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

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Abstract
The building industry's contribution as a non-clinical contributor to the quality of life is its impact on occupants' health. A health-based standardised questionnaire and a digital data collection device were used to investigate the susceptibility of building indoor air quality (IAQ) to infectious diseases. PM2.5 (63 µm/m3) and PM10 (228 µm/m3) obtained exceeded the international standard. Some associations between certain building characteristics and potential risk factors for certain diseases were seen. This study provides a platform for future intervention in housing and public health policies and addresses the conundrum of safe and healthy buildings for the urban populace in Nigeria.

Keywords: Housing Quality; Residents' Health; Quality Life; Nigeria

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1.0 Introduction

One of the major global trends of the twenty-first century is urbanisation, which has a big impact on people's health. According to UNDESA (2018) report, 68% of the world's population would be living in urban areas by 2050, with about 90% of them being in developing countries in Africa and Asia. Currently, more than 55% of people live in urban regions. Given that the majority of urban expansion in the future will occur in cities in the Global South, crowded cities with underdeveloped health systems will face particular difficulties. These have evolved into the perfect breeding grounds for new illnesses like the worldwide coronavirus pandemic and the Ebola epidemics in Africa. Urbanization and other significant urban development trends must be managed immediately to safeguard and advance health (Akande, 2021). To accomplish this and address the problems caused by urbanisation, particularly in the Global South, urban housing has emerged as one of the important players.

Housing provision in Africa needs to go beyond being seen as a matter of number rather than quality (Akande, 2021). 53 million urban Africans, according to estimates from 2015, continued to reside in slum settings, putting them at higher risk for mental health issues, respiratory issues, and vector-borne illnesses like malaria (Harrisberg, 2019). In many African cities, outbreaks of non-communicable diseases are being exacerbated by overcrowding, substandard construction, and poor indoor air quality that do not satisfy

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WHO criteria. In Nigeria, the poorest socioeconomic classes make up 51.2% of its urban population, which is estimated to be 202 million people. These individuals face housing crises (Idowu, 2013; IHME 2020) and experience a disproportionate amount of the negative health effects of substandard housing, including meningitis, pneumonia, and non-communicable diseases. These millions of people reside in slum-like conditions with gravely inadequate social facilities, creating substandard and subhuman surroundings (Lanrewaju, 2012). However, there is a significant and untapped potential for improving the health of urban residents through investments in higher-quality housing. Policies based on group contributions and synergistic interventions from urban studies researchers, architects, environmentalists, urban planners, environmental and public health scientists, policymakers, and other urban studies professionals are needed to sustain the drivers for these investments.

This study aims to investigate the interaction between residential housing design and infectious disease risks. The specific objectives are to (i) identify the building factors that expose residents to infectious disease risks (ii) determine the association between building design factors and the indoor environment (i.e., indoor air quality, ventilation adequacy) susceptible to infectious disease risks within the buildings.

2.0 Literature Review

Numerous studies have looked at how urbanisation may affect the standard of housing as well as how it may affect urban residents' health. A growing body of research (Tusting et al., 2020) demonstrates an association between infectious illness transmission and housing quality. According to recent studies, public health strategies might concentrate on improving housing quality to lower housing-related risk factors for infectious and other diseases (Akande et al., 2018). In addition, it has been demonstrated that urban housing quality affects residents' health significantly and is connected to a number of negative health consequences and the quality of the indoor environment has an impact on a variety of detrimental health effects. Studies by Kyle and Dunn (2008) show there is evidence of a connection between housing and health but many of these studies have adopted a restrictive approach by concentrating on the connection between a particular aspect of housing design, like ventilation, and a particular aspect of health in a particular population, like respiratory health in children.

According to research by Otto et al. (2022) poorly ventilated buildings have the largest indoor microbial loads, whereas those with optimal ventilation have lower indoor microbial loads. Due to the lack of methodologically sound and empirically solid evidence, these research conclusions were constrained because they mainly relied on questionnaires and the collection of microbiological samples without taking the buildings into account. According to research by Akande (2021) on how urbanisation affects housing quality and health, certain housing characteristics (such as the type of housing unit, the flooring, the materials used, and the type of windows) significantly raise the risk of contracting diseases like meningitis, measles, chicken pox, influenza, and other respiratory-prone conditions. Although their research was empirical, the sample size was insufficient to provide sufficient information regarding the health outcomes and impact of house design.

It is well-recognised that poor indoor air quality is a result of airborne microorganisms like bacteria, mould, and viruses (Chen, et al., 2006). These biological pollutants enter the body through inhaling and may result in respiratory illnesses since they are transported by airborne particles (Smith et al., 2000). Other elements that affect indoor air quality include building type and location, inadequate design, and ventilation systems and according to Dunn (2013), the indoor environment and the way occupants emit and deposit particular microbial populations are influenced by architectural design. Other researchers such as Hsu et al., (2016) have demonstrated how architectural design affects a building's biogeography and patterns of microbial diffusion indoors. According to research by Fahimipour et al., (2018), indoor environmental factors like temperature, humidity, light, and ventilation can promote sporadic bacterial and fungal growth. Because of this and other risky variables, people who live in poorly constructed homes are more likely to contract infectious diseases.

The aforementioned investigations make it increasingly clear that building and design features contain considerable exposures that may have an impact on the health of the occupants. Many health issues, according to Bonnefoy (2007), are either directly or indirectly related to the building or its design. The influence of poor house design on the transmission of infectious diseases has thus gotten less attention and hasn't been fully covered in most research, leaving significant gaps in knowledge about the relationship between housing design and health. To close these knowledge gaps, and to better comprehend the dynamics between residential house design and infectious illness concerns, it is vital to look into how they are related to one another. As a result, this study explores the relationship between population-level hazards for infectious diseases and residential home design.

3.0 Research Methodology

3 .1 Study area and population

The study was carried out in the Bauchi metropolis north east zone (Figure 1a &1b) of Nigeria having a population of 493,730 (NPC, 2008). Bauchi metropolis consists of seven residential wards subdivided into low, medium and high residential densities (Figure 1c &1d).

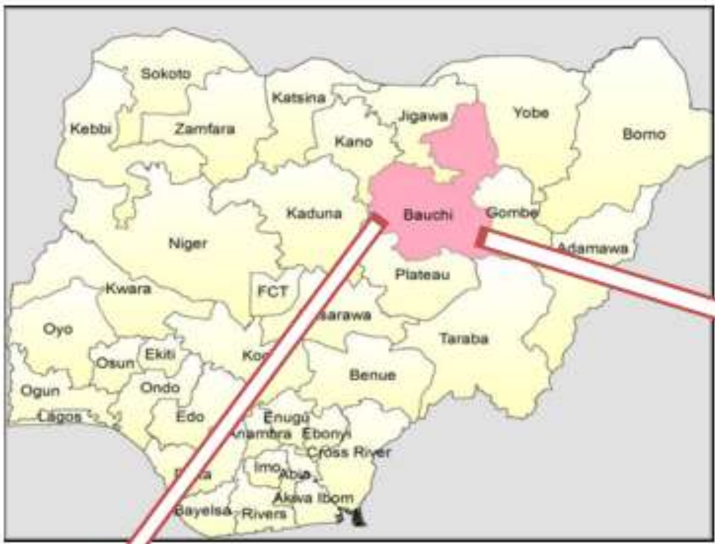

Figure1a: Map of Nigeria showing Bauchi State

Figure1b: Map of Bauchi State showing the towns


Figure1d: Google Map of Bauchi metropolis showing study area

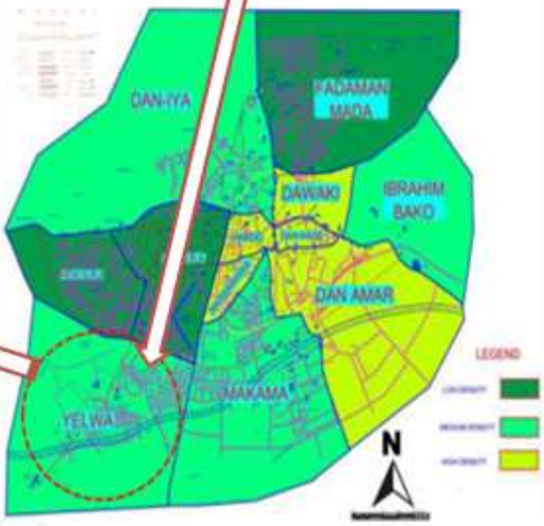

Figure 1c: Map of Bauchi metropolis showing the selected ward and housing density

Source: Muhammad et al., (2018)

3.2 Study population and sample size

According to the Geometric Progression Population Projection Formula (Kawu, 2016), Bauchi, which has a population of roughly 493,730, will have between 30,000 and 45,000 households, with an average household size of 8 to 12. These households make up the 5% sample population that was chosen through field surveys. The sample size (n) calculated using Turner's (2003) formula and represented in equations 1 and 2 was used to determine the number of questionnaires delivered in each neighbourhood for this research project.

$$n = \frac{(Z_a)^2 r(1-r) fk}{phe^2} \qquad \text{------------Equation 1}$$

The target population to factor parameter, r, is represented by the total population, p, which is calculated as 0.03 x 18 = 0.54 and represents the expected number of participants (n). According to Turner (2003), 0.03 was advised for each year of predicted population age, h=household size (which in underdeveloped countries is 6 people), and e=0.05 for the permitted error margin set at 5% of r. Additionally, f = 4 is the design effect, r = 50%, and Z=1.96, which represents the critical value of the normal distribution given in the Standard Normal Distribution Table at a 95% confidence level. It reflects the margin added to the sample size to account for the non-response rate and is an estimate of a portion of the number of expected respondents in the research with k=20%. Equation 1 was used to calculate the sample size, and equation 2's parameters and the aforementioned values were substituted.

$$n = \frac{(1.96^2 \times 0.5 \times 0.5 \times 4 \times 0.2)}{[0.54 \times 6 \times (0.05 \times 0.5)^2]} = 379.4 \approx 380$$ ------Equation 2

The smallest number of informants to be chosen from each of the groups was determined to be 380 participants. This calculation was compared to Taro (1967) sample size formula. Hence, the total number of surveys administered was rounded up to 400 because the total number obtained was 396. This number guided the overall distribution of questionnaires for this study. Each neighbourhood received fifty (50) questionnaires, which translates to a distribution rate of 10% of the neighbourhood's total population. Consequently, using simple random sampling, semi-structured questionnaires were distributed to a total of 400 houses in the study area. Statistical Package for Social Sciences (SPSS) version 23 was used to analyse the data using descriptive statistics (cross-tabulation) and a non-parametric test.

3.3 Sampling Technique

Eight residential neighbourhoods were purposefully selected from the Yelwa ward. These neighbourhoods are informal communities with comparable features, and people of middle- and low-income levels primarily live there. The questionnaire was distributed throughout the chosen neighbourhoods using a purposeful sampling strategy. This is carried out to guarantee a uniform spatial distribution and fair representation of the entire study area's population.

3.4 Instruments for Data Collection

The researcher developed a structured questionnaire that was utilised to gather pertinent data from the respondents. The home heads or the older persons present at the time of the survey in the neighbourhoods were given the questionnaires to complete. A hand-held digital camera was used to take pictures and document the current state of the environment and infrastructure in the chosen neighbourhoods. The four neighbourhoods that were chosen for the research project were identified using Google Maps. Scientific AirVisual Node device was used inside the homes to monitor indoor air quality and other environmental factors. These tools monitor indoor air pollution from cleaning, cooking, burning wood, and smoking. It tracked 24-hour air quality while measuring indoor air quality in real time. It keeps track of up to seven environmental factors, including air pressure, temperature, humidity, CO2, PM 2.5, and PM 10 levels. Additionally, it measures the air's humidity (0-100%) and temperature (-100C to +400C). Figure 2 shows the applied methodology.

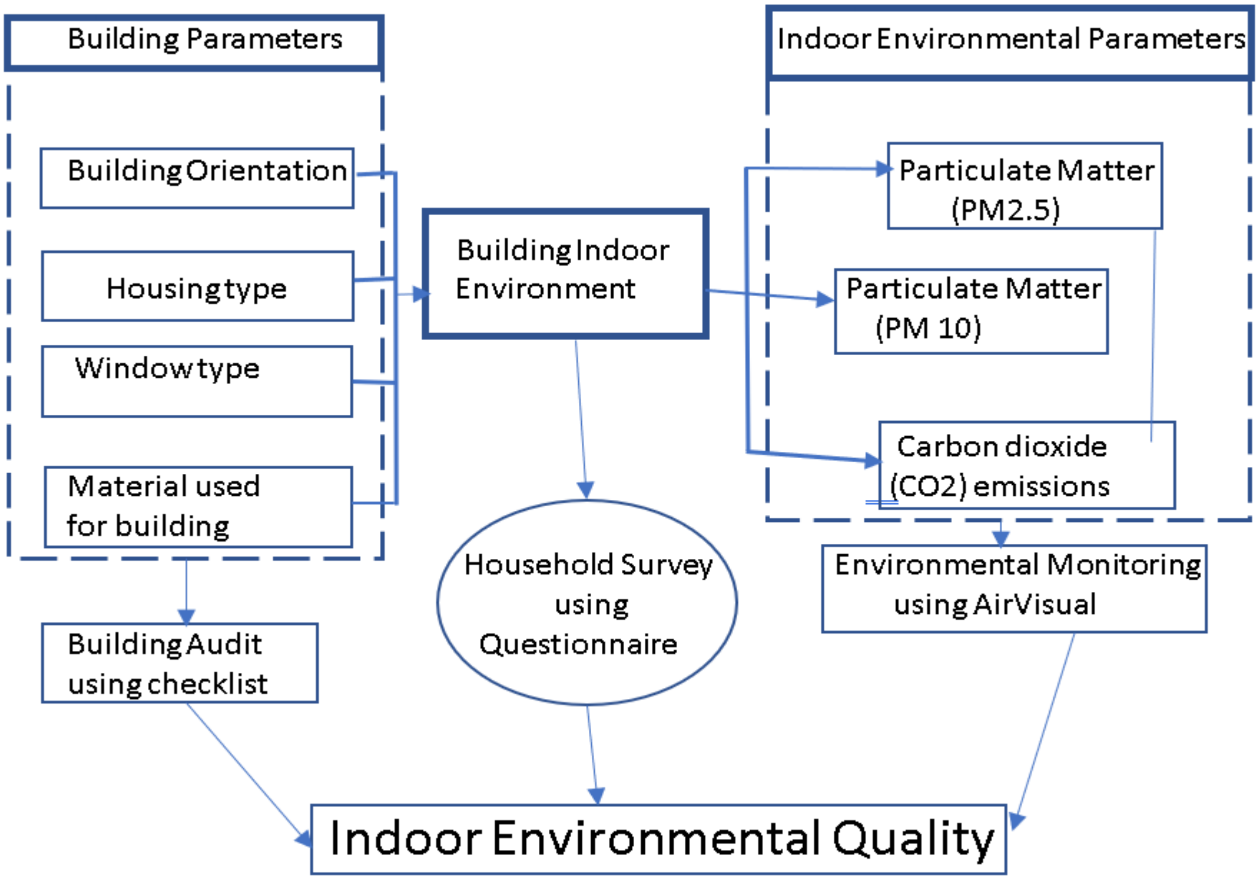

Figure 2: Applied methodology

3.5 Data collection procedure

The first step was gathering information on the neighbourhood's housing conditions. Next, a building audit was conducted under the direction of a checklist created for physical observations of the sample buildings. In 116 randomly chosen homes, the AirVisual Node device was installed and set up to continuously gather interior environmental data, such as temperature, relative humidity, particulate matter (PM2.5 and PM10), and CO2 emissions, at 1-minute intervals. For a collection period of 21 days, this provided 4,320 data readings every day, totalling 99,523 readings. The exposure of occupants to indoor CO2 emission, PM2.5, and PM10 particulate matter was quantified. Before being used, the questionnaire underwent pilot testing. One person from at least one-third of the homes in each building was interviewed using the systematic random sampling technique. In each building, the first household to be polled was assigned a random house number using a lottery system. Apart from the demographic data of the respondents, other measured variables and building character variables collected include building orientation, building type, the internal distribution of spaces and window opening design (i.e., the position of the openings, type, and size). Others are housing types and the materials used for the interior finishes.

4.0 Findings

For a Nigerian home with an average size of four family members, the plurality (47.6%) of respondents in this research reported a monthly income of less than N20,000 ($50) or roughly $1.25 per day. For cooking purposes within the home, around 50% of households use kerosene (0.7%), firewood (24.6%), charcoal (2.6%), or a mixture of the three (14%) (See Figues 3a and 3b). Compared to other energy sources, they emit more hazardous gases (e.g., electricity and gas). The majority (79.5%) of the homes had elevated PM concentrations. The range of the mean PM2.5 (63 µm/m3) and PM10 (228 µm/m3) concentrations was 10 µm/m3– 231 µm/m3 (PM2.5) and 20 µm/m3–1667 µm/m3 (PM10). This finding shows that most households were exposed to levels over the WHO guideline range of 25 and 50 µm/m3. Although from the mean CO2 values (584 ppm), ventilation appears was sufficient however, many houses were poorly ventilated as evident from the range of CO2 values obtained (i.e., 403 ppm to 2201 ppm). While the relative humidity (40.7%) is within recommended guideline levels (30%-70%), the mean temperature (28.9 °C) was marginally above the ASHRAE (2014) recommended guideline values (21°C - 26°C).

Figure 3a: Cooking area within courtyard as potential source of indoor pollution to the building

Figure 3b: Entrance to the house used as cooking area as potential source of indoor pollution

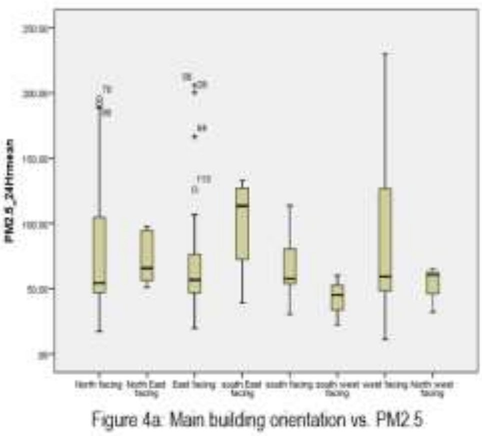

Figure 4a: Main building orientation vs. PM2.5

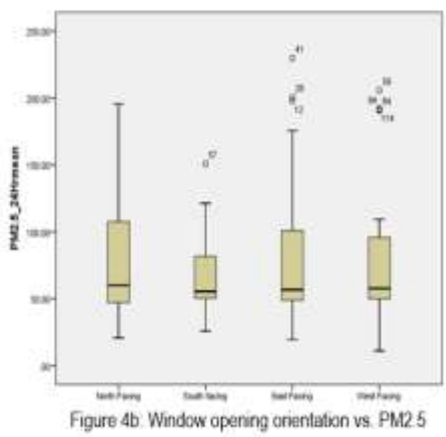

Figure 4b: Window opening orientation vs. PM2.5

The analysis's findings revealed a limply positive relationship between PM2.5, the orientation of the main building, and the orientation of the window opening (Figures 4a and 4b). To address respondents' ratings on the indoor environment, ventilation indicator and indoor air quality were subjected to binary logistic regression with occupant self-reported diseases treated as the predicted variable.

The results presented in Table 1 show that the p-values of the Wald statistics for CO2 and PM_{10} are not significant factors in the incidence of any of the diseases with the prevailing residents' indoor environment (RIE) indices as none of the Wald statistics for them is less than 0.05. However, for PM2.5, Only the incidence of Influenza can be said to be significantly related to PM2.5 (Wald = 4.775 p = 0.029).

Table 1: Respondents' ratings on indoor environment, ventilation indicator and indoor air quality

		Variables in the Equation						Model Summary		
Disease	Variable	B	SE	Wald	Df	Sig	Exp(B)	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
Tuberculosis	Rating on Natural daylight	-.862	.503	2.943	1	.086	.422			
	PM2.5_24Hrmean	.009	.014	.418	1	.518	1.009			
	PM10_24HrMean	.000	.003	.027	1	.870	1.000	31.916[a]	.054	.133
	CO2_24HrMean	-.001	.003	.040	1	.841	.999			
	Constant	-.404	2.237	.033	1	.857	.667			
Pneumonia	Rating on Natural daylight	-1.093	.363	9.043	1	.003	.335			
	PM2.5_24Hrmean	-.001	.011	.004	1	.947	.999			
	PM10_24HrMean	-.001	.003	.051	1	.821	.999	68.947[a]	.174	.253
	CO2_24HrMean	.002	.002	2.188	1	.139	1.002			
	Constant	.874	1.363	.411	1	.521	2.397			
Asthma	Rating on Natural daylight	-.832	.428	3.775	1	.052	.435			
	PM2.5_24Hrmean	-.001	.019	.001	1	.969	.999			
	PM10_24HrMean	-.002	.004	.123	1	.726	.998	40.621[a]	.067	.141
	CO2_24HrMean	.002	.002	1.068	1	.301	1.002			
	Constant	-.766	1.602	.229	1	.633	.465			
Meningitis	Rating on Natural daylight	-.043	.307	.020	1	.888	.958			
	PM2.5_24Hrmean	.007	.010	.544	1	.461	1.007			
	PM10_24HrMean	-.001	.002	.343	1	.558	.999	73.660[a]	.008	.012
	CO2_24HrMean	.000	.002	.007	1	.935	1.000			
	Constant	-1.213	1.408	.742	1	.389	.297			
Measles	Rating on Natural daylight	-.234	.290	.651	1	.420	.791			
	PM2.5_24Hrmean	.013	.011	1.453	1	.228	1.013			
	PM10_24HrMean	-.005	.003	2.040	1	.153	.995	76.137[a]	.055	.079
	CO2_24HrMean	.001	.001	1.050	1	.306	1.001			
	Constant	-1.227	1.345	.833	1	.362	.293			
Chickenpox	Rating on Natural daylight	-.392	.287	1.866	1	.172	.675			
	PM2.5_24Hrmean	-.008	.010	.711	1	.399	.992			
	PM10_24HrMean	.004	.002	3.350	1	.067	1.004	83.163[a]	.120	.167
	CO2_24HrMean	.001	.001	.762	1	.383	1.001			
	Constant	-.782	1.252	.390	1	.532	.458			
Influenza	Rating on Natural daylight	-.382	.282	1.831	1	.176	.682			
	PM2.5_24Hrmean	-.023	.010	4.775	1	.029	.977			
	PM10_24HrMean	.005	.003	3.352	1	.067	1.005	94.595[a]	.130	.180
	CO2_24HrMean	-.002	.001	1.845	1	.174	.998			
	Constant	3.751	1.367	7.529	1	.006	42.563			
Malaria	Rating on Natural daylight	-.306	.657	.217	1	.641	.736			
	PM2.5_24Hrmean	-.020	.017	1.273	1	.259	.981			
	PM10_24HrMean	.004	.005	.530	1	.467	1.004	25.613[a]	.015	.063
	CO2_24HrMean	.000	.003	.002	1	.961	1.000			
	Constant	5.383	3.167	2.888	1	.089	217.578			

The main building orientation, the direction of the window opening, and other variables like the primary source of cooking fuel and the primary source of lighting were found to have weakly positive relationships with PM10. The direction of the main building and the type of housing unit showed a weakly positive link for CO2. The findings demonstrate a strong correlation between the major building orientation and the occurrence of measles (p=0.02), meningitis (p=0.03), and tuberculosis (p=0.04). Further findings indicated that PM2.5 was adversely connected with the occurrence of the majority of diseases, but favourably correlated with TB, meningitis, and chicken pox. The relationships, however, are not substantially connected to PM2.5 because none of them have p-values below 0.05. Similarly, PM10 was positively connected with the incidence of other reported illnesses but adversely correlated with the occurrence of measles, asthma, and pneumonia. Except for chicken pox, where Rpb = 0.285, p <.05., none of the relationships have a p-value of less than 0.05 in the majority of cases. This suggests that, with the exception of chicken pox, the majority of disease incidences are not significantly connected to PM10. The outcome for CO2 is comparable to PM2.5. Some illnesses' occurrences were inversely connected with CO2, while others were favourably correlated. None of the correlation values had values less than 0.05, therefore they are all not statistically significant.

To investigate the relationship between the building factors and the prevalence of the reported diseases, chi-square values were computed at the 0.05 level of significance. A logistic regression analysis of the incidence of diseases was carried out on the RIE indices based on the materials with which the floor was made. The result is presented in Table 2. The materials used for floor covering, however, are substantially connected with meningitis (p=0.01), measles (p=0.02), and influenza (p=0.002) in buildings. In the meantime, no connection between CO2 and diseases or indoor air quality is revealed by logistic regression analysis. Whereas PM2.5 (Wald = 6.263, p = 0.012) is strongly connected to Influenza, PM10 (Wald = 4.029, p =.045) and Influenza (Wald = 4.002, p =.045) exhibit significant relationships with chicken pox.

Table 2: Association between Materials used for floor covering and the incidence of the listed diseases

Incidence of specific diseases		Materials used for floor covering					Total	Chi-Square value	df	Sig	Fisher's Test	df	Sig
		Earth/ Mud	cement	Tiles	Carpet (rubber)	Rug							
Incidence of Tuberculosis	No	4 6.0%	26 38.8%	19 28.4%	7 10.4%	6 9.0%	62 92.5%	2.320	4	0.677	2.204	4	0.633
	yes	1 1.5%	2 3.0%	2 3.0%	0 0.0%	0 0.0%	5 7.5%						
		5 7.5%	28 41.8%	21 31.3%	7 10.4%	6 9.0%	67 100.0%						
Incidence of Pneumonia	No	4 5.8%	20 29.0%	16 23.2%	6 8.7%	5 7.2%	51 73.9%	2.146	4	0.709	2.012	4	0.780
	yes	2 2.9%	10 14.5%	4 5.8%	1 1.4%	1 1.4%	18 26.1%						
	Total	6 8.7%	30 43.5%	20 29.0%	7 10.1%	6 8.7%	69 100.0%						
Incidence of Asthma	No	5 7.2%	26 37.7%	18 26.1%	7 10.1%	6 8.7%	62 89.9%	1.687	4	0.793	1.217	4	0.963
	yes	0 0.0%	3 4.3%	3 4.3%	1 1.4%	0 0.0%	7 10.1%						
	Total	5 7.2%	29 42.0%	21 30.4%	8 11.6%	6 8.7%	69 100.0%						
Incidence of Meningitis	No	1 1.5%	19 28.4%	18 26.9%	7 10.4%	6 9.0%	51 76.1%	14.856	4	0.005	12.159	4	0.008
	yes	4 6.0%	9 13.4%	3 4.5%	0 0.0%	0 0.0%	16 23.9%						
	Total	5 7.5%	28 41.8%	21 31.3%	7 10.4%	6 9.0%	67 100.0%						
Incidence of Measles	No	1 1.5%	17 25.8%	16 24.2%	7 10.6%	6 9.1%	47 71.2%	11.436	4	0.022	10.174	4	0.024
	yes	3 4.5%	12 18.2%	3 4.5%	1 1.5%	0 0.0%	19 28.8%						
	Total	4 6.1%	29 43.9%	19 28.8%	8 12.1%	6 9.1%	66 100.0%						
Incidence of Chickenpox	No	2 2.8%	21 29.2%	14 19.4%	6 8.3%	5 6.9%	48 66.7%	2.781	4	0.595	2.869	4	0.604
	yes	3 4.2%	8 11.1%	7 9.7%	2 2.8%	4 5.6%	24 33.3%						
	Total	5 6.9%	29 40.3%	21 29.2%	8 11.1%	9 12.5%	72 100.0%						
Incidence of Influenza	No	1 1.2%	15 18.5%	12 14.8%	0 0.0%	0 0.0%	28 34.6%	15.030	4	0.005	15.774	4	0.002
	yes	4 4.9%	19 23.5%	11 13.6%	9 11.1%	10 12.3%	53 65.4%						
	Total	5 6.2%	34 42.0%	23 28.4%	9 11.1%	10 12.3%	81 100.0%						
Incidence of Malaria	No	0 0.0%	1 1.0%	2 2.0%	0 0.0%	0 0.0%	3 3.0%	2.232	4	0.693	1.859	4	0.847
	yes	8 7.9%	40 39.6%	29 28.7%	10 9.9%	11 10.9%	98 97.0%						
	Total	8 7.9%	41 40.6%	31 30.7%	10 9.9%	11 10.9%	101 100.0%						

Similar findings were made for the building's bedroom capacity. While PM2.5 only significantly correlates with Influenza (Wald = 5.726, p = 0.017), PM10 significantly correlates with both Influenza and chicken pox (Wald = 3.987, p =.046).

5.0 Discussion of Findings

An important factor in affecting tenants' health is the internal environment of a building. Airflow in residential buildings that are naturally ventilated is influenced by factors like the windows in the structure. From this study, some elements in residential housing design were found to be related to PM, CO2, and occupant health. High indoor PM concentrations were observed in this study, and the households' choice of energy source for cooking may be one explanation for this (i.e., firewood, charcoal and kerosene). Other significant particle sources could have come from candlelight and a lack of greenery near the buildings. The levels of PM in the buildings surpassed the WHO Guidelines for PM2.5 (25 μm/m^3) and PM10 (50 μm/m^3), respectively, despite the fact that this study did not assess PM over a lengthy period of time. Surprisingly, this study did not discover any connection between the higher PM in the indoor environment and any of the reported illnesses, with the exception of chicken pox and influenza. This supports Bruce's (2000) assertion that the majority of studies conducted in underdeveloped nations failed to show a strong link between indoor air pollution and specific diseases. The study's findings also indicate that buildings typically have adequate ventilation, with average CO2 levels in bedrooms rarely exceeding 1000 ppm. The cause of this could be due to a number of interrelated variables, including how the building's residents operate their buildings and the fact that many homes are surrounded by courtyards. Households are able to leave their windows open throughout the day and night as a result. This finding backs up Bardhan and Debnath's (2016) assertion that windows and other openings affect natural ventilation and daylighting. This facilitates the quicker and easier elimination of household air pollutants, which refreshes the indoor atmosphere. In the meantime, poor indoor air quality may result from ambient air pollution in the surrounding area. Additionally, Hobday and Dancer (2013) claimed that exposure to sunshine and natural ventilation aid in the management of airborne illnesses by reducing the likelihood of transmission and reducing the microbial load. Therefore, the adequacy of the natural ventilation might easily have diluted the PM from biomass and kerosene utilised in the buildings, lowering its impact on occupant health.

6.0 Limitations of the study and areas for future research

This study's limitation is based on a few elements that could have enhanced its findings. For instance, if computational fluid dynamics (CFDs) had been employed to create models of the study's naturally ventilated buildings, greater results would have been obtained. The CFDs are computer models that replicate built-environment scenarios under a variety of environmental circumstances that are not possible to obtain from field investigations (Sarkar and Bardhan, 2019). Furthermore, indoor air quality and CO2 were only tracked for 8 to 12 hours each day as opposed to the WHO-recommended 24 hours, which could have affected the results. Additionally, the use of GPS would make it easier to identify specific buildings that are vulnerable to the spread of infectious diseases and serve as alerting hotspots. Additional research could investigate variables like air flow pattern and daylight autonomy utilising a variety of computational simulation models.

7.0 Conclusion& Recommendations

This study shows a connection between specific building characteristics (such as the building orientation, wall and floor materials, dwelling type, and number of rooms) and potential risk factors in residential housing for particular diseases (i.e., Meningitis, Measles, Chicken pox and Influenza). The PM were linked to influenza and chickenpox at the same time. Future intervention studies can make use of the research's conclusions. In addition to continuous monitoring of indoor PM and CO2, a large-scale study with a large sample size is advised. For the full spectrum of air quality measures and their relationship to occupant health outcomes through time and space to be captured, this is crucial. Through the use of various intervention tactics, such as increased ventilation provided by larger windows and the integration of chimneys and smoke hoods into kitchen design, intervention studies have demonstrated that poor indoor air quality can be dramatically improved. Such intervention studies may strengthen the scientific underpinnings for the creation of a simplified tick-box assessment framework that, in the future, may offer local healthcare professionals a tool for infectious risk analysis based on building type and window size evaluation. This might eliminate the need for extensive health questionnaires or environmental monitoring.

Contributions to Field of Study

This study provides a platform for future intervention in housing and public health policies and contributes towards efforts to address the conundrum of safe and healthy building for a growing urban poor populace in Nigeria.

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