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Effects of Housing Design on Indoor Environmental Quality and Residents' Health in Nigeria

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Abstract
Housing has an impact on occupants' health and well-being in addition to providing physical shelter. This study examined the effects of residential design characteristics on indoor environmental quality (IEQ) and occupant health in Nigeria. Significant outcomes were seen when environmental measurements and health questionnaires were combined in data collection from 236 houses. Findings show enhanced ventilation via window design and sustainable materials can alleviate respiratory and tiredness symptoms. The study concludes with a call for health-focused architectural interventions in house design and recommendations centre on design principles customised for tropical regions to foster healthy indoor environments.

Keywords: Housing Design; Residents' Health; Indoor Environmental Quality; Nigeria

1.0 Introduction

Adequate and healthful housing is increasingly recognised as a basic human right, necessary not only for shelter but also for maintaining physical and mental health (Tinson & Clair, 2020). Contemporary research confirms that housing design has a substantial impact on occupant health and well-being, with an increasing emphasis on the negative health effects of inadequate and poorly regulated housing (Olufadewa *et al.,* 2025). While previous attention was focused on tangible elements such as sanitation, overcrowding, and hygiene, recent research has highlighted the impact of soft housing features such as layout, lighting, ventilation, and material finishes on mental and respiratory health (Liu *et al.,* 2022; Daniyan, 2023; Akande *et al.,* 2024). Housing is now seen as more than just physical infrastructure; it is an active predictor of health, primarily through its impact on indoor environmental quality (IEQ), which includes air quality, temperature, light, and noise conditions (Akande *et al.,* 2023). Despite this evolving perspective, there is still no commonly accepted definition of "healthy housing" that considers environmental, psychological, and socio-spatial factors (Rohde *et al.,* 2020). Current research also highlights safety and perceived well-being as top concerns in housing and health research, but a comprehensive terminology for addressing well-being in housing remains lacking (Riva *et al.,* 2022). In Nigeria, poor housing design contributes to building-related illnesses (BRI) and promotes the spread of infectious diseases. While much of the known knowledge comes from industrialised countries, the relationship between housing and health in emerging countries like Nigeria remains largely unexplored. This study fills that gap and aim to investigate how housing design and IEQ influence health outcomes in Nigerian homes, with the purpose of supporting health-centred design principles for similar situations. The study's objectives include to (i) Establish a relationship between building design elements and occupant health. (ii) Identify the correlation between poor indoor air quality (PM2.5, PM10) and poorly ventilated (CO_2) homes and health complaints (iii) Determine the characteristics in the residential interior environment that impact and/or increase the occurrence of health issues.

2.0 Literature Review

Existing research on health and housing is mostly concerned with how environmental elements influence comfort and well-being. Substandard housing is usually associated with poor health, including overcrowding, unaffordability, and fuel poverty (Tinson & Clair, 2020). Studies (Xie *et al.,* 2023; Bates, 2025;) have also looked into demographic-related health risks, such as how an ageing population demands increased housing accessibility. While the COVID-19 lockdowns sparked increased attention in housing quality, space, and design, there has been little research into how inhabitants perceive these variables and how they influence lived experiences, well-being, and housing expectations. As a result, while considerable attention has been paid to house design standards, there has been little emphasis on how poor design directly affects mental and physical health. Recent research emphasises the importance of indoor environmental quality (IEQ) elements as air quality, ventilation, lighting, thermal comfort, and material selection in affecting occupant health.

Akande *et al.* (2023) found that metropolitan Nigerian housing with high levels of PM2.5 and PM10 frequently surpasses WHO safety criteria, contributing considerably to respiratory diseases. Furthermore, Curado *et al.* (2024) identified health concerns associated with asbestos-containing materials in schools, correlating weak regulatory compliance to respiratory disorders. Furthermore, housing design features such as window type and placement, ventilation systems, building orientation, and finishes have a substantial impact on IAQ and resident health. Indoor environmental stresses, particularly in poorly regulated and under-resourced Nigerian communities, have been linked to higher rates of infectious and chronic diseases (Akande *et al.,* 2024; Olufadewa, 2025). However, much of the existing literature isolates individual housing or IEQ variables, often within metropolitan contexts, rather than completely integrating them into a comprehensive knowledge of occupant health. This study addresses these research gaps by quantitatively analysing the relationships between various residential design features, indoor environmental parameters, and health outcomes in Nigerian housing contexts, thereby contributing to the development of inclusive, health-sensitive housing design frameworks that can be tailored to different climates and socioeconomic realities.

2.1 Theoretical Framework

The Salutogenic Model of Health serves as the theoretical basis for this research. This theory focuses on how environmental variables promote health and well-being rather than simply preventing disease. According to this paradigm, housing settings can be either salutogenic or pathogenic, depending on the design factors that influence IEQ (Antonovsky, 1996). The framework directs the evaluation of how certain design aspects (windows, orientation, and materials) shape IEQ metrics (air quality, thermal comfort, and illumination), hence influencing occupant health. It focuses on "Sense of Coherence" (SOC), which is achieved by (i) Comprehensibility: a predictable, well-ventilated, and well-lit environment. (ii) Manageability: Features such as operable windows and cleanable surfaces (for example, good floor finishing) allow residents to maintain their surroundings. (iii) Meaningfulness: Comfortable living conditions promote psychological well-being and dignity, which correlates with enhanced health perception. In addition, the Indoor Environmental Quality Framework (Manu & Rysanek, 2022) establishes criteria for assessing air quality, lighting levels, temperature conditions, and acoustic comfort, allowing for the empirical quantification of health risks in residential structures.

3.0 Methodology

This study was undertaken in Abuja, Bauchi, and Niger State, Nigeria, to reflect different levels of housing development. Abuja, the federal capital, is a fast urbanising city with substantial housing projects, whilst Bauchi and Niger (particularly Minna) were chosen as contrast cities with low building activity. These cities are spread across different climatic and geographical zones, offering a broad setting for evaluating housing design and health implications. To allow for generalisable statistical analysis, a quantitative method was used with a structured questionnaire. The instrument, based on existing literature and piloted for accuracy (Adu Gyamfi et al., 2022), collected information on demographics, indoor environmental conditions, house design elements, and health concerns. Air quality metrics, temperature and humidity were measured with Airnode sensors (Airvisual, USA), and the CO_2 results were calibrated against a Rotronic CL11 (Rotronic, BSRIA, Bracknell, UK). During the dry season (October-November), the occupant's exposure to indoor CO_2 emissions, PM2.5, and PM10 particulate matter was measured above 1m from the ground in the bedroom and living room for a minimum of 12 hours using Airnode sensors. A five-point Likert scale improved response clarity, and the instrument demonstrated strong reliability with a Cronbach's alpha of 0.80, which exceeded the consistency threshold of 0.70 (Tavakol & Dennick, 2011). To ensure broad representation of dwelling types, purposive, stratified, and systematic sampling approaches were used to select 385 houses from a population of around 3 million and a housing stock of 2,000 units. According to Krejcie and Morgan's (1970) sample size table, a minimum sample of 276 was sufficient, accounting for desired accuracy and available resources. The ultimate number of replies received was 276, resulting in a robust response rate of 71.7% (Table 1), confirming the study's statistical validity. Data were evaluated using descriptive and inferential statistics, as well as Pearson's correlation (p = 0.05), in SPSS Version 20 to investigate significant correlations between variables.

Table 1. Respondents' response rate

Location	Distribution (No) A	Returned (No) B	% of response rate (B/A*100)
Abuja	150	120	80.0%
Bauchi	120	116	96.6%
Minna	115	40	34.8%
Total	385	276	71.7%

4.0 Results

The bulk of responders (65.8%) were male, and nearly half earned less than N20,000 per month. Approximately half of the families used traditional fuels like firewood, charcoal and kerosene. Indoor temperatures (22°C - 40°C) and relative humidity (29%-82%) surpassed ASHRAE guidelines. The majority of respondents were determined to be educated. To fulfil the study's aims, respondents were asked if the quality of their indoor environment had ever affected their health or that of a family member. Table 2 presents an examination of the responses. Table 2 demonstrates that the statistical correlations indicate that some house design aspects have a substantial impact on inhabitants' health through the quality of indoor environmental conditions. These are summarised and presented as follows: (i) Window Type in Living Room (-0.341, p=0.044) exhibits a statistically significant negative connection. This suggests that poor or inappropriate window types in the living room are likely linked to negative health outcomes, possibly due to insufficient ventilation or lighting. (ii) The number of windows in the living room (-0.14, p=0.042) is similarly significant.

Table 2: Relationship between building characteristic and the health of the occupants

	Building characteristics	Correlation coefficient (P-value)	Outcome
A	**Window type in the living room**	**-0.341(0.044)**	**Significant**
B	**Number of windows in the living room**	**-0.14(0.042)**	**Significant**
C	Any existing openable window at opposite wall in the living room	0.084(0.073)	Not significant
D	**Level of light in the living room**	**-0.070(0.013)**	**Significant**
E	Window type in the bed room	0.297(0.114)	Not significant
F	Number of windows in the bed room	-0.110(0.575)	Not significant
G	Any existing openable window at opposite wall in the bed room	0.026(0.392)	Not significant
H	Level of light in the bed room	0.087(0.211)	Not significant
I	**Material for floor finishing**	**0.346(0.035)**	**Significant**
J	Material for wall finishing	0.068(0.426)	Not significant
K	Material for ceiling finishing	0.102(0.538)	Not significant
L	Material for roof finishing	0.203(0.206)	Not significant

As a result, having fewer windows may result in inadequate air circulation and daylight penetration, negatively impacting respiratory health and mental well-being. (iii) Openable Opposite Windows in Living Room (0.084, p=0.073) is not statistically significant. Despite the potential benefits of cross-ventilation, this was not a significant health variable in the sample. (iv) Level of Light in Living Room (-0.070, p=0.013) is significant, implying that insufficient natural illumination may contribute to poor mental health, eye strain, or increased energy use for lights. (v) Floor Finishing Material (0.346, p=0.035) shows a significant positive association. This suggests that certain floor materials (such as polished cement or tiles) may emit fewer pollutants or be easier to clean, hence enhancing hygiene and lung health. (vi) Other non-statistically significant elements (e.g., window kinds in bedrooms, wall/ceiling/roof finishes) may have limited direct effects or be contextually influenced by other variables (e.g., occupant behaviour or room usage).

To investigate the correlation between poor indoor air quality (PM2.5, PM10) and poorly ventilated (CO_2) homes and health complaints, two hypotheses were proposed with α=0.05. The results are shown in Table 3. The findings show a substantial link between influenza and PM2.5, as well as malaria and CO2. Similarly, there is a significant link between PM2.5 and chickenpox, as well as CO2 and chickenpox (p-value < 0.05).

Table 3: Relationship between indoor quality and incidence of health complains

			$PM_{2.5}$	PM_{10}	CO_2
Kendall's tau_b	Has the quality of the indoor environment ever affected your health or health of the any member of the family	Correlation Coefficient	-.159	-.018	-.096
		Sig. (2-tailed)	.146	.866	.379
		N	52	52	52
	Influenza	Correlation Coefficient	**-.228***	-.200	-.155
		Sig. (2-tailed)	**.031**	.058	.144
		N	**52**	52	52
	Malaria	Correlation Coefficient	-.109	-.092	**-.232***
		Sig. (2-tailed)	.308	.394	**.031**
		N	52	52	52
	Pneumonia	Correlation Coefficient	-.031	-.056	.008
		Sig. (2-tailed)	.782	.622	.942
		N	52	52	52
	Asthma	Correlation Coefficient	-.052	-.189	-.184
		Sig. (2-tailed)	.651	.101	.111
		N	52	52	52
	Meningitis	Correlation Coefficient	.105	.079	.203
		Sig. (2-tailed)	.359	.488	.077
		N	52	52	52
	Measles	Correlation Coefficient	.047	-.033	.106
		Sig. (2-tailed)	.681	.771	.351
		N	52	52	52
	Chickenpox	Correlation Coefficient	**-.277***	-.181	**-.231***
		Sig. (2-tailed)	**.014**	.106	**.040**
		N	**52**	52	**52**
	Tuberculosis	Correlation Coefficient	-.003	.074	.030
		Sig. (2-tailed)	.981	.521	.794
		N	52	52	52

Table 4 summarises and interprets the results obtained in a tabular fashion. Non-significant relationships were discovered for asthma, pneumonia, measles, TB, and meningitis; while these disorders have been associated to poor air quality, their occurrence in this study was statistically ambiguous.

Table 4: Interpretation of the correlation between indoor air pollutants and the incidence of health complaints.

Health Complaint	Significant Relationship ($p < 0.05$)	Pollutant	Interpretation
Influenza	Yes	PM2.5	Higher levels of fine particulate matter (PM2.5) are significantly connected with an increased risk of influenza.
Malaria	Yes	CO_2	Poor ventilation (high CO_2 levels) is connected to malaria incidence, presumably due to mosquito reproduction in stagnant indoor air.
Chickenpox	Yes	PM2.5, CO_2	Poor indoor air quality may have immune-suppressive consequences, as PM2.5 and CO_2 levels are significantly associated with chickenpox cases.
General Health Perception	No	PM2.5, PM10, CO_2	Respondents did not see a statistically significant link between indoor air quality and overall health. This could indicate a lack of health knowledge or the absence of apparent symptoms.

To determine the characteristics in the residential interior environment that impact and/or increase the occurrence of health issues. Ordinal logistic regression was used to determine the effect of indoor factors on the frequency of health complaints. The results are shown in Table 5.

Table 5: Factors within the residential indoor environment influencing incidence of health complaints.

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[Q10 = 1.00]	17.140	12.570	1.859	1	.173	-7.497	41.776
	[Q10 = 2.00]	19.270	12.638	2.325	1	.127	-5.501	44.041
Location	PM2.5	-.019	.034	.304	1	.582	-.085	.048
	PM10	.004	.002	4.192	1	.041	.000	.009
	AQIUS	-.022	.026	.700	1	.403	-.072	.029
	TEMPTC	.582	.400	2.117	1	.146	-.202	1.366
	HUMIDITY	.050	.040	1.536	1	.215	-.029	.128
	CO2	.004	.003	2.339	1	.126	-.001	.009

The interpretation of the Results in Table 5 on the analysis that assessed which indoor environmental parameters significantly predict the likelihood of health complaints among residents is summarised and presented in Tabular format in Table 6.

Table 6: Interpretation of the analysis that assessed which indoor environmental parameters significantly predict the likelihood of health complaints among residents

Variable	Estimate	p-value	Interpretation
PM10	0.004	0.041	Higher PM10 (coarse particulate matter) concentrations have a statistically significant favourable effect on the risk of health problems.
PM2.5	-0.019	0.582	There was no statistically significant influence on health incidence in this model.
Temperature (°C)	0.582	0.146	Not statistically significant, however a possible influence is hypothesised.
Humidity (%)	0.050	0.215	Not significant.
CO_2 (ppm)	0.004	0.126	Although not statistically significant at $p < 0.05$, there is a trend of greater CO_2 levels leading to more health problems.

PM10 has a substantial positive effect on health, with a coefficient of 0.004 and a p-value of $0.041 < 0.05$. This means that each unit rise in PM10 enhances the incidence of health.

5.0 Discussion

According to the Indoor Environmental Quality (IEQ) Framework, which encompasses thermal comfort, indoor air quality, visual comfort, and acoustic comfort this study identifies significant problems linked to indoor air quality. Poor illumination, particularly in living environments, has a negative impact on occupants' health, corroborating Arif *et al.* (2016), who relate insufficient daylight to headaches, weariness, and sadness. Window ventilation is also important; incorrect or insufficient window types are connected with stagnant air and higher indoor pollutants, consistent with the findings of Baeza-Romero *et al.* (2022). Drawing on Antonovsky's (1996) Salutogenic Model of Health, which emphasises health-promoting design, window type, lighting, and materials all have a substantial impact on both physical and emotional well-being. Findings from this study supports the emerging evidence that poor indoor air quality promotes viral and respiratory diseases. This align with the studies by Chong *et al.* (2022) who found that PM2.5 particles penetrate deep into the lungs, increasing the risk of respiratory infections. Additionally, higher CO_2 levels, a ventilation indicator, may facilitate disease transmission (Vanus *et al.,* 2021). Findings also reveals a substantial correlation between PM10 and increased health complaints, particularly in tropical, poorly ventilated areas, which supports Sharma *et al.,* 2024's findings on its association with respiratory and cardiovascular disorders. Although CO_2 and temperature were not statistically significant, their effects in weariness, cognitive deterioration, and enhanced pathogen viability align with research by Vanus *et al.* (2021). Overall, the study finds that housing design techniques aiming at reducing PM10 and enhancing ventilation are consistent with the salutogenic principle of enabling inhabitants to manage environmental risks and promote well-being (Antonovsky, 1996).

6.0 Implications for Policy and Practice.

The study's findings highlight the importance of health-focused housing policies in Nigeria, including enforcing design standards such as minimum window sizes, optimum ventilation, and adequate lighting—particularly in living spaces. It argues for the regulation of safe, low-maintenance materials, the incorporation of health indicators into building rules to promote salutogenic design, and giving residents more control over their indoor settings to improve both physical and mental health.

7.0 Conclusion and Recommendations

This study looked into how residential design elements such as window type, building orientation, lighting, and materials affect indoor environmental quality (IEQ) and occupant health in Nigeria. The study demonstrated a significant correlation between poor indoor air quality (PM2.5, PM10, and CO_2) and health difficulties, emphasising the importance of house design for public health. Based on IEQ criteria and the Salutogenic Model, the study emphasises that well-designed housing is an important driver of well-being. It advocates for interdisciplinary collaboration among architects, public health specialists, and policymakers, and suggests that future housing regulations prioritise ventilation, lighting, and material selection to promote healthier, more resilient urban populations. The study suggests numerous ways for promoting healthy housing in Nigeria, including: (i) Prioritising ventilation design through passive and cross-ventilation methods to reduce CO_2 accumulation; (ii) Integrating particulate matter (PM) control via low-emission materials, indoor air filters, sealed building envelopes, and green buffer zones to limit dust infiltration; (iii) Educating residents on the health impacts of indoor air quality, particularly PM10, through public health campaigns and providing tools like low-cost air quality monitors. (iv) Including indoor environmental quality (IEQ) measures like PM10 and CO_2 in national building regulations and affordable housing assessments. These approaches are consistent with Construction 5.0's emphasis on smart, health-oriented, and sustainable settings, particularly in developing countries where housing and health are inextricably connected.

8.0 Limitations of the Study, Improving the Research Findings and Directions for Further Research

The study's focus on only three cities limits the generalisability of findings to Nigeria's different regions. Its solely quantitative approach lacks the richness of qualitative insights. The reliance on self-reported health data presents possible bias, and the study did not account for other influencing factors such as lifestyle or pre-existing health issues. To strengthen the research, more diverse cities in Nigeria should be included, a mixed-methods approach combining quantitative and qualitative data should be used, clinical validation of health issues should be collaborated on, and longitudinal studies should be implemented to track changes over time and improve causal inference. Future research should look into regional climate differences in relation to housing and health, evaluate the impact of housing policies, investigate smart housing technologies under Construction 5.0, study resident behaviour and its health implications, conduct post-occupancy evaluations, and prioritise vulnerable groups such as children and the elderly for more inclusive housing solutions.

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Contribution of Research to the Architectural Field and Residential Environment

This study makes a substantial contribution to the architectural discipline by showing evidence-based correlations between specific house design elements—such as window types, orientation, lighting, and materials—and occupant health using the lens of Indoor Environmental Quality (IEQ). This study highlights the impact of design decisions on poor air quality indices (PM2.5, PM10, CO_2), emphasising architects' role in promoting public health. The study also links house design with the Salutogenic Model, shifting the architectural focus from providing shelter to designing surroundings that promote well-being. In the residential environment, the study promotes health-sensitive housing regulations, such as passive ventilation, dust-reducing construction techniques, and the use of non-toxic materials. It advocates for the incorporation of health indicators into building performance standards, stimulating interdisciplinary collaboration, and advancing the Construction 5.0 vision of smart, sustainable, and health-centered living spaces in Nigeria and other developing countries.

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