillance, and risk stratification, precision public health enables the identification of micro-environments and subpopulations at greatest risk for stroke and related cardiovascular conditions (Dowell, Tappero, & Frieden, 2016; Khoury, Iademarco, & Riley, 2018). In the context of Akwa Ibom State, such approaches can facilitate the deployment of targeted interventions—such as environmental remediation, blood pressure screening, and health education, in communities most affected by oil pollution and socioeconomic deprivation. The integration of precision strategies with population-level surveillance is critical for monitoring trends, evaluating intervention impact, and informing adaptive policy responses (Feigin et al., 2022; Nriagu et al., 2016).

A comprehensive response to the stroke burden in oil-producing communities requires the integration of socio-ecological, life course, and precision public health frameworks. Such an approach recognizes the interplay between environmental exposures, social determinants, and temporal factors in shaping disease risk and progression (Diez Roux, 2012; Halfon & Hochstein, 2002). Integrated models facilitate the design of interventions that are not only context-specific and culturally appropriate but also responsive to the cumulative and dynamic nature of risk in these communities (Sallis et al., 2008; Bambra et al., 2019). This synthesis supports the development of multifaceted strategies, combining environmental regulation, community empowerment, early-life interventions, and precision targeting, that can effectively address health disparities and reduce the burden of stroke in vulnerable populations.

The evidence underscores the necessity for policy frameworks and public health programs that prioritize environmental remediation, integrated surveillance, and the reduction of socioeconomic barriers to care (UNEP, 2011; Wahab, Okubadejo, & Danesi, 2021). Policymakers should consider cross-sectoral collaborations involving health, environment, and social welfare agencies to implement comprehensive interventions. Community engagement and culturally informed health promotion are essential to enhance intervention uptake and sustainability. Additionally, investment in longitudinal research and surveillance systems will be vital for monitoring exposure trajectories and evaluating the effectiveness of integrated strategies (Umoh, Ogunniyi, & Ekrikpo, 2020; Nriagu et al., 2016).

CONCLUSION

In conclusion, the stroke burden in Akwa Ibom State's oil-producing communities represents a multifaceted syndemic, shaped by the persistent convergence of environmental contamination, deep-rooted socioeconomic hardship, and inadequate health

infrastructure. The systematic application of the Socio-Ecological Model and Life Course Theory throughout this review offers a nuanced, layered understanding of how risk factors accumulate across the lifespan and interact across individual, community, and societal levels. This integrated perspective clarifies that stroke risk in these communities is not the result of isolated exposures, but rather the cumulative effect of chronic environmental toxins, poverty, psychosocial stress, and limited access to care beginning as early as prenatal development and continuing throughout the life course.

The incorporation of Precision Public Health principles provides actionable tools for translating this contextual understanding into effective, targeted interventions. Approaches such as biomarker surveillance, geospatial risk mapping, and community-level risk stratification enable the identification and prioritization of high-risk populations, optimizing resource allocation and intervention delivery. These strategies, rooted in a comprehensive framework, support the development of policies and public health programs that are both evidence-based and responsive to the complex realities faced by oil-producing regions.

Furthermore, the review's adherence to rigorous methodologies ensures the reliability and transparency of its findings, while its integrative approach highlights the necessity of coordinated, cross-sectoral efforts to address the intertwined determinants of stroke. Future research should emphasize longitudinal cohort studies to better quantify the impact of life course exposures and evaluate the effectiveness of integrated interventions. Ultimately, this synthesis advances epidemiological and public health knowledge by elucidating the syndemic nature of stroke in marginalized, environmentally burdened communities and charting a path toward comprehensive, context-sensitive strategies for prevention, intervention, and policy reform tailored to Akwa Ibom and similar settings.

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