Beyond Crashes: The Silent Burden of Non-Physically Injurious Traffic Externalities in Nigeria- An Integrative Review

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ABSTRACT

Urbanisation and rapid motorisation across Nigeria have intensified chronic environmental exposures associated with road transportation systems. While road traffic crashes have historically dominated transport safety discourse, accumulating evidence indicates that non-physically injurious traffic externalities including traffic-related air pollution (TRAP), noise, vibration, and heavy-metal contamination constitute a significant but under-recognised burden on public health and environmental sustainability. These "silent burdens" do not manifest as immediate physical injuries but progressively contribute to respiratory and cardiovascular diseases, cognitive impairment, psychosocial stress, and ecological degradation. This study adopts an integrative review methodology, systematically guided by the PRISMA 2020 Statement framework to enhance transparency and rigour in the identification, screening, and selection of relevant literature. Evidence was synthesised across multidisciplinary domains, including environmental engineering, epidemiology, behavioural science, and urban policy, drawing on peer-reviewed and grey literature published between 2000 and 2025. The PRISMA-guided process resulted in a final corpus of 50 studies, enabling a comprehensive examination of exposure pathways, health outcomes, and contextual drivers. Findings reveal disproportionately high exposure levels among socio-economically marginalised populations residing or working along major traffic corridors, largely driven by weak regulatory enforcement, inadequate urban planning, and pervasive informal land-use practices. The review further identifies critical gaps in environmental monitoring systems, policy integration, and longitudinal health evidence. Thus, the study demonstrates that non-physically injurious traffic externalities represent a major yet systematically neglected public health challenge in Nigeria and similar developing contexts. Addressing these cumulative risks requires a paradigm shift toward integrated policy responses, including strengthened environmental monitoring, enforcement of land-use setbacks, reform of vehicular emission standards, and the mainstreaming of environmental health considerations into transport and urban planning frameworks. This review provides a robust evidence base for advancing policy reform and guiding future research aimed at mitigating the long-term health and environmental impacts of transport-related externalities in rapidly urbanising regions.

Keywords: Environmental Contamination; Heavy metals; Non-physically injurious traffic externalities; Particulate Matters, Roadside residents exposure; Vehicular Emission; Traffic Noise; Urbanisation.

INTRODUCTION

Urban areas worldwide are increasingly grappling with the complex challenges posed by rapid motorization and expanding transportation networks. While transportation remains vital for economic growth and social connectivity, it simultaneously generates a range of negative externalities that extend beyond road crashes. These include air pollution, traffic noise, heavy metal contamination, and vibrations collectively termed non-physically injurious traffic externalities. These externalities do not result in immediate bodily harm but contribute significantly to deteriorating environmental quality, heightened health risks, and diminished well-being among exposed populations. Traffic-related air pollution (TRAP) alone has been identified as a severe global threat, responsible for premature mortality and a wide range of diseases (Akintomide et al., 2024; Long et al., 2021). Likewise, road traffic remains a major source of harmful pollutants, including particulate matter and nitrogen oxides, which continue to exceed safe limits in many cities worldwide (Vosough et al., 2022; Fernandes et al., 2019).

The rapid pace of urbanization and economic growth further intensifies these externalities, particularly in developing regions. Studies show that urban expansion, increased vehicle ownership, and inadequate infrastructure contribute to worsening congestion, degraded air quality, and elevated noise levels (Peñabaena-Niebles et al., 2020; Wen et al., 2020; Fageda et al., 2022). Globally, over 90% of urban residents are exposed to air pollution levels that surpass World Health Organization standards, resulting in millions of premature deaths annually (Vosough et al., 2022; WHO, 2021). Alongside air pollution, traffic noise has emerged as one of the most pervasive environmental stressors in urban spaces, linked to sleep disruption, stress, cardiovascular diseases, and cognitive impairment (Guijarro, 2019; Welch et al., 2023; Ibili et al., 2022). These impacts highlight a growing recognition of the need to address chronic, non-injury harms associated with transportation systems.

In the African context, and particularly in Nigeria, the situation is more acute due to rapid urban population growth, inadequate land-use planning, and weak regulatory enforcement. Nigeria's urban population continues to expand, with major cities like Lagos, Abuja, Kano, and Port Harcourt facing increasing pressure from vehicular emissions and dense traffic flows (Akanji & Obinna, 2025; Olise, 2025). Vehicle emissions contribute significantly to ambient air pollution in the country, with pollutants such as $PM_{2.5}$, PM_{10}, NO_2, CO, and SO_2 posing substantial health risks (Akanji & Obinna, 2025; Akintomide et al., 2023). Lagos alone records over 11,000 annual deaths attributable to air pollution (Ajayi et al., 2025). At the same time, noise pollution levels in many Nigerian cities far exceed national and WHO limits, yet remain poorly monitored and understudied (Ibili et al., 2022). This persistent exposure forms a silent public health challenge affecting millions of urban residents.

Compounding these issues is the pattern of roadside settlement and encroachment prevalent across many Nigerian cities. Informal traders, low-income households, and roadside squatters often occupy spaces along major highways and arterial roads in search of economic opportunities (Tijjani et al., 2025; Tijjani et al., 2023). However, such proximity to high-traffic corridors increases their vulnerability to non-physically injurious externalities, including exposure to toxic pollutants, chronic noise, and heavy metals deposited in roadside soils (Kim et al., 2019; Lallawmzuali et al., 2024). These environmental exposures are associated with elevated risks of respiratory and cardiovascular illnesses, neurotoxicity, stress, and other long-term health effects (Boahen, 2024; Kholikulov et al., 2025). The combination of socio-economic marginalization and environmental hazard exposure further exacerbates inequality in urban health outcomes.

Despite the growing body of evidence linking traffic externalities to significant health and environmental consequences globally, research in Nigeria remains fragmented. Many Nigerian studies focus on air pollution, noise, or heavy metal contamination in isolation, with limited integration of these exposures within a broader framework of non-physically injurious externalities. Moreover, robust emission inventories, continuous monitoring systems, and longitudinal health assessments remain largely absent (Ajayi et al., 2025; Olise, 2025). This results in substantial knowledge gaps regarding the cumulative and long-term impacts of chronic exposure on roadside residents and other vulnerable populations. Understanding these combined burdens is essential for informing evidence-based policies that address the full spectrum of transport-induced harms in Nigeria.

Given these realities, the present review aims to synthesize existing evidence on the long-term impacts of non-physically injurious traffic externalities on roadside residents in Nigeria. By consolidating research on air pollution, noise, heavy metals, and other chronic exposures, this study provides a comprehensive understanding of how transportation systems affect public health and environmental quality beyond road crashes. The justification for this review lies in the urgent need to highlight these silent but significant burdens, identify research gaps, and support the development of integrated mitigation strategies tailored to Nigeria's rapidly urbanizing environment.

METHODOLOGY

Review Design

This study adopted an integrative review design, which is particularly suited for synthesising diverse forms of empirical, conceptual, and policy-oriented evidence to address complex environmental and public health challenges such as non-physically injurious traffic externalities. The approach aligns with Torraco's (2005) conceptualisation of integrative reviews as a means of generating new theoretical insights through the systematic integration of heterogeneous knowledge domains. The methodological process followed the five-stage framework proposed by Whittemore and Knafl (2005), encompassing problem identification, literature search, data evaluation, data analysis, and presentation. To strengthen methodological rigour and meet the expectations of high-impact journals, the study incorporated elements of the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to guide the identification, screening, eligibility, and inclusion of studies while preserving the flexibility inherent in integrative synthesis (Kutcher & LeBaron, 2022). This hybrid methodological approach ensured transparency, reproducibility, and systematic documentation of the review process, culminating in a rigorously screened body of evidence for analysis.

Search Strategy

A comprehensive and systematic search strategy was employed to ensure adequate coverage of multidisciplinary literature on traffic-related environmental externalities and their associated health and socio-environmental implications. The search was conducted across major electronic databases, including Scopus, Web of Science, PubMed, ScienceDirect, and IEEE Xplore, to capture studies spanning environmental science, transport research, public health, and engineering domains. To address the limitations of indexed databases in capturing context-specific evidence, grey literature sources such as policy documents, institutional reports, environmental impact assessments, and publications from international organisations including the World Health Organization were also incorporated. The review covered studies published between 2000 and 2025, reflecting the period characterised by rapid urbanisation, increased motorisation, and growing environmental health concerns in Nigeria and comparable developing contexts. The search strategy combined controlled vocabulary and free-text keywords structured around key thematic domains, including traffic externalities, environmental exposures, health outcomes, and geographic context, with Boolean operators applied to refine search outputs. To enhance completeness, backward and forward citation tracking techniques were also employed to identify additional relevant studies not captured through database searches.

Eligibility Criteria and Quality Appraisal

The study selection process followed a structured and transparent approach consistent with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (PRISMA 2020 Statement; Page et al., 2021), involving a two-stage screening procedure comprising title and abstract review followed by full-text eligibility assessment. During the initial screening stage, studies unrelated to traffic-induced environmental exposures, those conducted outside urban or peri-urban contexts, and those focusing exclusively on road crashes or physically injurious outcomes were excluded. The second stage involved detailed full-text assessment using predefined inclusion and exclusion criteria to ensure relevance and methodological rigour. Studies were included if they addressed non-physically injurious traffic externalities such as air pollution, noise, vibration, and heavy metal contamination; were conducted in Nigeria or comparable developing urban contexts; and employed empirical, modelling, engineering, or conceptual approaches with measurable environmental or health outcomes. Studies were excluded if they focused solely on traffic injuries, were non-

English, or lacked substantive empirical or conceptual contribution. This systematic process resulted in a final sample of 50 studies, as illustrated in the PRISMA flow diagram (Figure 2.1). To ensure methodological consistency across diverse study designs, a multimodal quality appraisal framework was applied, whereby quantitative studies were assessed based on sampling adequacy, measurement validity, confounder control, and statistical robustness; qualitative studies were evaluated for credibility and analytical depth; engineering and modelling studies were assessed based on methodological transparency and validation procedures; and policy documents were appraised for relevance, institutional credibility, and evidentiary support. Each study was subsequently categorised according to its methodological strength, thereby enhancing the reliability of the integrative synthesis.

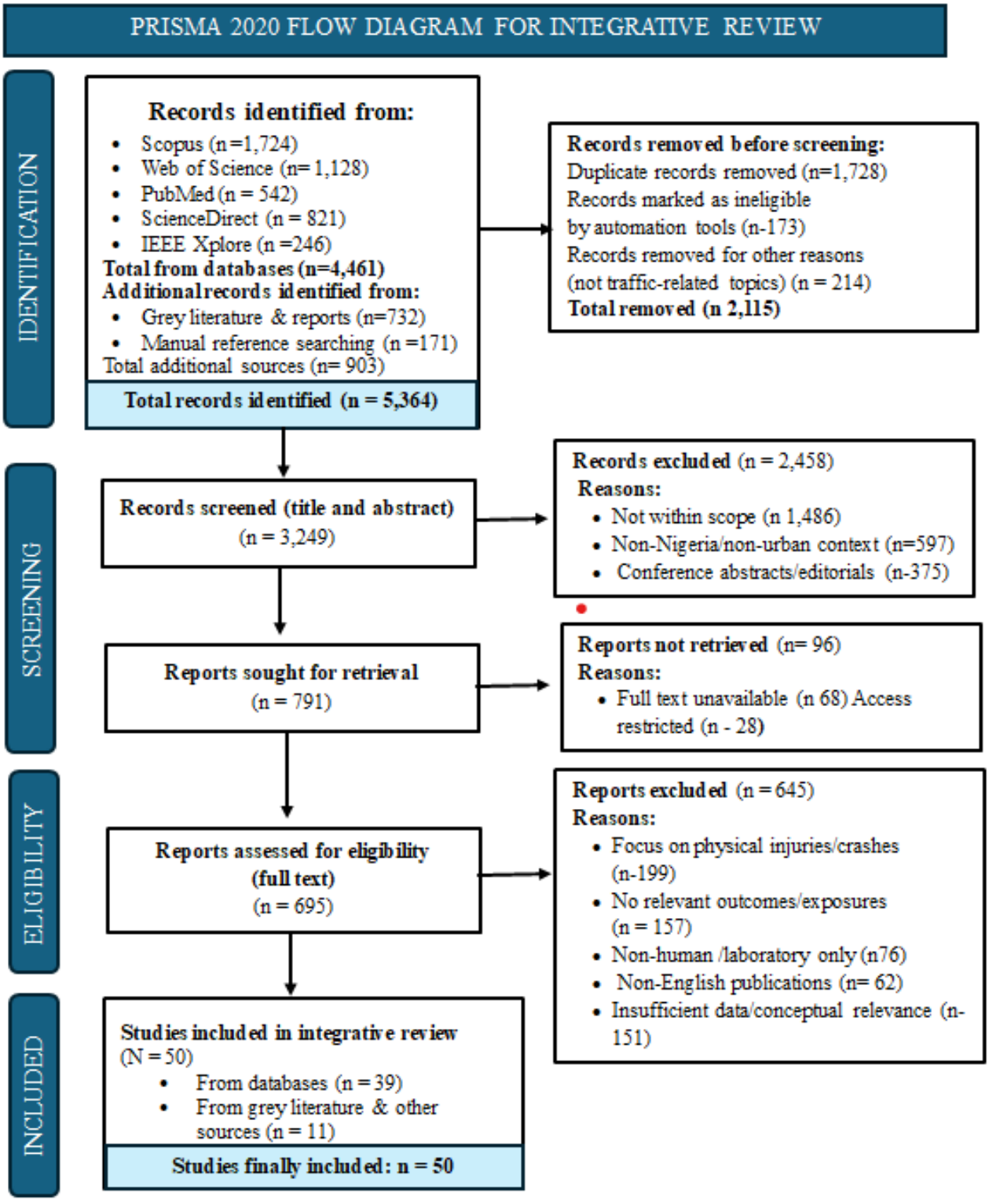

Figure 2.1: PRISMA 2020 Flow Diagram Illustrating the Study Selection Process for the Integrative Review

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Data Extraction and Analytical Procedures

Data extraction was conducted using a structured and standardised template designed to ensure consistency and comparability across the included studies, capturing key variables such as bibliographic details, study location, research design, type of traffic-related externality, exposure indicators (including particulate matter concentrations, noise levels, and heavy metal presence), health and environmental outcomes, and major findings with associated policy implications. The analytical procedure followed an iterative integrative synthesis approach as proposed by Torraco (2005), involving stages of data reduction, data display, and comparative analysis. Extracted data were initially organised into thematic clusters reflecting major disciplinary domains, including engineering and exposure assessment, epidemiological and health outcomes, behavioural and socio-environmental interactions, and regulatory or policy analyses. Cross-study comparison was then undertaken to identify patterns of convergence, divergence, and emerging relationships, while thematic integration was guided by the principles of data synthesis articulated by Whittemore and Knafl (2005), enabling triangulation across diverse methodological traditions. Reflexive synthesis was further employed to interpret conflicting evidence and ensure transparency in analytical decisions, thereby strengthening the robustness and coherence of the integrative review findings.

Integrative Synthesis and Conceptual Development

The final stage of the methodology involved the development of an integrative conceptual framework that systematically maps the interrelationships between traffic-related environmental exposures, contextual modifiers, and cumulative health and environmental risks associated with non-physically injurious traffic externalities in Nigeria. Consistent with the theoretical orientation of integrative reviews, this stage extends beyond descriptive aggregation to the generation of new conceptual insights through the synthesis of heterogeneous evidence (Torraco, 2005). Drawing on the analytical procedures outlined in Section 2.4, findings were integrated across disciplinary domains to identify recurring patterns of chronic exposure to air and noise pollution, pronounced socio-spatial vulnerabilities among roadside populations, regulatory and institutional limitations, and behavioural mediators influencing risk perception and adaptation. Guided by the principles of data integration and synthesis advanced by Whittemore and Knafl (2005), the process emphasised conceptual coherence, explanatory depth, and practical relevance, while reflexive synthesis, as recommended by Kutcher and LeBaron (2022), enabled the reconciliation of divergent findings and the incorporation of context-specific dynamics. Particular attention was given to the distinctive characteristics of Nigerian urban environments, including informal land-use practices, highway setback encroachment, and the prioritisation of economic survival over environmental health considerations. The resulting framework provides a robust basis for theoretical advancement, highlights critical gaps in existing knowledge, and directly informs the policy implications and research directions presented in subsequent sections.

CONCEPTUALISING NON-PHYSICALLY INJURIOUS TRAFFIC EXTERNALITIES

Non-physically injurious traffic externalities represent a category of transportation-induced impacts that, although lacking immediate bodily harm, exert chronic, cumulative, and often irreversible effects on human wellbeing and environmental quality. These externalities primarily traffic-related air pollution (TRAP), noise pollution, heavy-metal contamination, and road-induced vibrations emerge continuously from routine vehicular activities and the broader functioning of urban transportation systems. Unlike crash-related injuries, which tend to be acute, visible, and well-documented in transportation discourse, non-physically injurious externalities operate silently and persistently, accumulating exposure risks over time and disproportionately affecting vulnerable populations. Their significance has increasingly been recognised in global transport and environmental research, with mounting evidence linking chronic exposure to long-term morbidity and mortality (Akintomide et al., 2024; Long et al., 2021).

Distinguishing Non-Injury Traffic Externalities from Traditional Transport Harms

Historically, transportation safety scholarship has prioritised road crashes, trauma outcomes, and the economic cost of accidents. While these remain vital concerns, narrow focus on crash-related harms obscures the broader

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environmental burdens generated by motorisation. Non-physically injurious externalities differ conceptually and operationally from crash injuries in several ways. First, they lack a definable event; instead, they manifest through continuous, low-level exposures that may accumulate over years or decades. Second, their impacts are often diffuse, affecting large populations across wide geographical areas rather than discrete individuals involved in traffic incidents. Third, their health and environmental effects can be subtle, insidious, and difficult to attribute directly, heightening their invisibility in policy discourse.

Traffic-related air pollution exemplifies this phenomenon. Unlike vehicular collisions that produce immediate bodily injury, TRAP infiltrates urban environments silently, contributing to respiratory, cardiovascular, and inflammatory diseases that develop gradually over time (Fernandes et al., 2019; Vosough et al., 2022). Similarly, road traffic noise though often dismissed as a nuisance disrupts sleep, induces stress responses, and elevates long-term cardiovascular risks (Ibili et al., 2022; Welch et al., 2023). Heavy metals such as lead, cadmium, and zinc accumulate in roadside soils, posing chronic neurotoxic risks that can impair cognitive function or child development (Kim et al., 2019; Lallawmzuali et al., 2024). These harms, though not immediately visible, form a profound and widening public health burden.

Global Perspectives on Non-Physically Injurious Traffic Externalities

Globally, non-injury traffic externalities have emerged as a major concern in environmental health and urban studies. Over 90 percent of urban populations are exposed to air pollution levels exceeding World Health Organization limits, with millions of deaths annually attributed to airborne contaminants from transportation and industrial sources (Vosough et al., 2022; WHO, 2021). Cities in Asia, Latin America, and Africa face dual pressures of rapid population growth and expanding vehicle fleets, magnifying the intensity of chronic exposures. Studies from rapidly urbanising regions highlight the interaction between land-use patterns, road network density, and the spatial clustering of vulnerable populations as key determinants of health outcomes (Peñabaena-Niebles et al., 2020; Wen et al., 2020).

Within this global context, the Nigerian experience aligns with patterns observed in other developing regions yet also presents distinct features. Unregulated emissions from ageing vehicle fleets, widespread roadside trading, sprawling urban development, and weak enforcement of environmental regulations intensify exposures beyond levels typically observed in more regulated settings (Akanji & Obinna, 2025; Olise, 2025). This combination of structural, environmental, and socio-economic factors highlights the importance of understanding non-physically injurious traffic externalities not merely as isolated exposures but as systemic outcomes embedded within broader urbanisation processes.

Environmental Pathways and Mechanisms of Exposure

Non-physically injurious externalities arise from multiple, overlapping environmental pathways. Vehicular emissions generate particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide, sulphur dioxide, carbon monoxide, and a range of hydrocarbons that disperse unevenly across urban spaces, concentrating near busy roads (Akintomide et al., 2023; Fernandes et al., 2019). Noise pollution is emitted from engine operations, honking, tyre-road friction, and traffic flow variability, spreading through dense urban corridors and reverberating between buildings. Heavy-metal pollutants originate from brake wear, tyre abrasion, engine corrosion, and the deposition of contaminated particulates onto roadside soils (Kim et al., 2019; Boahen, 2024).

The physical behaviour of these pollutants is shaped by atmospheric conditions, urban morphology, traffic density, and roadway characteristics. For instance, particulate matter concentrations exhibit strong distance decay, with steep gradients typically observed within 100 metres of major roadways distances within which many Nigerian households, traders, and informal settlements reside (Lallawmzuali et al., 2024). Traffic noise behaves similarly but can propagate further depending on building density, topography, and reflective surfaces. These dynamics create highly localised environmental risk zones that disproportionately affect roadside populations.

The Nigerian Context: Urbanisation and Structural Vulnerabilities

Nigeria's urbanisation patterns intensify the impacts of non-physically injurious externalities. Large cities such as Lagos, Abuja, Kano, and Port Harcourt have witnessed explosive population growth alongside increasing vehicle ownership, inadequate public transportation, and sprawling unplanned settlements (Akanji & Obinna, 2025; Olise, 2025). This rapid growth has outpaced infrastructural expansion, resulting in congested roads, poorly maintained vehicles, and limited green buffers or setbacks. As urban spaces densify, residents increasingly reside in close proximity to major roads where exposure to air and noise pollution is highest.

Furthermore, informal economic activities such as street vending, roadside markets, and open workshops frequently cluster around high-traffic corridors due to their economic advantages. These spaces often unregulated serves as both livelihoods and primary social environments for millions, yet expose workers to traffic-induced pollution for prolonged periods (Tijjani et al., 2025; Tijjani et al., 2023). For children, roadside schools and residential proximity amplify long-term vulnerability to neurotoxic and respiratory risks associated with traffic emissions (Lallawmzuali et al., 2024; Boahen, 2024).

Cumulative and Intersecting Burdens

A defining feature of non-physically injurious traffic externalities is their cumulative nature. Unlike single-exposure events, these externalities interact synergistically. Exposure to particulate matter may compound the cardiovascular impacts of chronic noise, while heavy-metal contamination in soils may heighten neurological risks already aggravated by TRAP or psychosocial stress. Several studies indicate that chronic stress from noise pollution can exacerbate respiratory or cardiovascular vulnerabilities induced by airborne pollutants (Guijarro, 2019; Welch et al., 2023). In Nigerian settings where multiple exposures converge spatially, cumulative burdens may exceed levels documented in other regions.

This cumulative exposure model also intersects with socio-economic status. Households with limited resources often lack adequate housing insulation, air filtration, or soundproofing. Informal workers and low-income groups cannot relocate to safer distances from roads, resulting in chronic, multi-source exposures that accumulate throughout the life course. These intersections of environmental burdens and socio-economic disadvantage highlight the need for an integrated conceptualisation of non-physically injurious traffic externalities one that situates them within urban inequality frameworks and public health risk models.

Theoretical Implications for Transport, Environment, and Health Research

Conceptualising non-physically injurious traffic externalities in this integrated manner carries significant implications for both scholarship and policy. First, it challenges traditional boundaries between transport engineering, environmental science, and public health by positioning these externalities as overlapping risks that require interdisciplinary assessment. Second, it emphasises the need for long-term, cumulative exposure studies that move beyond short-term measurements or isolated pollutant assessments. Third, it highlights the importance of spatial justice frameworks for interpreting the distribution of environmental harms, especially in informal or marginalised urban settings.

In Nigeria, where urbanisation, informal economy dynamics, and infrastructural deficits shape exposure landscapes, these theoretical considerations are critical for developing effective mitigation strategies. Understanding the interconnected nature of non-physically injurious externalities provides the foundation for subsequent sections of this review, which examine sources, impacts, vulnerabilities, and institutional gaps.

SOURCES, SPATIAL PATTERNS AND ENVIRONMENTAL BEHAVIOUR OF TRAFFIC-INDUCED EXTERNALITIES

Non-physically injurious traffic externalities arise from diverse but interconnected sources embedded within the structure and operation of urban road transportation systems. Their environmental behaviour is shaped by complex interactions between vehicular activity, urban morphology, atmospheric conditions, and socio-spatial arrangements. In Nigerian cities undergoing rapid urbanisation, the dynamics of these externalities are amplified by infrastructure deficits, informal land-use patterns, and regulatory weaknesses. This section

synthesizes the sources, spatial distributions, and environmental processes shaping air pollutants, noise, heavy metals, and other chronic traffic-related exposures (Ajayi, 2025; Akintomide et al., 2023; Fernandes et al., 2019).

Primary and Secondary Sources of Traffic-Related Air Pollution

Traffic-related air pollution (TRAP) arises primarily from incomplete combustion of fossil fuels in internal combustion engines, producing $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and VOCs (Akintomide et al., 2023; Fernandes et al., 2019; Ajayi, 2025). In Nigerian cities, emissions are exacerbated by ageing fleets, poor engine maintenance, substandard fuels, and weak emission controls (Akanji & Obinna, 2025). Congestion and prolonged idling elevate ambient concentrations, creating persistent exposure for roadside residents. Secondary pollutants, including ozone, form via photochemical reactions under high temperatures and strong solar radiation, particularly in mixed-use industrial and transport corridors (Ajayi, 2025; Raheem et al., 2019).

Non-Exhaust Emissions: Brake Wear, Tyre Abrasion, and Road Dust Re-suspension

Non-exhaust sources substantially contribute to roadside pollutant loads. Brake wear, tyre abrasion, lubricating fluids, and corroded vehicle parts release heavy metals (Pb, Cd, Zn, Cu) into soils and road dust (Fussell et al., 2022; Jeong et al., 2022; Kim et al., 2019; Lallawmzuali et al., 2024). Road dust is resuspended into the air under dry, windy, and high-traffic conditions. Deteriorated roads, unpaved shoulders, and informal roadside activities (mechanics, petty trading, open burning) amplify deposition and resuspension, reinforcing chronic exposure for nearby populations.

Traffic Noise: Engines, Road Conditions, and Urban Form

Traffic noise in Nigerian urban corridors originates from engine operations, honking, tyre-road interaction, and poorly maintained vehicles (Guijarro, 2019; Ibili et al., 2022; Itaa et al., 2023). Road surface degradation, including potholes and uneven pavements, produces impulsive noise bursts, aggravating baseline levels and contributing to sleep disturbance, stress, and cardiovascular strain (Welch et al., 2023). Urban form modulates noise propagation: narrow streets with tall buildings create canyon effects, while open roadside settlements lack acoustic buffers, exposing residents to high-intensity noise.

Spatial Distribution and Distance-Decay Behaviour of Pollutants

Pollutant concentrations generally decline with distance from roadways (distance-decay), particularly $PM_{2.5}$, PM_{10}, NO_2, and ultrafine particles (Akintomide et al., 2023; Hameed et al., 2024; Lallawmzuali et al., 2024). In Nigeria, where residences, markets, and workplaces are often within 50-100 m of major roads, populations experience the highest exposures. Traffic density, fleet composition, topography, and heat-island effects further shape these patterns. Noise also decays with distance but is influenced by reflective surfaces, barriers, and vehicle types, leading to persistently high exposure in dense commercial zones or enclosed streets.

Urban Morphology, Land Use, and Environmental Behaviour

Urban morphology governs pollutant behaviour. Street canyons formed by dense, high-rise buildings trap particulate matter, prolonging residence time (Fageda et al., 2022; Matthaios et al., 2024; Wen et al., 2019). High-traffic commercial and industrial zones create emission hotspots, while informal settlements lacking green buffers face sustained exposure. Road curvature, slope, and width influence vehicle acceleration and deceleration patterns, amplifying emissions, brake and tyre wear, and reducing pollutant dispersal, intensifying exposure in dense corridors.

Meteorological Influences: Temperature, Wind, and Humidity

Meteorological conditions strongly control pollutant dispersion. High temperatures accelerate secondary pollutant formation, while low wind speeds and atmospheric stability allow accumulation near the ground

(Lallawmzuali et al., 2024; Onuorah et al., 2019). Dry seasons increase dust resuspension, elevating particulate burdens. Humidity affects particle agglomeration and deposition; high humidity may reduce airborne particulates but promotes mould growth in poorly ventilated dwellings, compounding health risks.

Implications of Environmental Behaviour for Roadside Populations

The interplay of urban form, traffic behaviour, and socio-economic patterns creates hotspots of simultaneous exposure to PM, NO_2, heavy metals, and noise (Ajayi, 2025; Akintomide et al., 2023; Lallawmzuali et al., 2024). Informal traders, schoolchildren, transport workers, and low-income households experience cumulative health risks. These patterned exposures constitute the "silent burden" of traffic externalities, disproportionately affecting populations with limited capacity to mitigate or avoid risk.

LONG-TERM HEALTH, COGNITIVE AND PSYCHOSOCIAL IMPACTS ON ROADSIDE RESIDENTS

Non-physically injurious traffic externalities exert cumulative impacts on health, cognition, psychological well-being, and quality of life, particularly among roadside populations chronically exposed to multiple stressors. In rapidly urbanising Nigerian cities with weak environmental regulation, these effects are amplified. This section synthesises empirical and conceptual evidence on the long-term consequences of exposure to air pollution, noise, heavy metals, and spatially concentrated environmental burdens (Ajayi, 2025; Akintomide et al., 2024; Lallawmzuali et al., 2024).

Respiratory and Cardiovascular Health Impacts

Prolonged exposure to $PM_{2.5}$, PM_{10}, and NO_2 increases the risk of asthma, COPD, and bronchitis, inducing inflammatory responses that accumulate over time (Akintomide et al., 2024; Ajayi et al., 2025; Akanji & Obinna, 2025; Olise, 2025). Cardiovascular risks—including hypertension, ischaemic heart disease, arteriosclerosis, and stroke—are linked to chronic exposure to $PM_{2.5}$, NO_2, and CO, amplified by co-existing noise stress (Long et al., 2021; Vosough et al., 2022; Fernandes et al., 2019). In Nigerian urban centres, unregulated vehicle emissions and congested road networks create cumulative exposure exceeding that in more regulated settings.

Neurological and Cognitive Impairments

Chronic exposure to heavy metals (Pb, Cd, Zn) and ultrafine particles is neurotoxic, impairing cognitive development, reducing IQ, and inducing behavioural disorders (Kim et al., 2019; Lallawmzuali et al., 2024; Boahen, 2024). Daily exposure in roadside schools, informal settlements, and markets increases oxidative stress, inhibits neurotransmission, and promotes neuro-inflammation. Long-term TRAP exposure further contributes to cognitive decline and elevated risk of neurodegenerative disease.

Psychosocial and Mental Health Impacts

Traffic noise induces sleep disruption, fatigue, impaired cognition, and cardiovascular strain (Ibili et al., 2022; Welch et al., 2023). Persistent noise elevates cortisol, stimulates sympathetic activity, and triggers stress, anxiety, and depression (Guijarro, 2019). In informal settlements, noise combines with poor housing, limited green space, and high population density to exacerbate psychosocial strain and reduce quality of life.

Risks to Children and Vulnerable Populations

Children are especially susceptible due to developing respiratory, neurological, and immune systems. Schools near busy roads expose children to sustained pollutant and heavy-metal exposure, resulting in cognitive impairment and reduced lung function (Lallawmzuali et al., 2024). Women, older adults, and individuals with pre-existing conditions experience amplified risks. Socio-economic vulnerability compounds biological susceptibility, reinforcing environmental injustice.

Long-Term Health Outcomes: Chronic Morbidity and Premature Mortality

Chronic exposure to TRAP and other pollutants drives morbidity and premature mortality (WHO, 2021). In Lagos, over 11,000 pollution-related deaths annually are attributable to traffic emissions (Ajayi et al., 2025). Exposure elevates risk for respiratory and cardiovascular diseases, stroke, cancer, and renal or endocrine dysfunction from heavy metals, while noise exacerbates stress-mediated disease pathways. Cumulative exposures over decades constitute a significant, largely unrecognised burden.

Interactions, Synergies, and Cumulative Exposure Pathways

Pollutants and stressors interact synergistically. Co-exposure to air pollution and noise exacerbates cardiovascular and respiratory outcomes, while heavy metals amplify neurological risks via oxidative stress (Akintomide et al., 2024; Kim et al., 2019; Lallawmzuali et al., 2024). Exposures are continuous, multi-source, and overlapping, highlighting the importance of a life-course perspective in assessing health impacts.

Societal and Economic Implications of Long-Term Health Impacts

Chronic disease from traffic externalities reduces workforce productivity, increases healthcare costs, and undermines household welfare, particularly for informal workers. Cognitive and respiratory impairments in children affect education and future income potential. Widespread exposure in vulnerable communities reinforces poverty cycles, making non-physically injurious traffic externalities both a public health and developmental challenge, necessitating urgent multi-sectoral intervention.

SOCIO-SPATIAL VULNERABILITIES AND INEQUITIES IN EXPOSURE

Non-physically injurious traffic externalities are not socially or spatially neutral. Their distribution reflects urban morphology, socio-economic stratification, and institutional arrangements governing land use and environmental protection. In Nigerian cities, rapid urbanisation, informality, and entrenched inequalities concentrate chronic exposure to traffic-related air pollution, noise, and heavy metals among specific populations (Ajayi et al., 2025; Akintomide et al., 2023; Lallawmzuali et al., 2024). This section synthesises evidence on how spatial location, social structure, economic activity, and regulatory weakness produce uneven exposure burdens.

Roadside Settlements and Proximity

Proximity to major roads is a primary determinant of pollutant exposure. Steep distance-decay gradients for PM, NO_2, and heavy metals place highest concentrations within 50–100 m of traffic corridors (Akintomide et al., 2023; Lallawmzuali et al., 2024). In Nigeria, dense roadside settlements, informal markets, and low-income dwellings cluster in these zones due to economic accessibility and labour-market needs (Tijjani et al., 2025; Tijjani et al., 2023). Structural proximity, shaped by affordability and weak planning enforcement, amplifies cumulative health risks for residents exposed over decades (Akanji & Obinna, 2025; Ajayi et al., 2025).

Informal Economic Structures and Chronic Occupational Exposure

Informal workers roadside traders, transport operators, mechanics spend prolonged hours in high-exposure traffic corridors. Open-air workplaces lack regulatory control and rely on pedestrian and vehicular flows, embedding exposure in daily occupational practice. Continuous 8-12 h exposure to PM, NO_2, and heavy metals exceeds WHO and national limits (Akanji & Obinna, 2025; Akintomide et al., 2023). Lifetime exposure, beginning in childhood or early adulthood, constitutes a persistent occupational hazard, particularly for those unable to mitigate risk.

Housing Quality, Urban Infrastructure, and Environmental Stressors

Low-quality, poorly ventilated, and minimally insulated housing permits infiltration of airborne pollutants and noise. Potholes, degraded roads, and absence of vegetative buffers exacerbate dust resuspension and noise

intensity (Ibili et al., 2022; Welch et al., 2023; Olise, 2025). These conditions transform intermittent exposure into a chronic environmental stressor, leaving indoor spaces ineffective as protective environments.

Socio-Economic Inequality and Uneven Exposure

Low-income populations disproportionately reside and work near major traffic corridors, lacking regulated land-use, setback enforcement, or environmental infrastructure (Akanji & Obinna, 2025; Tijjani et al., 2023; Olise, 2025; Ajayi et al., 2025). Rapid urbanisation and insufficient planning exacerbate pollutant burdens among these communities, raising long-term risks of respiratory, cardiovascular, and psychosocial impacts (Vosough et al., 2022; Ibili et al., 2022; Peñabaena-Niebles et al., 2020; Wen et al., 2020).

Gendered Dimensions of Exposure

Women in roadside occupations face heightened cumulative exposure to PM, noise, and heavy metals due to prolonged daily presence (Boahen, 2024; Lallawmzuali et al., 2024). Social roles including childcare and household responsibilities amplify vulnerability, as women are both exposed themselves and bear the economic and emotional burden of pollution-related illness in their families.

Children and Adolescents as High-Risk Groups

Children are highly susceptible to traffic pollutants due to physiological and behavioural factors. Exposure to $PM_{2.5}$, Pb, and Cd impairs lung function, cognition, and behaviour (Kim et al., 2019; Lallawmzuali et al., 2024). Schools located near busy roads with inadequate ventilation and noise insulation exacerbate these risks, undermining learning and sleep, and creating long-term developmental and socio-economic disadvantages (Guijarro, 2019; Welch et al., 2023; Boahen, 2024).

Intersectionality and Layered Vulnerabilities

Vulnerability emerges from intersecting socio-economic, spatial, and demographic disadvantages. Children, elderly individuals, and low-income workers in informal settlements experience overlapping exposure to traffic emissions, noise, and heavy metals (Wen et al., 2020; Fageda et al., 2022; Akanji & Obinna, 2025; Olise, 2025). Limited healthcare access, poor housing, and low adaptive capacity amplify these cumulative risks, highlighting structural inequities (Lallawmzuali et al., 2024; Boahen, 2024; Tijjani et al., 2025; Vosough et al., 2022; WHO, 2021).

Governance, Regulatory Weakness, and Institutional Drivers

Weak enforcement of emission limits, noise thresholds, and zoning laws allows pollutant hazards to persist (Ajayi et al., 2025; Olise, 2025). Outdated standards, fragmented governance, and lack of localised monitoring hinder management of hotspots. Informal settlements and markets expand without oversight, placing residents in high-exposure zones. Institutional weaknesses transform manageable risks into chronic public health burdens, disproportionately affecting those with limited political and socio-economic power.

INSTITUTIONAL AND REGULATORY GAPS IN MANAGING TRAFFIC-RELATED EXTERNALITIES

Traffic-related air pollution, noise, and heavy-metal contamination in Nigerian cities persist largely due to institutional and regulatory failures. Weaknesses in environmental governance, urban planning, transport management, and public health regulation undermine mitigation efforts, normalising chronic exposure for vulnerable roadside populations (Ajayi et al., 2025; Olise, 2025). This section synthesises evidence on how institutional deficits entrench environmental risks and inhibit effective management strategies.

Absence of Robust Monitoring Systems and Emission Inventories

Effective regulation requires continuous, high-quality data. Nigerian cities lack comprehensive ambient monitoring for PM, gaseous pollutants, noise, and heavy metals. Major urban centres, including Lagos, have

insufficient high-resolution records to identify hotspots, model exposures, or evaluate interventions (Ajayi et al., 2025). Noise monitoring is similarly sparse, despite evidence of persistent exceedances of national and WHO guidelines (Ibili et al., 2022; Welch et al., 2023). The absence of localised emission inventories for $PM_{2.5}$, NO_2, and SO_2 prevents quantification of sectoral contributions and targeted regulation, revealing a foundational institutional weakness.

Weak Enforcement of Environmental and Vehicular Emission Standards

Regulations exist but are inconsistently enforced. Vehicular emission standards lag behind international benchmarks, and enforcement agencies are under-resourced (Akanji & Obinna, 2025; Fernandes et al., 2019). Ageing vehicle fleets, poorly maintained engines, substandard fuel, and informal transport modes perpetuate high emissions, particularly along congested corridors. Insufficient inspections and regulatory evasion maintain chronic externalities that disproportionately affect roadside populations and informal workers.

Land-Use Planning Failures and Unregulated Roadside Settlement

Urban planning in Nigeria struggles to manage rapid population growth and informal settlement expansion. Weak zoning enforcement allows residences, schools, markets, and workshops to develop within hazardous proximities to major roads (Tijjani et al., 2025; Tijjani et al., 2023). The absence of buffer zones and setbacks, coupled with fragmented coordination among planning, transport, and environmental authorities, concentrates pollutants in densely populated areas (Olise, 2025). Land-use governance failures thus convert environmental hazards into everyday living conditions, increasing cumulative health risks.

Fragmented Institutional Responsibilities and Weak Coordination

Multiple agencies govern transportation, environment, and public health, yet interagency coordination is limited. Overlapping mandates create policy ambiguity, while the lack of integrated environmental health governance impedes comprehensive mitigation (Peñabaena-Niebles et al., 2020; Wen et al., 2020). Air pollution, noise, and heavy-metal contamination require multisectoral interventions; institutional fragmentation perpetuates inefficiency and weak accountability.

Insufficient Public Health Integration and Risk Communication

Environmental health is poorly integrated into public health planning, which prioritises infectious diseases over chronic exposures. Monitoring and screening for pollution-related conditions such as asthma, hypertension, and neurotoxic effects are limited (Ajayi et al., 2025). Risk communication to affected communities is minimal, reducing uptake of behavioural mitigation measures. This neglect reinforces systemic vulnerability and undermines national health resilience.

Limited Research Infrastructure and Weak Evidence Base

Policy development is constrained by the scarcity of context-specific research. Existing studies are often cross-sectional, short-term, or pollutant-specific, with longitudinal and multi-pollutant analyses largely absent (Ajayi et al., 2025; Olise, 2025). Episodic monitoring limits understanding of cumulative exposures, weakening evidence-based interventions and allowing persistent externalities.

Policy Inattention and Crash-Centric Bias

Transport safety in Nigeria is framed almost exclusively around road crashes, marginalising chronic, non-injury harms (Ajayi et al., 2025; Olise, 2025). Crash-centric policies underinvest in environmental monitoring, vehicular emissions enforcement, and public awareness of long-term health risks. Evaluation frameworks rarely include environmental health indicators, systematically ignoring the silent burden borne by millions of roadside residents. This governance bias perpetuates non-physically injurious exposures, contributing to Nigeria's rising non-communicable disease burden.

EVIDENCE GAPS AND RESEARCH PRIORITIES FOR NIGERIA

Despite increasing awareness of the health and environmental impacts of traffic-related air pollution, noise, and heavy-metal contamination, Nigeria's evidence base remains fragmented and insufficient for guiding comprehensive interventions. While some studies document pollutant concentrations above regulatory limits and associated health effects, integrated, longitudinal, and multisectoral research capturing cumulative non-physically injurious externalities is largely absent (Ajayi et al., 2025; Olise, 2025). This section identifies key evidence gaps and outlines research priorities to inform environmental health governance and policy.

Lack of Longitudinal and Life-Course Studies

Long-term exposure trajectories and cumulative health outcomes are poorly understood due to the scarcity of longitudinal studies. Most Nigerian research relies on cross-sectional measurements or short-term monitoring (Akanji & Obinna, 2025; Akintomide et al., 2023), which cannot capture chronic disease progression, delayed neurodevelopmental effects, or intergenerational impacts. For example, the pathways linking early-life exposure to $PM_{2.5}$, NO_2, or heavy metals with later-life respiratory, cardiovascular, and cognitive outcomes remain largely unexplored (Kim et al., 2019; Lallawmzuali et al., 2024). Establishing long-term cohort studies, especially among children and vulnerable roadside populations, is essential to quantify lifetime burden, identify critical exposure windows, and strengthen causal inference.

Insufficient Multi-Pollutant and Cumulative Exposure Research

Current research frequently examines air pollution, noise, or heavy metals in isolation, despite simultaneous exposure in real-world roadside environments. Global evidence shows interactions between noise-induced stress and particulate inflammation that elevate cardiovascular risk (Welch et al., 2023; Guijarro, 2019), and heavy-metal neurotoxicity may be compounded by particulate co-exposure (Boahen, 2024). In Nigeria, multi-pollutant exposures are likely intensified by rapid motorisation and weak regulation (Vosough et al., 2022; Fernandes et al., 2019). Integrative studies using harmonised monitoring and spatial frameworks are needed to capture cumulative exposures accurately.

Limited Spatially Resolved Data and Modelling Capacity

Many studies rely on point measurements at limited locations, lacking the spatial resolution needed to assess heterogeneity across streets, neighbourhoods, and micro-environments. Urban morphology including building density, street canyon effects, and land-use configurations strongly influences pollutant dispersion (Fageda et al., 2022; Wen et al., 2020), yet few studies integrate high-resolution spatial modelling or GIS-based approaches. Research employing land-use regression, dispersion models, and geo-statistical methods is urgently needed to identify hotspots, guide setback enforcement, and support environmental justice interventions.

Weak Integration of Behavioural, Social, and Economic Dimensions

Environmental exposure research in Nigeria often neglects social, behavioural, and economic determinants. Informal roadside trading, for example, is economically necessary but carries high occupational exposure risk (Tijjani et al., 2025; Tijjani et al., 2023). Household adaptation strategies such as ventilation practices, housing modifications, or exposure avoidance remain underexplored across socio-economic groups. Future research should employ qualitative and mixed methods to capture lived experiences, perceptions of environmental risk, and socio-economic constraints shaping exposure, enhancing the relevance of interventions.

Inadequate Research on Institutional Dynamics and Regulatory Effectiveness

Institutional analyses are limited because while some studies highlight weak monitoring and enforcement (Olise, 2025; Ajayi et al., 2025), little is known about governance structures, political incentives, budget constraints, and inter-agency coordination affecting environmental health outcomes. Evaluating the effectiveness of vehicular inspections, regulatory enforcement, and policy frameworks is critical. Comparative research on regulatory models in other rapidly urbanising contexts could inform adaptation for Nigeria.

Limited Focus on Vulnerability, Equity, and Environmental Justice

Few studies interrogate how exposure risks are distributed across social groups or intersect with structural inequality. Evidence shows that low-income households, informal workers, women, and children disproportionately inhabit high-exposure zones near major roads (Akanji & Obinna, 2025; Peñabaena-Niebles et al., 2020), yet environmental justice implications remain undertheorised. Future research should examine how socio-economic exclusion, spatial marginalisation, and intergenerational exposure pathways reproduce vulnerability, providing an ethically grounded basis for policy.

Lack of Intervention and Impact Evaluation Studies

Empirical evaluation of interventions technological, infrastructural, behavioural, or regulatory is limited. Policymakers lack evidence on which measures reduce exposure under real-world conditions. Pilot studies, quasi-experiments, and before-after evaluations are needed to assess the effectiveness of interventions such as road redesign, green buffers, public transport improvements, and emission enforcement, supporting evidence-based environmental health policy.

POLICY RECOMMENDATIONS

Addressing the cumulative and often overlooked burden of non-physically injurious traffic externalities in Nigeria requires a coherent, evidence-driven and multi-sectoral policy framework that integrates environmental regulation, transport governance, urban planning, and public health systems. The findings of this review underscore that air pollution, traffic noise and heavy-metal contamination are not isolated phenomena but interconnected externalities shaped by socio-spatial inequalities, weak institutional enforcement, and rapid urbanisation. Consequently, effective policy responses must move beyond fragmented interventions toward a systems-based approach that simultaneously tackles exposure pathways, vulnerability patterns, and governance limitations. The following recommendations are structured to align with this integrative logic, ensuring both policy coherence and practical applicability within Nigeria's urban context.

Strengthening Environmental Monitoring and Data Systems

A critical foundation for effective intervention lies in the establishment of robust, decentralised, and continuous environmental monitoring systems capable of capturing the spatial and temporal dynamics of traffic-related externalities. Current limitations in Nigeria's monitoring infrastructure constrain the ability to identify pollution hotspots, assess cumulative exposure, and evaluate policy effectiveness (Ajayi et al., 2025; Olise, 2025). Strengthening this system requires the deployment of real-time air quality and noise monitoring stations along major transport corridors, complemented by periodic soil and vegetation testing for heavy-metal contamination in high-risk zones such as markets, schools, and residential clusters. Equally important is the institutionalisation of open-access environmental data platforms, which would enhance transparency, support evidence-based decision-making, and foster civic engagement. Integrating monitoring outputs into urban planning and public health surveillance systems would further enable proactive, rather than reactive, environmental governance.

Reforming Vehicular Emission Standards and Transport Regulation

Given that road transport constitutes a dominant source of particulate matter, nitrogen oxides, and urban noise pollution, strengthening vehicular emission control and transport regulation is imperative. This requires the enforcement of updated emission standards, mandatory and periodic vehicle inspection regimes, and targeted incentives for phasing out high-emission and ageing vehicle fleets (Akanji & Obinna, 2025). Policy efforts should also prioritise improvements in fuel quality and the gradual transition toward low-emission mobility systems, including compressed natural gas (CNG) buses and electric public transport options. However, regulatory reform must be accompanied by institutional capacity strengthening, including improved funding, technical equipment, and inter-agency coordination, to ensure compliance and reduce regulatory capture. Embedding environmental performance indicators within transport policy frameworks would further reinforce accountability and long-term sustainability.

Integrating Environmental Health into Urban Planning and Land-Use Regulation

Urban planning policies must be repositioned to explicitly incorporate environmental health considerations as a central design principle, particularly in rapidly expanding Nigerian cities. This includes stricter enforcement of road setback regulations for new developments and strategic retrofitting of existing high-exposure environments such as roadside markets, schools, and informal settlements (Tijjani et al., 2025; Tijjani et al., 2023). In practical terms, this may involve relocation, redesign, or protective restructuring of vulnerable land uses to reduce direct exposure to traffic pollutants. The integration of green infrastructure, including vegetative buffers, urban tree corridors, and pedestrianised zones, offers a cost-effective and multifunctional approach to mitigating both air and noise pollution while enhancing urban liveability and climate resilience (Wen et al., 2020; Fageda et al., 2022). Importantly, planning interventions must be sensitive to livelihood implications, ensuring that environmental improvements do not inadvertently exacerbate socio-economic vulnerability.

Targeted Protection for Vulnerable and High-Risk Groups

The disproportionate exposure of certain population groups including children, roadside traders, transport workers, and low-income households necessitates targeted and equity-driven policy interventions. Schools located near high-traffic corridors should be prioritised for environmental risk assessments, with mitigation strategies such as relocation, installation of protective barriers, or indoor air filtration systems implemented where necessary (Lallawmzuali et al., 2024; Boahen, 2024). Similarly, informal economic activities concentrated along highways should be gradually transitioned into purpose-built, safer environments that preserve economic accessibility while reducing exposure risks. Occupational health initiatives must also be expanded to include awareness campaigns, routine health screening, and provision of affordable protective measures. By explicitly addressing vulnerability, policy interventions can achieve not only environmental improvements but also social justice outcomes.

Enhancing Institutional Coordination and Governance Capacity

The fragmented nature of environmental, transport, and urban governance in Nigeria remains a major barrier to effective intervention, underscoring the need for stronger institutional coordination and governance capacity. Establishing inter-agency task forces that bring together environmental protection agencies, transport authorities, urban planners, and public health institutions would facilitate harmonisation of standards, data sharing, and integrated policy implementation (Olise, 2025; Ajayi et al., 2025). Capacity-building efforts should focus on strengthening technical expertise, upgrading laboratory and monitoring infrastructure, and enhancing enforcement mechanisms at municipal and state levels. Furthermore, embedding accountability frameworks, including performance monitoring and public reporting systems, would improve transparency and reduce institutional inefficiencies. Effective governance reform is therefore central to translating policy intent into measurable outcomes.

Public Health Integration and Community Risk Communication

A critical but often neglected dimension of policy response is the integration of environmental exposure into public health systems and community awareness frameworks. Routine health surveillance should incorporate screening for pollution-related conditions, including respiratory, cardiovascular, and neurological disorders, particularly among high-risk populations. At the same time, sustained public education campaigns are necessary to improve awareness of environmental risks, promote behavioural adaptation, and encourage community participation in mitigation efforts. Community-based monitoring initiatives, involving schools, markets, and local associations, can serve as powerful tools for enhancing local ownership and reinforcing the legitimacy of policy interventions. By bridging the gap between environmental science and public health practice, this approach supports a more preventive and participatory model of urban health governance.

Promoting Evidence-Based Interventions and Applied Research

The effectiveness of policy interventions is inherently dependent on the availability of robust, context-specific evidence, which remains limited in the Nigerian context. There is a need for sustained investment in applied research focusing on longitudinal health impacts, multi-pollutant exposure assessment, and spatially explicit

analysis of urban environmental risks (Ajayi et al., 2025; Olise, 2025). Pilot interventions, such as the implementation of green buffers, low-emission zones, traffic-calming strategies, and market relocation schemes, should be systematically evaluated to generate scalable insights. Strengthening collaboration between academic institutions, government agencies, and international partners would further enhance knowledge transfer and innovation. Embedding research within policy cycles ensures that interventions are not only evidence-informed but also adaptive to evolving urban realities.

Reframing Urban Transport Policy beyond Crash Prevention

Finally, there is a fundamental need to reconceptualise urban transport policy in Nigeria beyond its traditional focus on road traffic crashes and physical injuries, to include environmental health as a core performance dimension. Air pollution, noise exposure, and heavy-metal contamination should be integrated into transport planning metrics, regulatory frameworks, and evaluation indicators. This shift requires aligning transport policy with environmental sustainability and public health objectives, thereby promoting a more holistic understanding of road safety that encompasses both immediate and long-term health risks. By embedding environmental externalities into the core of transport governance, policymakers can transition from reactive, short-term interventions to proactive, preventive strategies that address the silent but pervasive burden experienced by millions of urban residents.

CONCLUSION

Non-physically injurious traffic externalities comprising air pollution, chronic noise exposure, and heavy-metal contamination pose a pervasive yet often overlooked public health and environmental challenge in Nigeria's rapidly urbanising cities. Although these exposures do not produce the immediate, visible impacts of road crashes, their cumulative effects on respiratory, cardiovascular, neurological, and psychosocial health are profound, particularly for vulnerable populations such as children, informal workers, and low-income households. Structural factors, including unplanned settlements, poor housing quality, and inadequate urban infrastructure, exacerbate these risks, creating high-exposure environments that persist over the life course.

Institutional and regulatory weaknesses further compound the problem due to fragmented governance and inadequate monitoring systems. Also, the weak enforcement of emission and noise standards and the persistence of crash-centric transport policies together normalise chronic exposure to traffic-related pollutants. These governance gaps intersect with socio-economic inequalities, producing disproportionate burdens for populations with the least capacity to mitigate risk. The lack of integrated research, particularly longitudinal and multi-pollutant studies, limits evidence-based policymaking, leaving interventions reactive rather than preventative.

Addressing these silent burdens requires a holistic, multisectoral approach that integrates environmental health into urban planning, transport policy, and public health systems. Strengthening monitoring infrastructure, enforcing emission and noise regulations, implementing green infrastructure and buffer zones, and targeting protective interventions for high-risk populations are essential. Equally critical is fostering applied research and community engagement to inform and evaluate mitigation strategies. By reorienting transport and urban development policies to recognise chronic environmental hazards as central to public health, Nigeria can reduce long-term health inequities, promote sustainable urban environments, and safeguard the well-being of its rapidly growing urban populations.

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