ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

Climate Exposure and Health Vulnerability Among Older Adults in Nigerian Cities

Adejumobi David Oyinlade[1]; Adeboyejo Aina Thompson[2*]; Ogunkan David Victor[3]; Oluwafisayo A. Adebimpe[4]

[1,2]Department of Urban and Regional Planning, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.
[3]Department of URP, Bells University of Technology, Ota, Ogun State, Nigeria
[4]Department of Psychiatry, College of Health Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

[2]ORCID ID https://orcid.org/0000-0003-2676-2188

Corresponding Author: Adeboyejo Aina Thompson[2*]

Publication Date: 2025/11/05

Abstract: Against the background of growing climate variability and the heightened health risks it poses to aging populations, this study investigates how climate exposure, socioeconomic factors, and health vulnerability intersect among older adults in urban Nigeria. Using a cross-sectional survey of 1,225 respondents aged 50 years and above in Ibadan, Kano, and Makurdi, information was collected on socioeconomic conditions, climate-related experiences, and self-reported health outcomes. Composite indices for Socioeconomic Status (SES), Climate Exposure (CEI), Disease Burden (DBI), and overall Vulnerability (VI) were developed using Principal Component Analysis and standardized scoring techniques. More than 90 percent of respondents reported noticeable climatic changes, with significant spatial variation in rising temperatures, flooding, and unpredictable seasons. Disease burden was highest in Kano and Ibadan, where respiratory infections, malaria, and hypertension were most prevalent. Income, occupation, residential density, and length of stay emerged as significant predictors of vulnerability, while demographic factors had limited influence. The study emphasizes the need for climate-responsive urban health strategies that prioritize older adults in densely populated and economically deprived neighborhoods.

Keywords: *Climate Vulnerability, Disease Burden, Socioeconomic Inequality, Older Adults, Urban Nigeria, Climate Exposure.*

How to Cite: Adejumobi David Oyinlade; Adeboyejo Aina Thompson; Ogunkan David Victor; Oluwafisayo A. Adebimpe (2025). Climate Exposure and Health Vulnerability Among Older Adults in Nigerian Cities. *International Journal of Innovative Science and Research Technology*,10(10), 2500-2511. https://doi.org/10.38124/ijisrt/25oct1343

I. INTRODUCTION

Climate change represents one of the most pressing threats to global public health in the twenty first century (IPCC, 2022; World Health Organization, 2021). Its impacts, including rising temperatures, extreme weather events, and shifting rainfall patterns, are increasingly evident across sub–Saharan Africa. Nigeria, the continent's most populous nation and one of the fastest urbanizing societies globally, faces rising exposure to climate induced hazards that directly and indirectly affect human health (World Bank, 2023; Raimi *et al*., 2021). These challenges are particularly pronounced in cities, where rapid and often unplanned development exacerbates vulnerability through overcrowding, inadequate housing, and overstretched infrastructure (Adelekan, 2020; Gbadegesin & Olabisi, 2022).

Urban areas contribute substantially to economic productivity but also pose harsh living conditions for socioeconomically disadvantaged populations (Olanrewaju & Fregene, 2020). The dense built-up environment amplifies heat accumulation, while limited green infrastructure reduces natural cooling (Sado & Adeyemi, 2023). Poor drainage and settlement expansion increase flood risk, resulting in water contamination and the spread of climate sensitive diseases such as cholera and diarrhoea (Echendu, 2020; Atufu, 2021). Concurrently, air pollution and industrial emissions elevate the incidence of respiratory complications (Niyi Odumosu, 2025).

Older adults represent a population group disproportionately affected by climate related health risks (Graham & Schofield, 2021; Cadmus *et al*., 2022). Age

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

related physiological decline, preexisting conditions, and limited adaptive capacity heighten susceptibility to heat stress, infections, and other environmental hazards (Omoemu *et al*., 2025; Oyeyemi *et al*., 2023). Declining income and dependence on informal housing further constrain resilience, while policies frequently overlook the specific needs of this group (Federal Ministry of Health, 2024).

Despite the growing recognition of climate health risks, empirical studies focusing on the vulnerability of older urban residents in Nigeria remain limited. Most research generalizes across entire urban populations or other vulnerable groups, creating a gap in understanding how aging, socioeconomic disadvantage, and environmental exposure intersect to shape health outcomes (Nguyen & Smith, 2020; Nnadi *et al*., 2024). Furthermore, few studies examine spatial variations across cities with distinct ecological and infrastructural profiles (Adelekan, 2020; Iyanda *et al*., 2023).

These gaps underscore the need for contextually grounded research capturing the multidimensional nature of vulnerability among older adults in Nigerian cities. Cities such as Kano, Ibadan, and Makurdi provide a useful basis for comparison due to their diverse climatic and socioeconomic conditions (Echendu, 2020). Such evidence is essential for informing targeted urban adaptation strategies, particularly in informal and underserved settlements (Ogbonna *et al*., 2024).

This study investigates the relationship between climate exposure, socioeconomic characteristics, and disease burden among older adults living in Nigerian cities. By integrating composite indices such as the Socioeconomic Status Index (SSI), Climate Exposure Index (CEI), Disease Burden Index (DBI), and Vulnerability Index (VI), it provides a comprehensive assessment of climate and health interactions in later life.

The findings are expected to generate policy relevant evidence supporting more inclusive climate adaptation and public health programs. Enhancing the resilience of older adults and improving the quality of urban housing, health services, and neighborhood environments are essential for achieving sustainable, age inclusive urban development.

II. LITERATURE REVIEW

Climate change has emerged as one of the most critical public health challenges worldwide, with urban environments experiencing its impacts most acutely (IPCC, 2022; World Health Organization, 2021). In Nigeria, rapid and often unregulated urbanisation has resulted in densely populated neighbourhoods, inadequate infrastructure, and deteriorating housing conditions, all of which heighten vulnerability to climate related health risks (Adelekan, 2020; Olanrewaju & Fregene, 2020; Gbadegesin & Olabisi, 2022). Evidence from recent climate assessments shows rising temperatures, erratic rainfall, extended heat periods, and more frequent flooding events across many Nigerian cities (World Bank, 2023; Echendu, 2020; Iyanda *et al*., 2023). These climatic disruptions interact with existing socio-environmental inequities to produce spatially uneven health risks among urban residents (Raimi *et al*., 2021).

Older adults constitute one of the most vulnerable population groups in this context. Physiological decline associated with ageing limits their ability to regulate body temperature and resist infection (Graham & Schofield, 2021). Chronic health conditions such as hypertension, arthritis, respiratory disorders, and cardiovascular diseases are common among older people and can be aggravated by extreme climatic conditions, air pollution, and stressful living environments (Omoemu *et al*., 2025; Niyi-Odumosu, 2025). In addition, many older adults in Nigeria have limited financial security, continue to rely on informal economic activities, and often lack adequate access to formal healthcare (Nnadi *et al*., 2024; Cadmus *et al*., 2022). These disadvantages reduce their adaptive capacity, making them disproportionately affected by climate sensitive diseases (UNICEF & WHO, 2021).

The emerging literature highlights several climate related health concerns that affect older adults in Nigerian cities. High temperatures intensify the risk of cardiovascular strain and respiratory complications (Sado & Adeyemi, 2023; Iyanda *et al*., 2023), while high humidity and stagnated water bodies support disease vectors such as mosquitoes, thereby sustaining persistent malaria incidence (Bello *et al*., 2023; Ogunwale *et al*., 2024). Flooding events increase water contamination and the spread of diarrhoeal illnesses such as cholera and typhoid (Atufu, 2021; Echendu, 2020). Dust accumulation, particularly in the dry harmattan season, is associated with increased respiratory infections and eye problems (Niyi-Odumosu, 2025). Most concerning is the growing coexistence of infectious diseases and noncommunicable chronic conditions, reflecting a dual disease burden that increases with age and worsens under changing climatic conditions (Omoemu *et al*., 2025).

Beyond direct health consequences, the places in which older adults live play a significant role in shaping exposure and susceptibility. Housing in many low income and high-density urban neighbourhoods is characterised by poor ventilation, weak structural integrity, inadequate drainage, and lack of sanitary facilities (Gbadegesin & Olabisi, 2022; Ogbonna *et al*., 2024). Such conditions increase internal heat stress, promote the breeding of pests and disease vectors, and limit the ability of residents to manage environmental hazards around them (Adelekan, 2020). Neighbourhood characteristics including walkability, access to healthcare, physical safety, and social cohesion are increasingly recognised as critical determinants of physical and psychological well-being among older populations (Oyeyemi *et al*., 2023; Ewurum, 2025). Studies in Nigerian cities have shown that neighbourhoods with unsafe pedestrian environments, poor waste management, and limited amenities restrict older adults' mobility and contribute to emotional stress, social isolation, and reduced quality of life (Cadmus *et al*., 2022; Nnadi *et al*., 2024).

Socioeconomic disparities further reinforce vulnerability. Older adults in low-income households often

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

live in informal settlements lacking resilient services such as functional drainage systems, safe water supply, and reliable electricity (Olanrewaju & Fregene, 2020; Ogbonna *et al*., 2024). Limited education and income restrict their ability to invest in housing improvements or adopt adaptation measures like cooling devices, mosquito proofing, or flood protections (Nguyen & Smith, 2020). Length of residence has also been discussed in the literature as an important aspect of adaptive capacity. Long term residents typically possess richer local environmental knowledge, stronger social networks, and better access to community support during hazardous events compared with those who have recently relocated (Adelekan, 2020).

International and African scholarship underscores the importance of understanding vulnerability as multidimensional, shaped by exposure to hazards, sensitivity of individuals, and their adaptive capacity (Yoon *et al*., 2021; Nguyen & Smith, 2020). However, in Nigeria, vulnerability assessments often overlook older adults and seldom incorporate combined indicators that reflect socioeconomic conditions, environmental quality, and disease burden (Federal Ministry of Health, 2024; Graham & Schofield, 2021). Most studies either generalise findings across entire populations or limit their scope to specific diseases without integrating the broader living environment or spatial variations across city zones (Raimi *et al*., 2021; Echendu, 2020). Consequently, there is little empirical evidence explaining how climate exposure, housing and neighbourhood quality, and health outcomes intersect among older adults in different urban settings within the same city.

There is also a dearth of studies that examine spatial variations in vulnerability within individual cities such as Lagos State, where residential zones differ markedly in their built environment characteristics, levels of infrastructural development, and socioeconomic composition (Ndimele, 2024). While some research recognise these intra-urban inequalities, most fail to extend their analysis to the unique needs and health realities of older residents. Similarly, mental and emotional well-being, which is increasingly recognised as a core component of healthy ageing, remains largely absent in the conversation on climate vulnerability in Nigerian urban research (Ewurum, 2025; Oyeyemi *et al*., 2023).

This review demonstrates that a significant knowledge gap persists regarding the combined influence of socioeconomic factors, environmental exposures, and housing conditions on older adults' vulnerability to climate related health stressors. The current study responds to this gap by focusing explicitly on older adults in three Nigerian cities and investigating how their socioeconomic characteristics, physical housing conditions, neighbourhood environments, and perception of well-being vary across different climatic and residential zones. By employing composite indices and examining spatial patterns of exposure and disease burden, the study offers a more holistic assessment of vulnerability that can guide age inclusive urban planning and climate responsive health interventions.

III. METHODOLOGY

➢ *Study Design*

The study adopted a cross-sectional, survey-based design aimed at investigating the relationship between socioeconomic determinants, climate exposure, and health outcomes and vulnerability among older adults in Nigerian urban centers. The cross-sectional nature of the design allowed for the simultaneous collection of data on socioeconomic characteristics, experiences of climate-related events, and reported health conditions. While this design does not permit causal inferences, it provides a strong basis for exploring associations between determinants and health outcomes, especially in the context of climate-sensitive diseases.

➢ *Study Area*

The research was conducted in Ibadan, Kano, and Makurdi, three urban centers chosen for their ecological and geographical diversity. These cities fall into distinct climatic zones as classified under Köppen's climatic classification system (Köppen, 1970), thereby reflecting Nigeria's environmental variability. Ibadan represents the forest-savanna transition zone in the southwest, Kano is located in the semi-arid Sahelian zone of the north, while Makurdi lies in the Guinea savanna environment of the middle belt. By covering these three climatic belts, the study ensured representation of diverse climatic conditions, urban characteristics, and health vulnerabilities across the country.

➢ *Study Population and Sampling*

The target population consisted of household heads aged 50 years and above. This age threshold was selected because older adults face increased vulnerability to climate-sensitive health conditions such as respiratory, vector-borne, and chronic diseases, and are more likely to provide reliable retrospective household information. Inclusion criteria required that participants be permanent residents of the study cities, aged 50 and above, and willing to provide informed consent. Individuals who were transient residents or unable to respond due to severe illness were excluded. A multi-stage sampling strategy was used to select respondents, with wards and neighborhoods sampled proportionally, followed by random household selection.

➢ *Data Collection Tools*

Data were collected using a structured questionnaire, which comprised three major components:

- Socioeconomic characteristics of respondents such as income, education, occupation, type of housing, and energy use.
- Perception and experiences of climate-related events including flooding, heatwaves, harmattan, water shortages, and temperature variations.
- Health outcomes measured through self-reported climate-sensitive diseases.

➢ *Variables*

The study classified its variables into three groups:

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

- Independent variables: socioeconomic characteristics such as education, income, occupation, residential density etc.
- Dependent variables: grouped climate-sensitive diseases including vector-borne, water/food-borne, respiratory, skin/eye, and chronic conditions.
- Control/contextual variables: climate exposure experiences including floods, temperature changes, and rainfall variability.

IV. DATA ANALYSIS

Analysis proceeded in multiple steps. Descriptive statistics summarized demographic, socioeconomic, and exposure characteristics. Composite indices were constructed as specified in Table 1. PCA was employed for the SES index, ensuring that the most significant contributors (such as income and education) had proportionally greater influence. The CEI was constructed through additive scoring, standardized for comparability, and tested for internal consistency. Disease outcomes were modeled as both binary and count variables to capture single and multiple burdens. Associations between indices and disease outcomes were examined through logistic regression and Poisson/Negative Binomial models, adjusting for demographic controls such as age, gender, marital status, and city. Sensitivity analyses were conducted by re-estimating indices using alternative coding strategies to ensure robustness of results.

Table 1 Variable-to-Index Mapping Table

Index	Purpose	Variables Included	Coding Notes	Construction Method
Socioeconomic Status (SES) Index	Summarize respondent's socioeconomic position	education; monthly income, occupation status; residential density etc	Categorical variables converted to ordinal scales (e.g., education 0–3, income groups ordered). Standardized before analysis.	Principal Component Analysis (PCA) applied to standardized variables. The first component extracted as the SES score (continuous).
Climate Exposure Index (CEI)	Measure exposure to climate-related hazards	Flood occurence; heatwave; acute shortage of water; severe harmattan; rising temperature, unpredictable rainy season; longer period of rainy season; longer period of dry season	Variables coded 0=none, 1=some, 2=frequent/severe. Reverse-coded where necessary so higher = more exposure.	Items summed into a composite score, then standardized (z-scores). Reliability tested using Cronbach's alpha. PCA used to confirm dimensionality.
Disease Burden Index (DBI)	To develop a single composite measure capturing the overall burden of climate-sensitive diseases among respondents.	malaria, yellow fever, cerebrospinal meningitis; diarrhea, cholera, typhoid; respiratory infection, tuberculosis, asthma; skin infection, eye infection, measles); high blood pressure, arthritis.	Each disease coded as binary: 1 = reported, 2 = not reported. Category scores aggregated and standardized to represent total disease burden per respondent/household.	Summed binary scores across all disease categories to form a continuous index. DBI analyzed as (a) continuous count of reported diseases, or (b) binary (1 = any disease reported, 2 = none). Logistic regression applied for binary outcomes; Poisson/Negative Binomial regression for count data.
Vulnerability Index (VI)	Capture combined risk arising from high exposure, high disease sensitivity, and low adaptive capacity	CEI index; DBI standardized score; SES index (reversed); key adaptive variables (education, income, length of stay, housing condition)	SES z-scores reversed so that lower SES = higher vulnerability. CEI and DBI retained as is. All components standardized before aggregation.	Composite constructed as: VI = (CEI + DBI) – SES (all standardized). Higher scores indicate greater vulnerability. PCA or confirmatory factor analysis (CFA) used to test internal validity and dimensional consistency.

The composite indices outlined in the Variable-to-Index Mapping Table added analytical strength by transforming diverse variables into structured, interpretable measures. The SES Index, built through PCA, effectively captured variations in economic and social positioning. PCA ensured that education and income, the strongest contributors to variance, were weighted accordingly, thus reflecting relative socioeconomic inequality across the three cities.

The Climate Exposure Index (CEI) consolidated multiple hazard experiences into a single score. Its standardized construction ensured comparability across respondents, while internal reliability tests confirmed that reported exposures clustered meaningfully. This highlighted cumulative exposure effects: respondents simultaneously reporting frequent floods, severe harmattan, and rising night temperatures consistently scored higher on the CEI, which

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

was also associated with increased vulnerability to respiratory and vector-borne diseases.

The Disease Burden Indices provided structured insights into the clustering of health risks. For instance, the binary construction revealed prevalence, while count outcomes captured the intensity of multi-disease burdens. This dual approach show that higher CEI scores often coincided with the co-occurrence of multiple diseases, underscoring the compounding nature of climate impacts on health.

Finally, the Vulnerability Index (VI) integrated the Socioeconomic Status (SES), Climate Exposure (CEI), and Disease Burden (DBI) indices to capture the multidimensional nature of susceptibility to climate related risks. SES scores were reversed so that lower socioeconomic standing contributed to higher vulnerability, while CEI and DBI were retained in their original directions to reflect increased exposure and health sensitivity. The resulting composite, representing the combined effects of poverty, environmental stress, and disease burden, provided a holistic measure of population vulnerability

Together, these indices enhanced methodological rigor by grounding complex social and environmental realities into standardized, reproducible measures. Their use enabled a nuanced understanding of how socioeconomic disadvantage and climate exposure interact to shape health outcomes among older urban residents in Nigeria.

V. RESULTS AND DISCUSSION

- *Socio-Economic Characteristics of Older Adults Across Cities*

Table 2 presents the socioeconomic characteristics of older adults across the three study cities, Kano, Ibadan, and Makurdi. Gender distribution shows noticeable variation, with Kano having a male majority (78.0 %), Ibadan an almost equal male and female balance, and Makurdi also dominated by males (62.8 %). This difference is statistically significant ($\chi^2 = 90.618$, $p < 0.001$), suggesting that gender plays an important role in exposure and response to climate sensitive diseases, possibly due to differences in social roles and outdoor activities.

Table 2 Socio-Demographic Characteristics of Older Adults by City

Variable	Category	Kano (783)	Ibadan (364)	Makurdi (78)	Chi-Square	p-value
Gender	Male	78.0%	50.3%	62.8%	90.618	0.000
	Female	22.0%	49.7%	37.2%		
Marital Status	Married	86.5%	78.8%	76.9%	128.513	0.000
	Divorced	1.0%	4.9%	6.4%		
	Separated	0.0%	11.8%	6.4%		
	Widowed	12.5%	4.4%	10.3%		
Education Qualification	No formal education	7.3%	9.1%	9.0%	16.023	0.099
	Primary school	11.2%	7.1%	10.3%		
	WASCE	30.0%	33.2%	26.9%		
	OND/NCE	30.9%	31.9%	29.5%		
	HND/BSc	19.0%	16.8%	17.9%		
	MSc/PGD	1.5%	1.9%	6.4%		
Residential Density	High	49.8%	49.5%	50.0%	0.026	1.000
	Medium	33.3%	33.8%	33.3%		
	Low	16.9%	16.8%	16.7%		
Age Group	50–64	70.6%	69.8%	66.7%	3.657	0.454
	65–79	28.1%	28.0%	29.5%		
	80+	1.3%	2.2%	3.8%		
Income Group (₦)	<66,000	63.5%	68.1%	66.7%	2.684	0.612
	66,100–220,000	28.9%	25.8%	26.9%		
	220,100–663,000	7.7%	6.0%	6.4%		
Occupation Status	Unemployed	1.1%	0.8%	3.8%	22.744	0.065
	Retired	8.3%	6.9%	6.4%		
	Trading	29.2%	25.5%	37.2%		
	Civil servant	13.0%	12.9%	7.7%		
	Artisan	18.9%	23.9%	21.8%		
	Clergy	3.6%	1.9%	1.3%		
	Teaching	7.9%	8.8%	12.8%		
	Others	17.9%	19.2%	9.0%		
Length of Stay (years)	<16	42.4%	42.6%	52.6%	7.996	0.092
	16–40	48.4%	44.2%	37.2%		
	>40	9.2%	13.2%	10.3%		

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

Marital status also varies considerably among the cities. The majority of older adults were married in Kano (86.5 %), Ibadan (78.8 %), and Makurdi (76.9 %), while the widowed, divorced, and separated categories show moderate variation across the cities. The association is statistically significant (χ^2 = 128.513, p < 0.001), implying differences in household composition and available social support, which can influence access to care and resilience during climate related health stressors.

In terms of educational attainment, most respondents had at least secondary education, with a smaller proportion reporting no formal education. The variation across the cities is not significant (χ^2 = 16.023, p = 0.099), suggesting a relatively uniform educational structure that may contribute to comparable levels of health awareness and coping strategies among older adults.

Occupational status, as presented in Table 1, reveals that trading and artisan work were the most common engagements among older adults, accounting for 28.7 % and 20.6 % respectively across all cities. In Kano, trading (29.2 %) and artisan work (18.9 %) dominated, while in Ibadan, artisan work (23.9 %) and trading (25.5 %) were most prevalent. Makurdi records the highest proportion of traders (37.2 %) and artisans (21.8 %). Other notable occupations include civil service and teaching, though at lower proportions. The chi square test (χ^2 = 22.744, p = 0.065) shows no significant difference in occupation across cities, indicating that older adults generally share similar livelihood patterns despite contextual differences.

Education, occupation, residential density, age, income, and length of stay all show statistically insignificant variations, reflecting shared socioeconomic experiences among the elderly in these urban centers. However, gender and marital status demonstrate strong associations with city context, suggesting that social support systems and gender roles remain key factors in understanding the vulnerability of older adults to climate sensitive diseases in Nigeria's urban environment.

➢ *Perception and Experiences of Climate-Related Events*

The analysis of climate related experiences across Kano, Ibadan, and Makurdi reveals that older adults in all three urban centers were widely aware of changes in their climatic environment (Table 3). More than 90 % of respondents acknowledged observing notable changes, suggesting strong collective recognition of the evolving climate. This awareness forms a critical backdrop for understanding how social and environmental exposures shape health outcomes in later life.

Table 3 Perceptions and Experiences of Climate-Related Changes by City

Climate Change Indicator	Kano (% Yes)	Ibadan (% Yes)	Makurdi (% Yes)	Total (% Yes)	χ^2	p-value	Significance
Observed notable changes	92.8	91.8	93.6	92.6	0.555 (2)	0.758	Not significant
Rising daytime temperature	84.7	91.8	85.9	86.9	10.990 (2)	0.004	Significant
Rising night temperature	69.0	77.2	70.5	71.5	8.306 (2)	0.016	Significant
Longer rainy season	35.5	26.9	37.2	33.1	8.907 (2)	0.012	Significant
Longer dry season	60.2	67.9	62.8	62.6	6.301 (2)	0.043	Significant
Unpredictable rainy season	74.7	83.2	89.7	78.2	17.113 (2)	0.000	Highly significant
Acute water shortage	64.9	65.7	61.5	64.9	0.479 (2)	0.787	Not significant
Flood occurrence	38.3	28.6	21.8	34.4	16.294 (2)	0.000	Highly significant
Severe harmattan	43.7	50.3	47.4	45.9	4.436 (2)	0.109	Not significant
Stunted vegetal growth	52.5	61.0	50.0	54.9	10.963 (4)	0.027	Significant

Statistically significant variations were recorded across several important climate parameters. Reports of rising daytime and night time temperatures were considerably higher in Ibadan (91.8 % and 77.2 %, respectively) compared with Kano and Makurdi. This points to intensified exposure to urban heat. Elevated temperatures increase the risk of dehydration, cardiovascular strain, and respiratory complications, conditions that have greater impact on older adults due to reduced ability to regulate body temperature. These trends signal a growing public health concern in dense urban environments where heat retention is amplified.

Seasonal variability also emerged as a major climate stressor. Perceptions of a longer rainy season (p = 0.012) and a longer dry season (p = 0.043) indicate that traditional seasonal boundaries are becoming less predictable. This shift was reinforced by the highly significant perception of an unpredictable rainy season (p < 0.001), particularly common in Makurdi (89.7 %). Irregular rainfall patterns can worsen diseases such as malaria, cholera, and typhoid by altering mosquito breeding cycles and contaminating water sources. These risks are often more severe for older adults living in low-income settlements with limited access to healthcare and safe water.

Spatial differences in reports of flooding (p < 0.001) highlight ecological disruptions linked to rapid urban development. Kano recorded a higher share of flooding experiences (38.3 %), reflecting poor drainage and extensive land cover changes. Flooding promotes disease transmission, restricts mobility, and damages property, increasing social and economic vulnerability among older adults. Significant variation in reports of stunted vegetation growth (p = 0.027) further signals declining environmental quality and reduced natural cooling, which indirectly affects thermal comfort and overall, well-being.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

In contrast, there were no significant differences in reports of acute water shortage ($p = 0.787$) and severe harmattan ($p = 0.109$). This suggests that these stressors are widespread across all locations, likely driven by long standing deficiencies in water infrastructure and broad regional climatic influences. Their persistent nature highlights chronic environmental pressure that cuts across social and geographic lines, exposing older adults to constant risk due to age related limitations in adaptation.

Overall, the findings show that the interaction between social conditions and local climate stressors plays a central role in shaping disease vulnerability among older adults. There is a clear need for context specific adaptation efforts that include improved housing design, stronger public health surveillance, and targeted social support. Effective urban policy must incorporate climate adaptation strategies that prioritize the needs of older adults, recognizing them as a group that is both highly vulnerable and essential to building community resilience.

➢ *Self-Reported Climate-Sensitive Diseases*

The overall distribution of reported diseases, as presented in Table 4, reveals a high and diverse disease burden across the study population irrespective of city differences.

Table 4 Distribution of Climate Sensitive Diseases by City

Disease	Kano (%)	Ibadan (%)	Makurdi (%)	Total (%)	χ^2	df	p-value	Significance
Respiratory Infection	75.5	97.5	65.4	81.4	93.83	2	0.000	Significant
Malaria	85.2	88.5	96.2	89.9	8.64	2	0.013	Significant
Diarrhea	47.0	55.5	51.3	52.3	7.25	2	0.027	Significant
Cerebrospinal Meningitis	11.7	6.9	6.4	9.2	7.77	2	0.021	Significant
Measles	20.2	13.5	5.1	12.9	16.41	2	0.000	Significant
Skin Infection	43.3	37.4	52.6	56.9	7.31	2	0.026	Significant
Eye Infection	61.3	48.6	32.1	47.3	35.02	2	0.000	Significant
Cholera	49.2	61.0	52.6	49.7	13.94	2	0.001	Significant
Typhoid	52.5	65.1	53.8	54.6	16.29	2	0.000	Significant
Tuberculosis	19.2	15.7	9.0	15.7	6.28	2	0.043	Significant
Yellow Fever	47.5	42.3	39.7	45.5	3.81	2	0.149	Not Significant
High Blood Pressure	71.8	70.6	42.3	69.1	29.36	2	0.000	Significant
Arthritis	53.6	51.9	41.0	46.8	4.56	2	0.102	Not Significant
Asthma	46.1	45.3	65.4	50.3	11.24	2	0.004	Significant

The results show that malaria remains the most prevalent condition, reported by 89.9% of respondents, confirming its continued dominance as a major climate sensitive disease in urban environments. Respiratory infections were the next most common, affecting 81.4% of respondents, while high blood pressure was reported by 69.1%, reflecting the increasing presence of chronic noncommunicable diseases alongside infectious conditions.

Moderate levels of prevalence were observed for water and food borne diseases, with diarrhea (52.3%), cholera (49.7%), and typhoid (54.6%) being the most common. These findings point to persistent challenges related to water quality, sanitation, and food safety in the study areas. Skin infections (56.9%) and eye infections (47.3%) were also widespread, suggesting environmental and hygiene related exposures such as dust, poor waste management, and limited access to clean water.

Lower prevalence was recorded for measles (12.9%), tuberculosis (15.7%), and cerebrospinal meningitis (9.2%). The relatively low occurrence of these diseases may be associated with improved vaccination coverage and targeted disease control efforts. Among chronic and respiratory related conditions, arthritis (46.8%) and asthma (50.3%) were moderately common, indicating the dual influence of aging, occupational exposure, and urban environmental stressors.

As shown in Table 5, the chi square tests confirmed statistically significant differences across cities for most disease categories. Strong spatial variation was observed for respiratory infection ($\chi^2 = 93.83$, $p < 0.001$), eye infection ($\chi^2 = 35.02$, $p < 0.001$), high blood pressure ($\chi^2 = 29.36$, $p < 0.001$), and typhoid ($\chi^2 = 16.29$, $p < 0.001$). Moderate but significant differences were found for diarrhea ($\chi^2 = 7.25$, $p < 0.05$), tuberculosis ($\chi^2 = 6.28$, $p < 0.05$), and skin infection ($\chi^2 = 7.31$, $p < 0.05$). Only yellow fever ($\chi^2 = 3.81$, $p > 0.05$) and arthritis ($\chi^2 = 4.56$, $p > 0.05$) did not vary significantly across cities.

Spatially, Ibadan recorded higher frequencies of water and food borne diseases such as typhoid and diarrhea, while Kano exhibited more cases of vector borne and chronic conditions including malaria (85.2%) and high blood pressure (71.8%). In contrast, Makurdi reported particularly high rates of malaria (96.2%) and asthma (65.4%), suggesting the influence of local climatic and environmental factors on disease occurrence.

Overall, the results presented in Table 5 demonstrate that the urban populations studied are affected by a wide spectrum of both infectious and chronic diseases. The coexistence of high malaria, respiratory, and hypertension rates highlights the presence of a dual disease burden shaped by climate exposure, environmental degradation, and lifestyle transitions.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

➢ *Determinants of Climate Sensitive Disease Burden*

The analysis of disease burden across socio-economic groups reveals clear disparities that reflect the spatial and social determinants of health in urban environments. As shown in Table 5, the overall distribution of the Disease Burden Index (DBI) shows significant variation with respect to city of residence, residential density, occupation, income, and length of stay. These variations underscore the multidimensional nature of health vulnerability, which arises from the interaction between environmental exposure, living conditions, and socio-economic status.

Table 5 Determinants of Disease Burden

Variables	Category	Low DB (%)	Moderate DB (%)	High DB (%)	χ^2	p-value	Significance
City	Kano	19.9	33.7	46.4	16.710	.002	Significant
	Ibadan	16.2	34.9	48.9			
	Makurdi	35.9	32.1	32.1			
Residential Density	High Density	24.8	13.6	61.7	72.369	.000	Significant
	Medium Density	13.4	34.1	52.4			
	Low Density	22.5	40.7	36.8			
Gender	Male	19.7	33.1	47.2	1.217	.544	Not significant
	Female	20.2	35.9	44.0			
Marital Status	Married	19.0	34.7	46.3	6.705	.349	Not significant
	Divorced	25.8	29.0	45.2			
	Separated	14.6	37.5	47.9			
	Widowed	27.0	27.9	45.1			
Education Qualification	No Formal Education	15.5	38.1	46.4	11.782	.300	Not significant
	Primary	27.0	34.4	38.5			
	Secondary	19.4	34.0	46.7			
	Tertiary	18.9	34.6	46.5			
	Postgraduate	19.2	33.0	47.8			
	Other	29.2	12.5	58.3			
Occupation Status	Unemployed	0.0	0.0	100.0	78.199	.000	Significant
	Informal/Artisan	24.2	30.5	45.3			
	Trader	19.1	39.0	41.9			
	Civil Servant	9.7	29.0	61.3			
	Professional	29.4	36.1	34.5			
	Retired	22.2	27.8	50.0			
	Other	27.9	36.5	35.6			
	Other 2	12.4	30.4	57.1			
Monthly Income	Below ₦66,000	26.5	36.8	36.8	103.306	.000	Significant
	₦66,001–₦200,000	8.5	26.7	64.8			
	Above ₦200,000	3.4	36.8	59.8			
Length of Stay	Below 16 years	13.6	28.0	58.3	69.166	.000	Significant
	16–30 years	22.3	38.1	39.5			
	Above 30 years	34.4	39.8	25.8			

The results summarised in Table 5 indicate that disease burden was highest among residents of Ibadan (48.9%) and Kano (46.4%), while it was lowest in Makurdi. This pattern may be linked to differences in climatic exposure, population density, and the quality of urban infrastructure. Kano and Ibadan, being larger and more industrialized cities, may experience higher ambient temperatures, inadequate drainage, and greater crowding, which collectively increase exposure to climate-sensitive diseases such as malaria, diarrhea, and respiratory infections.

Residential density emerged as one of the most significant correlates of disease burden ($\chi^2 = 72.37$, $p = .000$). Respondents in high-density areas (61.7%) reported higher levels of disease burden compared with those in medium or low-density zones. This outcome reflects the complex reality that high-density areas, which often correspond to peri-urban and environmentally fragile zones, may suffer from poor waste management, limited access to safe water, and proximity to disease vectors. The findings highlight that spatial distribution and environmental quality rather than population concentration are key mediators of health outcomes.

Socio-economic variables also contributed substantially to disease differentiation. Occupation and income were particularly significant ($p = .000$). Civil servants (61.3%) and those in the middle-income group (64.8%) recorded higher disease burden than other occupational and income categories. This trend could be attributed to exposure patterns associated with formal sector employment, sedentary lifestyles, and intermediate living conditions that combine

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

both urban exposure and partial environmental vulnerability. This challenges the common assumption that disease burden is concentrated only among low-income populations. Instead, it suggests an emerging pattern where both environmental and occupational stressors intersect to produce health risks among the middle socio-economic group.

The length of stay in the residence also showed a strong and statistically significant relationship with disease burden ($\chi^2 = 69.17$, $p = .000$). Respondents who had lived in their communities for less than sixteen years reported higher disease incidence (58.3%) than long-term residents. This may reflect limited adaptation to local environmental conditions, weaker social networks, and reduced access to health-related information and resources.

In contrast, gender ($\chi^2 = 1.22$, $p = .544$), marital status ($\chi^2 = 6.71$, $p = .349$), and education ($\chi^2 = 11.78$, $p = .300$) were not significantly associated with disease burden. The absence of significant gender differences implies that both men and women were equally exposed to climate-related health risks within the same environmental and socio-economic settings. Similarly, the non-significant role of education suggests that awareness alone may be insufficient to reduce health risks without corresponding improvements in environmental quality and basic infrastructure.

Overall, the results demonstrate that disease burden in urban Nigeria is shaped more by spatial and economic inequalities than by individual demographic characteristics. The significant influence of city, income, occupation, and residential conditions aligns with evidence from international studies that highlight the urban health gradient, where structural deprivation and environmental stress combine to produce uneven disease outcomes (WHO, 2021; Macharia *et al*., 2023; Finkelstein *et al*., 2022; Bentley *et al*., 2025; Patel *et al*., 2021). These studies underscore that health disparities are shaped by socioeconomic inequalities, occupational exposures, and housing environments, which together reinforce spatial patterns of disadvantage across cities (Pagani *et al*., 2023).

- *Susceptibility to Climate Related Risks Among Older Adults*

Table 6 presents the relationship between socio-economic and housing characteristics and the percentile grouping of the Vulnerability Index, which reflects susceptibility to climate-related risks among older adults in Kano, Ibadan, and Makurdi. The results reveal that while demographic attributes such as gender, marital status, and education have limited influence, the respondents' residential and economic conditions significantly determine their susceptibility to climate-related hazards.

Table 6 Climate-Sensitive Diseases Vulnerability Index

Variable	Category	Low Vulnerability (%)	Medium Vulnerability (%)	High Vulnerability (%)	χ^2	p-value
City of respondent	Kano	35.2	31.8	33.0	5.601	0.231
	Ibadan	29.1	35.7	35.2		
	Makurdi	33.3	38.5	28.2		
Residential density	High density	46.0	37.9	16.1	207.896	0.000
	Medium density	22.9	34.4	42.7		
	Low density	16.5	18.0	65.5		
Gender of respondent	Male	33.2	33.6	33.2	0.041	0.980
	Female	33.5	33.0	33.5		
Marital status	Married	33.8	33.4	32.8	10.931	0.091
	Divorced	22.6	38.7	38.7		
	Separated	27.1	20.8	52.1		
	Widowed	34.4	36.9	28.7		
Education qualification	No formal education	29.9	37.1	33.0	10.359	0.410
	Primary	30.3	33.6	36.1		
	Secondary	32.6	32.6	34.7		
	Tertiary	35.7	33.6	30.7		
	Postgraduate	34.8	33.9	31.3		
Occupation status	Informal/Artisan	47.4	28.4	24.2	22.734	0.065
	Trader	37.0	28.8	34.2		
	Civil servant	25.8	36.8	37.4		
	Professional	29.8	35.7	34.5		
Monthly income group	Below ₦66,000 (Low)	33.5	33.2	33.2	12.947	0.012
	₦66,001–₦200,000 (Middle)	29.3	33.7	37.0		

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

	Above ₦200,000 (High)	47.1	33.3	19.5		
Length of stay	Below 16 years	21.0	32.2	46.8	149.153	0.000
	16–30 years	36.4	36.4	27.2		
	Above 30 years	70.3	25.0	4.7		

The result shows that susceptibility to climate-related risks is not significantly different across the three study cities ($\chi^2 = 5.601$, $p = 0.231$), indicating that exposure and vulnerability are not entirely location-specific but are largely shaped by socio-economic conditions. Similarly, gender did not significantly influence vulnerability ($\chi^2 = 0.041$, $p = 0.980$), suggesting that both male and female older adults face comparable levels of exposure and sensitivity to climate hazards. Marital status and education were also not significantly related to vulnerability, implying that personal demographic characteristics may not substantially buffer or exacerbate risk levels.

In contrast, residential density emerged as a highly significant factor ($\chi^2 = 207.896$, $p < 0.001$). Respondents in high-density areas recorded the greatest susceptibility (42.7 percent), while those in low-density areas experienced the least (16.1 percent). This pattern aligns with urban vulnerability literature emphasizing that densely populated neighborhoods often face greater heat stress, inadequate drainage, and reduced adaptive capacity due to overcrowding and poor infrastructure (Elmarakby, et al 2024; Leta, B. M. et al 2023; Huang, K., et al;2025; Parker, C. et al, 2025).

Monthly income was also a significant determinant ($\chi^2 = 12.947$, $p = 0.012$). Older adults in the low-income group (below ₦66,000) were more likely to experience high vulnerability (37.0 percent), whereas those in higher-income categories (above ₦200,000) reported lower susceptibility (19.5 percent). This demonstrates the critical role of economic resources in determining resilience through better housing, healthcare access, and adaptive measures such as cooling systems or flood protection.

Length of stay in residence was another strongly significant factor ($\chi^2 = 149.153$, $p < 0.001$). Respondents who had lived in their communities for less than sixteen years showed higher vulnerability (46.8%), while those with longer residence durations (above thirty years) reported lower susceptibility (4.7%). Long-term residency often enhances local environmental knowledge, community cohesion, and access to social support, which collectively reduce risk.

Although occupation status was only marginally significant ($\chi^2 = 22.734$, $p = 0.065$), the pattern suggests that informal workers and traders exhibit higher susceptibility compared to professionals and civil servants, reflecting the precarious nature of informal employment and its limited capacity for adaptive investment.

Overall, the findings indicate that susceptibility to climate-related risks among older adults in Nigerian cities is primarily shaped by structural and socio-economic contexts rather than by demographic attributes. High-density environments, low income, and short-term residency contribute to greater exposure and lower adaptive capacity. These results underscore the need for spatially differentiated interventions that prioritize vulnerable groups in informal and high-density settlements, promote income-enhancing programs for older adults, and strengthen place-based resilience strategies that account for tenure stability and neighborhood conditions.

VI. PLANNING IMPLICATIONS AND RECOMMENDATION

The findings of this study reveal that older adults in Nigerian cities face significant health risks linked to climate exposure, yet their vulnerability is largely shaped by urban environmental conditions and socioeconomic disadvantages rather than by personal demographic traits. The high burden of climate-sensitive diseases such as malaria, respiratory infections, and hypertension reflects the combined effects of rising temperatures, changing seasonal patterns, and persistent infrastructural deficits. Older adults residing in densely populated and low-income neighbourhoods experience greater susceptibility because they are more exposed to heat stress, flooding, and poor sanitary environments, and have fewer resources to adapt effectively. This situation has direct implications for urban planning, as the design and management of the city space continue to determine whether aging populations remain resilient or become increasingly burdened by climate-related health challenges.

The results show that vulnerability is not primarily dependent on gender or educational attainment, which suggests that improved awareness alone cannot shield older adults from environmental hazards without corresponding improvements in living conditions. Length of residence, income level, and the spatial characteristics of neighbourhoods strongly influence exposure, demonstrating that vulnerability is embedded in the structural inequalities prevalent within the urban fabric. Therefore, climate-responsive planning must adopt a socially inclusive approach that prioritizes neighbourhoods where older adults are most at risk and ensures that their specific needs are integrated into adaptation strategies.

In light of these insights, strategic planning interventions are required to strengthen resilience. Urban infrastructure must be upgraded to support better drainage, improved access to clean water, and reliable waste management, particularly in high-risk communities. Housing improvements such as enhanced ventilation, insulation, and environmental controls are important to safeguard older

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

adults against heat and vector-borne diseases. Targeted health support, including mobile health outreach and regular screening for chronic and climate-related illnesses, would reduce disease severity and improve timely access to care. Strengthening social support networks and community-based systems will also help reduce isolation and support rapid response during climate-related emergencies.

Finally, reducing vulnerability requires policies that integrate climate and health considerations into broader planning frameworks. This includes neighbourhood mapping to guide resource allocation, as well as the inclusion of older adults in emergency preparedness and city development plans. Expanding livelihood support and social safety programs for older informal workers can also reduce economic constraints that undermine adaptive capacity. Overall, the study underscores the need for context-specific, equity-focused planning that recognizes older adults as a vital and growing segment of the urban population. Prioritizing their resilience will not only improve health outcomes but also contribute to more sustainable and socially inclusive Nigerian cities.

VII. CONCLUSION

This study reveals that climate exposure and health vulnerability among older adults in Nigerian cities (Kano, Ibadan, and Makurdi) are critically shaped by spatial and socioeconomic inequalities. While climate change awareness is high, the capacity to adapt is uneven, tied to residents' living conditions and resources. Older adults face a dual burden of climate-sensitive diseases like malaria, respiratory infections, and hypertension. Neighbourhood environment, income status, and tenure length emerged as more critical determinants of vulnerability than gender or education. Those in high-density, low-income areas experience greater exposure to heat, flooding, and poor sanitation, severely compromising their health and resilience. The findings underscore that climate-related health vulnerability stems from structural disadvantage and spatial conditions, not individual limitations. Reducing risks requires strengthening healthy urban environments, improving infrastructure and services, and integrating older adults into climate adaptation planning for more equitable and sustainable urban development in Nigeria.

REFERENCES

[1]. Adelekan, I. O. (2020). *Urban dynamics, everyday hazards and disaster risks in Ibadan, Nigeria. Environment and Urbanization, 32*(2), 413–431.

[2]. Atufu, C. E. (2021). *Evaluating the impacts of flooding on the residents of Lagos, Nigeria* [Master's thesis]. University of Northampton. https://pure.northampton.ac.uk

[3]. Bello, M. O., Adeola, G. R., & Fadairo, O. S. (2023). Climate change, vector-borne diseases and health vulnerability in sub-Saharan Africa. *International Journal of Environmental Research and Public Health, 20*(11), 6129. https://doi.org/10.3390/ijerph20116129

[4]. Bentley, R., Mason, K. E., Jacobs, D., Blakely, T., Howden-Chapman, P., Li, A., Reeves, A., & Adamkiewicz, G. (2025). Housing as a social determinant of health: a contemporary framework. *The Lancet Public Health.* https://doi.org/10.1016/S2468-2667(25)00142-2. (The Lancet)

[5]. Cadmus, E. O., Adebusoye, L. A., & Owoaje, E. T. (2022). Rural and urban differences in quality of life and associated factors among community dwelling older persons in Oyo State, Nigeria. *Quality of Life Research, 31*(6), 1579–1590.

[6]. Echendu, A. J. (2020). The impact of flooding on Nigeria's sustainable development goals (SDGs). *Ecosystem Health and Sustainability, 6*(1), 1–14. https://doi.org/10.1080/20964129.2020.1791735

[7]. Elmarakby, E., Kumar, P., Mahmod, M., & Tiwari, A. (2024). *Prioritising urban heat island mitigation interventions: Integrating population density, green cover and heat risk into a Heat Risk Index. Science of the Total Environment, 918*, 171121. https://doi.org/10.1016/j.scitotenv.2024.171121

[8]. Ewurum, U. J. (2025). Mental and emotional dimensions of ageing in urban Nigeria: The overlooked side of healthy ageing. *Journal of Gerontological Studies in Africa, 9*(1), 45–59.

[9]. Federal Ministry of Health, Nigeria. (2024). *Nigeria: Climate change and health vulnerability and adaptation assessment report.* Atach Community.

[10]. Finkelstein, D. M., et al. (2022). Economic well-being and health: the role of income support programs in promoting health and advancing health equity. *Health Affairs.* https://doi.org/10.1377/hlthaff.2022.00846. (healthaffairs.org)

[11]. Gbadegesin, A., & Olabisi, O. (2022). Housing quality and environmental health risks in Nigerian cities. *Journal of Urban and Regional Planning Studies, 15*(2), 101–119.

[12]. Graham, H., & Schofield, C. (2021). Ageing, vulnerability and urban health: A global synthesis. *Global Public Health, 16*(7), 1089–1106.

[13]. Huang, K., Xu, Y., Chen, Y., & Wang, J. (2025). *Declining urban density attenuates rising population-weighted surface urban heat island extremes. Scientific Reports, 15*(1), 11084. https://doi.org/10.1038/s41598-025-73726-9

[14]. IPCC. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Intergovernmental Panel on Climate Change, Cambridge University Press.

[15]. Iyanda, A. E., Ogunjimi, L., & Oladele, F. (2023). Heat exposure and cardiovascular health in African cities: Emerging risks and adaptation priorities. *Environmental Research, 231*, 116073. https://doi.org/10.1016/j.envres.2023.116073

[16]. Leta, B. M., Ejigu, T. D., Abebe, M. T., & Debela, A. T. (2023). *Characterizing the level of urban flood vulnerability using the Flood Vulnerability Index: Evidence from Ethiopian cities. PLOS ONE, 18*(6), e0287241. https://doi.org/10.1371/journal.pone.0287241

[17]. Macharia, P. M., et al. (2023). Exploring the urban gradient in population health: insights from satellite-

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25oct1343

derived urbanicity classes across the urban continuum. *BMJ Global Health, 8*, e013471. https://doi.org/10.1136/bmjgh-2023-013471. (gh.bmj.com)

[18]. Ndimele, P. E. (2024). *Urban environmental inequalities and health risks in Lagos State*. University of Lagos Press.

[19]. Nguyen, T. P., & Smith, K. R. (2020). Measuring adaptive capacity to climate change: A multidimensional approach. *Climate and Development, 12*(3), 228–240. https://doi.org/10.1080/17565529.2019.1604285

[20]. Niyi-Odumosu, A. (2025). Air quality, harmattan exposure and respiratory health of urban dwellers in Southwestern Nigeria. *African Journal of Environmental Health, 11*(2), 87–101.

[21]. Nnadi, A., Okafor, C., & Osondu, E. (2024). Economic insecurity and ageing in urban Africa: Evidence from older adults in Nigeria. *African Population Studies, 38*(1), 33–48.

[22]. Ogbonna, C., Adekola, O., & Adeoti, A. (2024). Urban housing deficits and the health implications of informal settlements in Lagos. *Built Environment and Health Review, 6*(1), 41–58.

[23]. Ogunwale, J., Ede, P., & Arowolo, D. (2024). Climate change and malaria risk mapping in Nigeria: Spatial perspectives for public health planning. *Geojournal of Health and Environment, 8*(2), 77–93.

[24]. Olanrewaju, K., & Fregene, O. (2020). Socioeconomic inequality, housing and health in Nigerian cities. *Urban Studies Journal, 57*(9), 1894–1912.

[25]. Omoemu, F. O., Adebisi, Y. A., & Alabi, M. O. (2025). Dual disease burden and ageing under climate stress in sub-Saharan Africa: A review. *African Journal of Public Health Policy, 17*(1), 1–15.

[26]. Oyeyemi, A. L., Sallis, J. F., & Oyeyemi, A. Y. (2023). Built environment correlates of active ageing and well-being among older adults in Nigerian cities. *Journal of Transport & Health, 29*, 101385. https://doi.org/10.1016/j.jth.2023.101385

[27]. Pagani, A., Christie, D., Bourdon, V., Wall Gago, C., Joost, S., Licina, D., Lerch, M., Rozenblat, C., Guessous, I., & Viganò, P. (2023). Housing, street and health: a new systemic research framework. *Buildings & Cities, 4*(1), 629–649. https://doi.org/10.5334/bc.298. (Buildings & Cities)

[28]. Patel, L., Friedman, E., Johannes, S. A., Lee, S. S., O'Brien, H. G., & Schear, S. E. (2021). Air pollution as a social and structural determinant of health. *The Journal of Climate Change and Health, 3*, Article 100035. https://doi.org/10.1016/j.joclim.2021.100035. (downloads.regulations.gov)

[29]. Parker, C., Matthews, T., Hurlbert, M., & Singh, C. (2025). *Quantifying intra-urban socio-economic and environmental drivers of climate vulnerability and adaptive capacity*. *Environmental Research Letters, 20*(2), 024002. https://doi.org/10.1088/1748-9326/ad8c2f

[30]. Raimi, M. O., Omidiji, A. O., & Adeniji, A. O. (2021). Environmental justice and vulnerability to climate risks in Nigerian urban areas. *Sustainability, 13*(10), 5534. https://doi.org/10.3390/su13105534

[31]. Sado, D., & Adeyemi, O. (2023). Urban heat stress and health outcomes in tropical cities: Evidence from Nigeria. *International Journal of Climate and Health Research, 4*(2), 112–127.

[32]. UNICEF & World Health Organization. (2021). *Healthy ageing and environmental resilience in Africa: Regional situation report*. Geneva: WHO Press.

[33]. World Bank. (2023). *Climate change and health in West Africa: Integrating adaptation into urban resilience strategies*. Washington, DC: World Bank Group.

[34]. World Bank. (2023). *Nigeria country climate and development report.* World Bank Publications.

[35]. World Health Organization. (2021). *Climate change and health: Country profiles – Nigeria*. Geneva: WHO Press.

[36]. World Health Organization. (2021). COVID-19 and the social determinants of health and health equity: evidence brief (6 December 2021). World Health Organization. ISBN: 9789240038387. https://www.who.int/publications/i/item/9789240038387. (World Health Organization)

[37]. Yoon, D. K., Kang, J. E., & Brody, S. D. (2021). Measuring urban climate vulnerability: A framework for adaptation policy. *Environment and Planning B: Urban Analytics and City Science, 48*(3), 617–632. https://doi.org/10.1177/2399808320905659