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Age/Ageing and Clothing Insulation in Naturally Ventilated Living Rooms in ESHDC High-Density Estates, Enugu Metropolis, Nigeria

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Abstract*— The research examines the relationship between age and clothing insulation in naturally ventilated living rooms within high-density estates developed by the Enugu State Housing Development Corporation (ESHDC) in the Enugu Metropolis, Nigeria. The research relies on principles of the Adaptive Comfort Model and Environmental Possibilism, which recognise human behaviour as a critical factor in assessing the quality of the environment. It is a short-term research, involving a cross-sectional survey, using structured questionnaires administered in the evenings between 4:00 PM and 7:00 PM, across naturally ventilated living rooms in the two ESHDC high-density estates in the Metropolis, between June and August 2024, coinciding with the peak period of the rainy season in southern Nigeria. It employs a stratified sampling technique, resulting in a proportional sample of 130 respondents, and of 130 living rooms randomly chosen from the sampling frame of 433 housing units. The bivariate analyses based on a confidence error of $p \leq 0.05$, revealed the following key findings: 1.) No significant relationship between Occupant Age (OA) and Type of Cloth Insulation (TCI), as $p = 0.772$ (>0.05), contradicting the assumption that older persons prefer layered clothing for warmth. This result highlights the need for further research on the impact of age and clothing on thermal comfort in the warm-humid tropical climates. 2.) Positive and significant correlations with environmental variables such as the air temperature, air movement and humidity conditions. The outcomes underscore the importance of environmental quality for improving the thermal satisfaction of the active ageing population. The research recommended that an understanding of age/ageing and clothing insulation in the built environment could enhance environmental quality, promote the quality of life of the active age, thereby reducing disability and dependence associated with age/ageing globally.

Keywords: Age/Ageing, Clothing Insulation, Environmental Quality, Quality of life/Thermal Satisfaction.

I. INTRODUCTION

The scientific interest in age/ageing and clothing insulation has increased due to the need for a good quality of life for progressive ageing and for a productive population globally. Providing a good environment, whether it is natural, built or social, has to be acceptable to the inhabitants irrespective of age differences – an environmental issue confronting humanity (Sanchez-Gonzalez, 2015). Age refers number of years a person or thing has been alive or existed. Whereas ageing is used to describe a person or a thing that is getting old. Ageing therefore implies a natural process of a continuous deterioration of a person or a thing, resulting in both physiological and physical changes (Amarya et al., 2018). Hence, the use of the word age or ageing implies these explanations in this context.

Clothing insulates a person from exchanging heat with the surrounding air and surfaces as well as influencing the loss of heat through the evaporation of sweat. However, choice of clothing can influence by a person, whereas the environmental variables may be beyond human control. Thermal comfort is very much dependent on the insulating effect of the clothing on the person. According to Ho et al., (2011) clothing is an important thermal factor that aids in maintaining the thermal balance of human body, and ensuring that heat loss, skin temperature, air movement and humidity at body surface produces a sensation of comfort.

Knowing that both the old and young people often share spaces in a residential building such as the living rooms calls for the assessment of environment quality (i.e. Air temperature, air movement and humidity conditions of an indoor environment). Additionally, a careful assessment of environment quality calls for more understanding of the age/ageing and clothing insulation as measures to improve and sustain quality of life and thermal satisfaction of building occupants. The clothing insulation alone cannot guarantee a good quality life and well-being of occupants if the environment quality is lacking within a building. The environment quality relates to its physical variables and the capacity to improve occupant's thermal comfort. Age/ageing and clothing insulation are among critical factors that influence human adaptations and thermal perceptions in the built environment. According to Shahzad et al., (2018) and Strein-Cercel et al., (2008) non-thermal factors like the occupant's age and clothing insulation can impact on how a person feels even if the air temperature, air movement and relative humidity are constant.

Ageing relates to a human body and its physiological

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International Journal of Science, Engineering and Management (IJSEM)

Volume 13, Issue 04, April 2026

mechanism, as it affects physical activity, muscle health and frailty of a person. Findings from health science studies have reaffirmed that ageing decreases the ability of the body to control its temperature and sweating, resulting in older persons having a lower heat balance and preferring a warmer environment than younger ones (Health and Safety Executive [HSE], 2021; Wang et al., 2023). Consequently, older persons experience low levels of activity and increased desire for higher clothing insulation due to their low metabolic rate and low muscle strength as well. Hence, the need for building designers to take into account the age groups and type of cloth insulation at the initial design phase, with the view to integrate proper adaptive controls to improve environmental quality for the thermal comfort of the old and young people using naturally ventilated living rooms in high-density estates in warm-humid tropical climate.

Modern architecture defines a living room as an enclosed space in the residential building used for reception/entertainment of guests, relaxation and socialisation. Many scholars describe the living room an indispensable space, the centre of attraction, the image maker, and the central hub in the home where family members gather to interact, watch television, listen to the news, dine, or engage in indoor games and in mini ceremonies (Hou, 2016; Marshall, 2012; Rechavi, 2008). Additionally, a living room plays crucial role in fostering family ties, forming character, and strengthening the cultural integration within a larger society (Ogunola, 2018). Given its significance, a good environment quality guarantees quality of life for the active ageing groups, and the proper choice of clothing insulation for enhanced thermal satisfaction as well.

Preliminary investigation observed that the majority of occupants in the ESHDC high-density preferred to wear light clothing materials in the evenings. The observations suggested that the indoor environment quality as the probable cause - which often prompted occupants to wear clothing materials with the low thermal insulation property, as a strategy to achieve a thermal balance. Therefore, this study posits that the understanding of relationship between ageing and clothing insulation could help in providing the desired quality environment for a good quality of life capable of supporting active ageing population in the given community. According to Gonzalez, (2015), progressive or active ageing population can reduce challenges associated with disability and dependence, and in general, cuts down expenditure on health and social care services delivery, and eliminating negative effects on productivity as well. This investigation is the integral component of the broader research initiative - Assessing the effect of natural ventilation on thermal conditions of naturally ventilated living rooms in high-density estates within the Enugu Metropolis, Nigeria. To date, no detailed study on the influence of age/ageing and clothing insulation in naturally ventilated living rooms in the ESHDC high-density estates located in warm-humid tropical climate of Enugu State. This gab in human comfort research underscores the importance of further investigation. Accordingly, this research assesses the relationship between ageing and clothing insulation in the naturally ventilated living rooms within ESHDC high-density in the Metropolis. This research philosophy is pragmatism – using the mixed methods approach – involving both the objective and subjective assessments. This research relies on the principles of the Adaptive Thermal Model [ACM] and the Environmental Possibilism [EP]. Both principles acknowledge behaviour, knowledge and available resources as the critical factors in regulating the thermal environments. The research aims to make recommendations for improved thermal satisfaction and quality of life for occupants of living rooms irrespective of differences in their ages. Two hypotheses that underpin this study: 1. ‘There is no significant relationship between the occupant’s age and type of clothing insulation in naturally ventilated living rooms in ESHDC high-density estates’. 2. ‘There is no significant relationship between thermal satisfaction and environment quality’.

Area of the Study

The study was conducted in Enugu Metropolis the present capital city of Enugu State, located in south-eastern part of Nigeria, approximately between latitudes 06^0 21" and 06^0 30” N of the equator and longitudes 07^0 26’ E and 07^0 37” E of the Greenwich Meridian (Figure 1 shows the map of Enugu State, the hatched portion designates the Capital Territory. The word ‘Enugu’ means ‘Hill top’ which implies a city on top of hill. The Metropolis (aka Coal City) owes its name to its geographical location on top of hills, and the discovery of coal in 1909 by a team of British geologists. It is the oldest urban area in the South-east Nigeria. The National Population Commission [NPC], (2006), projects population of the Metropolis to be 2 million in 2015, with a population density of 427.6 persons per square kilometre. Igbo people are the main ethnic nationality, and the presence of other nationalities gives the city the cosmopolitan character (Enugu State Government Diary, 2013). The mass exodus of people into the Metropolis has affected adversely environment quality, thereby impacting health, well-being and quality of life of active ageing population (Nigeria Institute of Town Planners [NITP], 2016; Sanchez-Gonzalez, 2015).

ISSN (Online) 2456 -1304

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Volume 13, Issue 04, April 2026

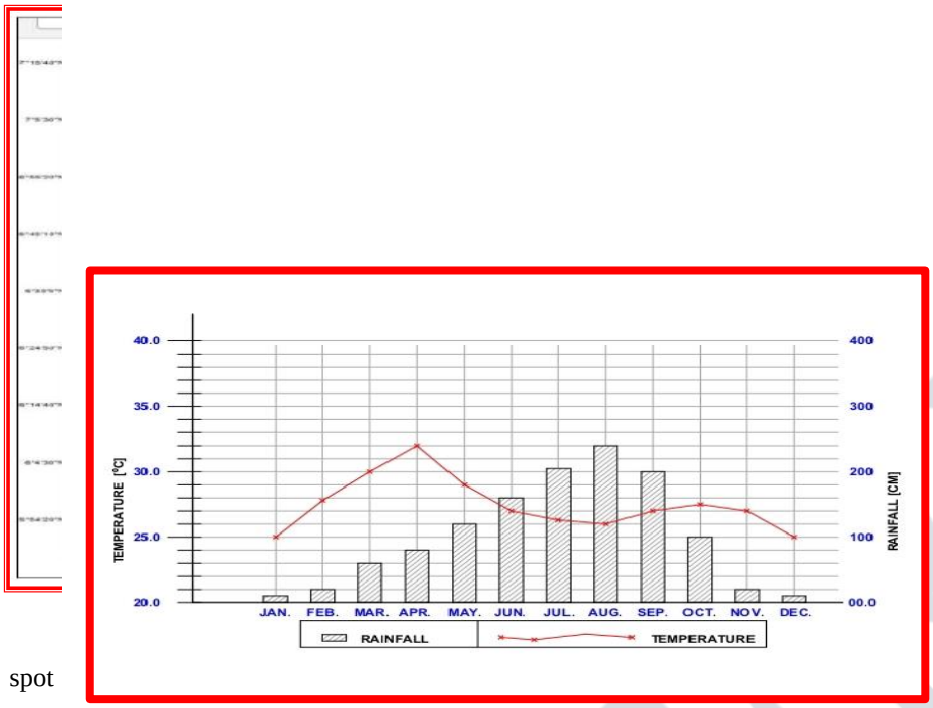


Figure 1. Map of Enugu State (showing the Metropolis in hatched spot

Source: Enugu Government Diary, (2013).

Climatic/Topographic characteristics of the Study Area

The Metropolis sits on undulating hilly topography, with six rivers, namely Aria, Asata, Ekulu, Idaw, Nyaba and Ogbete rivers, helping to modify microclimate of the Metroplois. According to Koppen's global climate classification, Enugu State belongs to the Tropical Moist Climate, [TMC]. Its vegetation is of the tropical rainforest with the derived savannah characters. The Metropolis sits at an altitude of 304.7m above sea level and it is naturally humid. The average maximum temperature is 34.9^0 C, with average lows of about 22.3^0 C and its annual mean temperature is about 26.7^0 C. The rainy and dry seasons are the only seasonal periods in Enugu State (Iloege, 2001).

The Figure 2 presents graphic chart of Average Monthly Temperature and Rainfall in Nigeria, 1991 – 2021

The southern regions experience strong rainfall events during the rainy season from March to October, with the peak period of the rainy season occurs from June to August, with the annual average amounting between 200cm – 400cm, and the annual mean temperature is about 25.0^0 C – 27.0^0 C in the same period (World Bank Group, WBG, 2021).

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Volume 13, Issue 04, April 2026

Figure 2. Average Monthly Temperature and Rainfall in Nigeria, 1991 – 2021
Source: World Bank Group, WBG, (2021): Climate Risk Profile, Nigeria

LITERATURE REVIEW

Age/Ageing

The Adaptive Comfort Model integrates occupant's personal information as a critical element of the thermal comfort assessment. Hence, the need to gain an insight into occupant's age as it impacts on individual thermal expectations on daily basis, and on individual love for more time indoors and for prolonged thermal comfort (Vellei et al., 2023; Haliu et al., 2021; Adunola & Ajibola, 2016). The Environmental Gerontology indicates the importance of the environment on active and progressive ageing. Providing good environments supports active population globally – Active ageing can improve health and quality of life, and reduce the problems of disability and dependence, and in general, cuts down on social spending and health spending, thereby mitigating negative productivity (Sanchez-Gonzalez, 2015). Hence, a comprehensive information about age/ageing status is very crucial in providing the environment quality for a good quality of life and thermal satisfaction for all age cadres in a given community. Aside key six factors of thermal comfort, other non-thermal factors of which age is one of them can influence occupants' thermal perceptions (Shahzad et al., 2018; Adegun & Odesola, 2018). Age influences how a person adapts, perceives and interacts with the environments in various climatic zones. Past studies have revealed age/ageing can have an impact on how people feel and behave even if air temperature, humidity and air movement are all constant (Health and Safety Executive, HSE, 2021; Wang et al., 2023).

In addition, health science has also revealed that ageing decreases ability of body to control its temperature and sweating, resulting in older people having a lower heat balance and preferring a warmer environment than younger people. Age/ageing can also slow levels of activity and increase clothing insulation as well. Older people prefer higher ambient temperature because of their lower activity level and metabolic rate than younger people due to reduced muscle strength, lower work capacity, lower sweating capacity, lower hydration levels and lower vascular reactivity and cardiovascular stability (Wang et al., 2023). Also, ageing comes with the decrease in the amount of fat below the skin that makes it harder to stay warm, hence the need for older people to wear layers of clothing to feel warm (Health and Safety Executive, HSE, 2021).

Clothing Insulation

Clothing insulation is the thermal insulation provided by clothing (ANSI/ASHRAE - 55, 2010). Clothing is important for the survival of human beings on the planet earth. Clothing can be said to be an artificial skin made from material fabrics that protects humans from adverse environmental conditions, and maintains the thermo-physiological comfort and human body thermoregulatory mechanism (Luitel et al., 2020; Gidik et al., 2016; Schiavon & Lee, 2012). Clothing plays a crucial role in the maintenance of heat balance as it modifies heat loss and the moisture loss from skin surface. According to Ho et al., (2011) clothing is a crucial thermal factor that aids in maintaining the thermal balance of human body, and ensures that heat loss, skin temperature, air movement and humidity at body surface produce a sensation of comfort.

Additionally, clothes insulate a person from exchanging heat with surrounding air and surfaces as well as influencing the loss of heat through the evaporation of sweat. However, clothing can be directly controlled by persons whereas environmental factors may be beyond human control. Thermal comfort is very much dependent on the insulating effect of the clothing on person. Wearing too thick cloth or personal protective equipment (PPE) may be a primary cause of thermal discomfort even if the environment is neither warm nor hot. The nature of climate can also influence thermal insulation, and as well determines clothing patterns in different climate zones globally. The estimated clothing values of garments as shown in Table 1. Clothing values are calculated in a scale called Clo value. I clo = 0.155m2 k/w

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Volume 13, Issue 04, April 2026

insulation to the body. One clo is the amount of insulation that allows a person at rest to maintain thermal equilibrium in an environment at 21^0C (70^0F) in a normally ventilated room at 0.1m/s air movement (ANSI/ASHRAE-55, 2010).

Table 1. Estimated clothing values for selected garments

Clothing Item	1 clo	Clo Value
T- shirt	0.09	0.014
Short sleeve shirt	0.09	0.029
Normal, long sleeves	0.25	0.039
Flannel shirt/ long sleeves	0.3	0.047
Light-weight trousers	0.2	0.031
Overalls	0.28	0.043
Thin sweater	0.2	0.031
Jacket	0.35	0.054
Fabric coloured cushion swivel chair	0.1	0.016

Source: Adopted from: Ifebi, (2020); International Standard Organisation, ISO, 9920 (2007)

Other factors that influence clothing insulation are posture and activity. Sitting or lying affects thermal insulation due to the compression of air layers in clothing, and the clothing materials of a chair or a bed can provide considerable insulation. However, sleeping or resting situations can be better estimated if the person is completely inactive. The active body motion decreases the insulation of clothing ensemble by allowing more air motion within the clothing ensemble. Air motion affects clothing insulation (ANSI/ASHRAE - 55, 2010; ASHRAE Handbook, 2005). Data on an active person for a specific condition is possible with the aid of this equation **#1**:

$$\mathbf{1_{cl,\ active} = 1_{cl}\ x\ (0.6 + 0.4/M)\ 1.2met < M > 2.0met \ldots\#1.}$$

Where M is the metabolic rate in met units and 1cl is the insulation without activity. For metabolic rates less than or equal to 1.2 met, no adjustment is recommended.

Clothing insulation is correlated with outdoor air temperature, indoor operative temperatures, relative humidity and dress code (Schiavon & Lee, 2015), and also with the number of persons, furniture/equipment in a room (Hawendi et al., 2019). Due to a complex nature of estimating clothing insulation, Schiavon & Lee, (2015) posit a model to predict how building occupants to enhance HVAC system operation. Clothing preference plays an important role in achieving thermal comfort, and the likely effective means of adjustment and adaptation in the thermal environment. Additionally, clothing preference may also depend on other factors unrelated to thermal conditions, such as for a dress code or social influences and style preferences due to culture, gender or work condition (ANSI/ASHRAE - 55, 2010).

Environmental Quality, Quality of life & Thermal Satisfaction

The environmental quality in this context relates to the four non-control thermal variables that impact on the thermal conditions: Air Temperature, Mean Radiant Temperature [MRT], Air Movement and Relative Humidity. Air temperature is an environmental factor that underpins occupants' perceptions of thermal comfort. Air temperature is the measure of the hotness or coldness of the air in a room. Extreme cold and hot conditions can create thermal discomfort conditions in a room, thereby limiting physiological ability to resist thermal stress due to ageing challenges. Accordingly, Brown et al., (2012) caution that the indoor thermal conditions can be potentially life threatening for occupants if the core body temperature reaches conditions of hyperthermia above 37. 5^0C – 38. 3 ^{0}C (99.5^0F – 100.9^0F) or hypothermia below 35^{0}C (95^{0}F). Thus, highlighting the emphasis on creating quality environment for thermal satisfaction and for a good quality of life for all occupants irrespective of age cadres.

Quality of life (QoL) relates to environmental quality and thermal satisfaction, it deals with both the tangible and qualitative aspects – the subjective measure of how good a person's life is from their own perspective. The QoL differs from the 'standard of living', which focuses more on material wealth and personal values. The World Health Organization [WHO] explains Quality of life (QoL) as a subjective evaluation of a person's perspective of reality relative to person's goals as observed through the lens of culture and value systems. Furthermore, the National Institutes of Health [NIH] provides a detailed explanation of QoL, as the concept that aims to capture the well-being of a population or an individual regarding both the positive and negative elements at a specific point in time. And it also adds common facets of QoL which includes personal health (physical, mental & spiritual), relationships, education status, work environment, social status, wealth, a sense of security and safety, freedom, autonomy in decision-making, social belonging and physical surroundings (Teoli & Bhardwaj, 2023).

Age/Ageing also relates to a human ability to control the rate of heat gain and the loss of heat from the body. Air temperature has become a significant factor that determines occupants' thermal satisfaction, and measured in thermal sensation votes. Scholars define thermal comfort in terms of the acceptable air temperature, the neutral point at which occupants are neither cold nor hot (McCartney & Nicol, 2002). It is also known as a comfort or optimum temperature. Results from empirical studies done in tropical warm-humid regions of Nigeria and Cameroun on the comfort or optimum temperatures, revealed acceptable comfort temperature range of 28^{0}C to 30.4^{0}C, which lies within the thermo-neutral operative ranges of 29^{0}C to 32^{0}C recommended by Adaji et al., (2019) and Kameni et al., (2014).

Mean Radiant Temperature (MRT)

The indoor radiant temperatures come heat transfers from

ISSN (Online) 2456 -1304
International Journal of Science, Engineering and Management (IJSEM)
Volume 13, Issue 04, April 2026

building envelope, window, ceiling, roof, furniture and equipment, and even from occupants (Hawendi et al., 2019). The building envelope separates the indoor space from the outdoor environment, thereby filtering direct influences of the climatic variables such as outdoor air temperature, humidity, wind, rainfall, and solar radiation. Materials within the indoor spaces such as floors, partitions, furniture, and equipment can emit or absorb heat, and thus modifying the indoor air temperatures, and environment quality. According to Givoni, (1997) the solar radiation, air, and light can enter indoor spaces through windows. The increase in demand of energy required for cooling or heating can be a serious issue if the ageing and clothing insulation are not considered at initial design phase. Environment quality is partially influenced by thermal loads of the materials of building envelope components of the walls, windows, roof, and interior finishing as they either add or reduce energy building use. To some extents, the amount of energy used for thermal comfort relates to thermal load of building and body metabolic rate of occupants. The ageing and thermal insulation are also crucial factors in estimating energy for improving quality of environment and well-being of building occupants of all age cadres.

Air Movement

Air movement is one of the important environmental factors that influences indoor thermal conditions and thermal perceptions by the building occupants (Onochie et al., 2024). According to Rizk and Henze, (2014), air movement cools occupants in two ways: First, it cools the occupants directly by increasing convective and evaporative heat transfer from body surface by wind driven ventilation. Second, it cools occupants indirectly by removing heat stored in the building components by stack effect ventilation. The level of air movement that a person is in contact with determines one's thermal perception. According to Nguyen et al., (2012) the sensible air movement enhances convective and evaporative heat transfer through skin, thereby causing a reduced skin temperature and skin moisture.

For a proper ventilating cooling of human skin, the outdoor temperature must be below 35^0C for the convective heat transfer from human skin to its surroundings to be effective, considering the temperature of the skin at approximately 37^0C, and then the latent heat of skin is removed by the process of heat transfer (Nicol et al., 2014). Air movement is measured in m/s. The faster the indoor air movement the greater the exchange of heat between body and the surrounding air if the relative humidity is within the range of 40%. - 60%. According to Nicol et al., (2014) faster air movement accelerates convective and evaporative processes, thereby causing changes in skin temperatures and clothing surface heat transfer, thus produces a physiological cooling effect.

Relative Humidity

Nicol et al., (2014) assert that humidity has a negligible effect on thermal comfort, but it is an important variable to measure in the warm-humid climate. Humidity means the amount of moisture content or water vapour in the air. It is also important to note that rainfall is a crucial factor influencing atmospheric conditions. Charalampopoulos, (2017) submits that precipitated water in the atmosphere leads to a reduction in both air and surface temperature values, and simultaneous increases in values of relative humidity. The relative humidity is just a ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at a particular air temperature, and values are in percentages.

The rate at which air absorbs water from the body by evaporation is dependent on the vapour pressure at the skin temperature in relation to the vapour pressure of the surrounding room air. The higher indoor humidity condition makes it difficult for human body to lose heat through evaporative process, resulting in excessive sweating or sticky condition of skin, and increased skin temperature and thermal discomfort. The rate body loses water impacts occupant's thermal comfort, and it is affected by vapour pressure at skin temperature in relation to vapour pressure in the surrounding room air (Humphrey et al., 2018; Nicol et al., 2014).

The relative humidity has thus become a crucial factor influencing perceptions by building occupants in several ways: The levels of indoor relative humidity can influence building physical conditions as well as well-being of the occupants. Too wet condition in a building due to a higher relative humidity can cause deformation of the materials, and the other Sick Building Syndrome [SBS] such as mould growths on walls, stains on walls, paint deterioration, odours, and increased mite populations. Additionally, too dry condition in a building due to lower relative humidity can cause respiratory problems, itching in eyes, skin dryness, as well increasing the spread of infectious diseases. ASHRAE-55 Standard (2020) submits that a higher humidity influences indoor thermal conditions and impacts negatively on occupants' thermal satisfaction. Hence, the need to ensure relative humidity limits (i.e. >30% < 60%) is maintained alongside comfort temperature for the overall well-being of occupants in naturally ventilated living rooms (Nicol et al., 2014).

II. RESEARCH METHODOLOGY

The research design adopted a cross-sectional survey. Data were collected using a structured questionnaire, administered to occupants, inquiring about relationship between ageing and clothing insulation preference in naturally ventilated living rooms. This survey was conducted in the evenings (between 4:00 PM to 7:00 PM), during the peak period for indoor activity in many homes, from June to August 2024. It was in the peak of the rainy season in the southern Nigeria, when the thermal environment is relatively low (World Bank Group [WBG], 2021).

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Volume 13, Issue 04, April 2026

A residential density stratified sampling technique adopted for the study. The study specifically targeted the high-density residential buildings developed by the Enugu State Housing Development Corporation (ESHDC), focusing on three-storey multifamily apartment blocks comprising the 2-bedroom and the 3-bedroom units. The sampling frame illustrated in the Table 2: consisted of 433 housing units, distributed across two high-density estates.

Table 2. ESHDC High-Density Estates in Enugu Metropolis

Names	Number of Housing units
African Real Estate	109
Maryland Housing Estate	324
Total	433

Source: Physical Planning Unit, ESHDC (2023).

To have a feasible and representative research sample, the study applied both the sampling

By ratio and percentage proportional allocation techniques. According to St. Olaf College (2023), a minimum ratio of 30% ensures equitable representation. Kothari (2014) also supports percentage proportional allocation to reduce a large sample frame to a manageable size. Applying the 30% random selection to the housing units in each estate yielded a total research sample of 130 housing units. Both housing units and individual respondents selected accordingly, and detailed in Table 3.

Table 3. Sample Size: ESHDC High-Density Estates in Enugu Metropolis

Names	Number of housing units	Number of respondents
African Real Estate	33	33
Maryland Housing Estate	97	97
Total	130	130

Source: Fieldwork, (2023)

III.DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.1. Description of ESHDC High-Density Estates (Multi-Storey apartment blocks) – A Case Study

The two ESHDC high-density estates consist of three-storey apartment blocks (multi-storey buildings) situated on gently undulating terrain with effective natural drainage. These estates are located in two areas—Uwani and Independence Layout - both within Enugu South Local Government Area, in the Enugu Metropolis. The buildings are made of plastered hollow block walls, operable glazed windows, and reinforced concrete slabs for the ground and first floor ceilings (soffits). The third-floor ceilings are made of asbestos sheets, while the roof covering consists of aluminium industrial roofing sheet

Figure 3 presents a pictorial view of the African Real Estate in Uwani, comprising blocks of apartments with deep/long balconies/terraces, large fenestrations - >10%<30%WWR, exposed bare earth surfaces, an absence of defined parking lots, and evidence of housing modifications. Also visible are water storage tanks, suggesting the absence of a reliable public water supply in the estate.

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Volume 13, Issue 04, April 2026



Figure 3. Pictorial view of Real Estate, Uwani, Enugu South L.G.A.
Source: Fieldwork (2024)

Figure 4 depicts Maryland Estate at Independence Layout, highlighting features such as narrow Balconies, limited fenestrations (i.e. >10% <30%WWR), extensive hard surfaces, large and unkempt open spaces, narrow and big streets, defined parking areas, and drainage channels. Water storage tanks are also visible, indicating the absence or irregular supply of pipe-borne water in the estate. However, unlike the Uwani estate, there is no clear evidence of housing transformation in Maryland Estate.



Figure 4. Maryland Estate – Views of Multi-storey apartment blocks (condominiums)

ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Volume 13, Issue 04, April 2026

Source: Fieldwork (2024)

4.2. Analysis of aggregated data of Occupant's Age

The Figure 5 showed various age cadres of respondents in the two ESHDC high-density estates investigated: The age cadres of 31 -40 years and above 60 years, representing the valid percent of 27.6% and 21.1% respectively. The next cadre of 41-50 years, valid percent of 20.3%; the others cadres of 18-30 years and 51-60 years, the percent of 15.4% for each cadre.

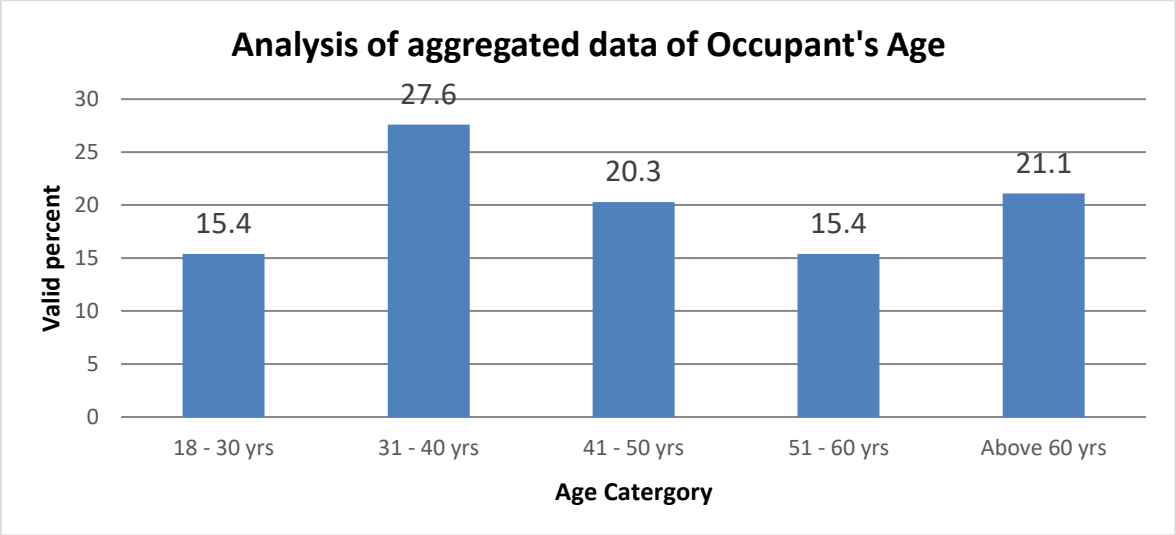


Figure 5. Analysis of aggregated data of Occupant's Age
Source: Fieldwork (2024)

4.3. Analysis of aggregated data of Type of cloth insulation

The Figure 6 revealed that a majority of respondents in the two sampled estates preferred to wear T-shirts and long sleeve shirts when staying in living rooms in the Evenings – valid percent of 39.8% for respondents who preferred T-shirts and 36.6% for respondents who preferred long sleeve shirts. Also, a sizeable number of respondents, the valid percent of 19.5% preferred a thin sweater, and the valid percent of 0.8% preferred jacket.

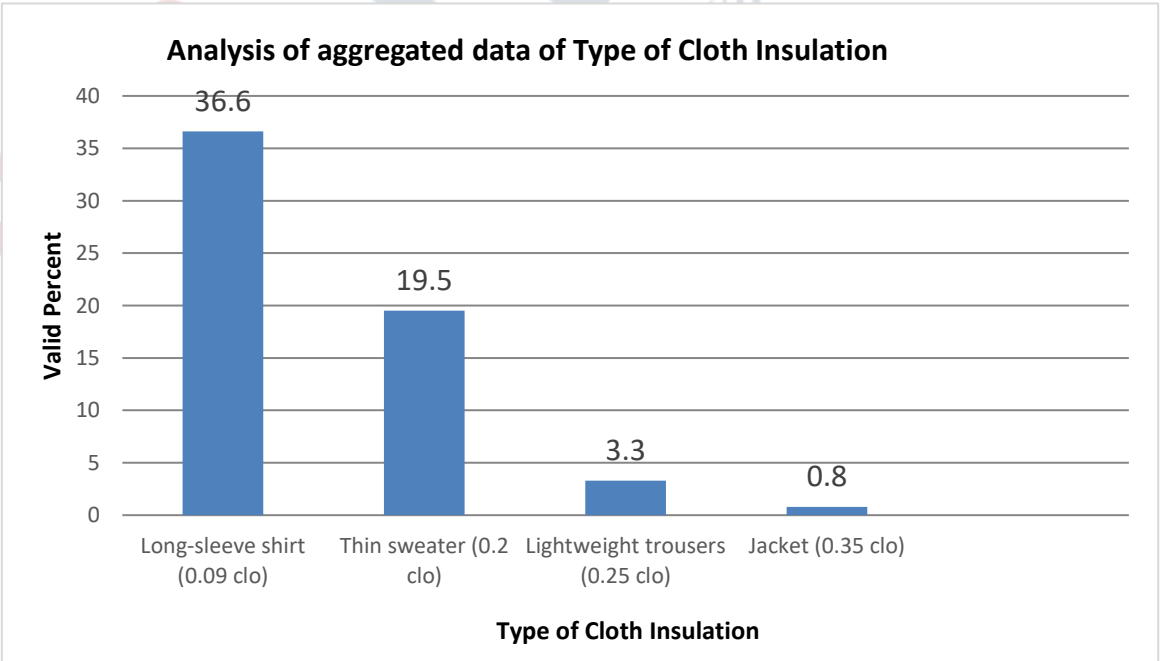


Figure 6. Analysis of aggregated data of Type of Cloth Insulation
Source: Fieldwork, (2024)

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International Journal of Science, Engineering and Management (IJSEM)

Volume 13, Issue 04, April 2026

4.4. Analysis of aggregated data of number of occupants in House

The Figure 7 showed distributions of occupants per house unit across the two estates sampled: An average of 3-5 persons, a valid percent of 45.5%: 5-6 persons/house unit with the valid percent of 27.3%: 1-2 persons/house unit with the valid percent of 19.0%, and the valid percent of 8.3% for more than 6 persons/house unit.

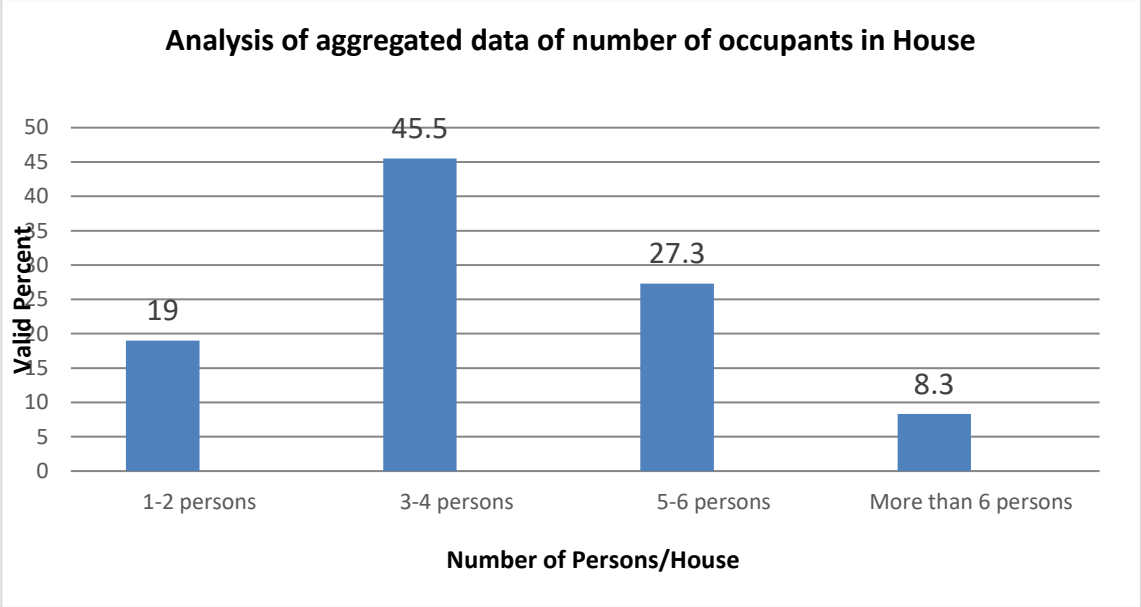


Figure 7. Analysis of aggregated data of number of occupants in house
Source: Fieldwork (2024)

4.5. Analysis of aggregated data of Type of Activity

The Figure 8 revealed the frequencies of activities done in the living rooms across sampled high-density estates in the evenings: Many occupants indulged in Sitting active, valid percent of 37.4%; Sitting quiet - valid percent of 23.6%; and, followed closely by Reclining - valid percent of 20.3%, and Sleeping is the least performed activity in living rooms, the valid percent of 4.1%.

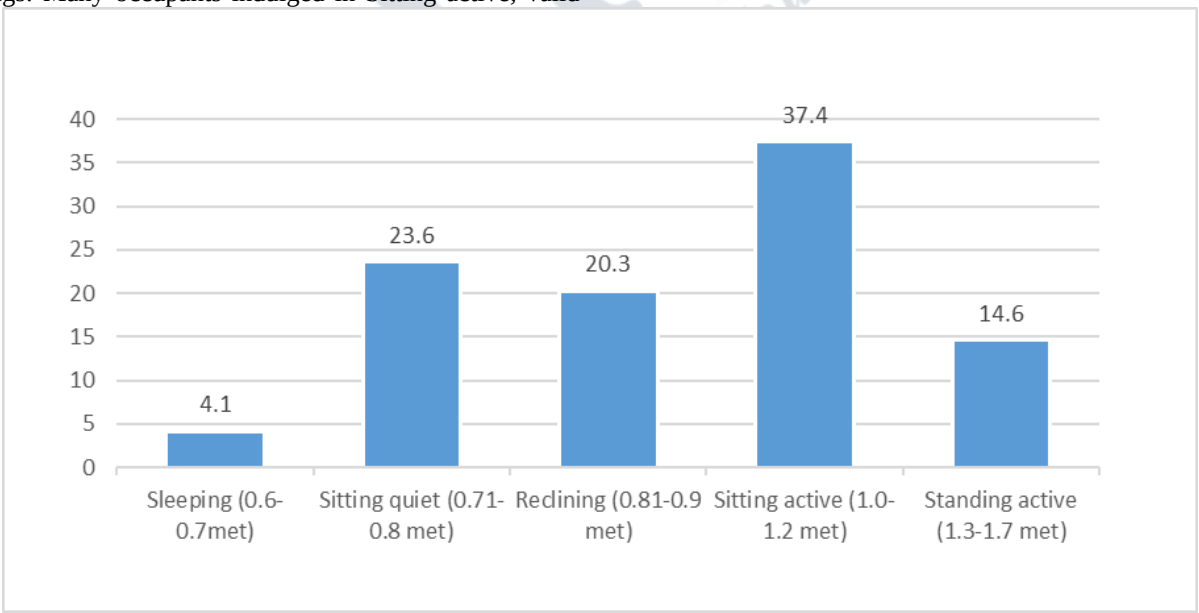


Figure 8. Analysis of aggregated data of Type of Activity in the Living Rooms
Source: Fieldwork, (2024).

4.6. Analysis of aggregated data of Level of Air Temperature Preference in the Living Rooms

The outcomes presented in Figure 9 revealed that more than a half of the respondents preferred 'No change

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Volume 13, Issue 04, April 2026

condition', representing valid percent of 52.8%, a slightly less than a half of the respondents preferred 'cooler' condition, representing the valid percent of 47.8%. The difference in occupant's level of air temperature preference could be due to the individual thermal expectation at the time of day and season as well (Vellei et al., 2018).

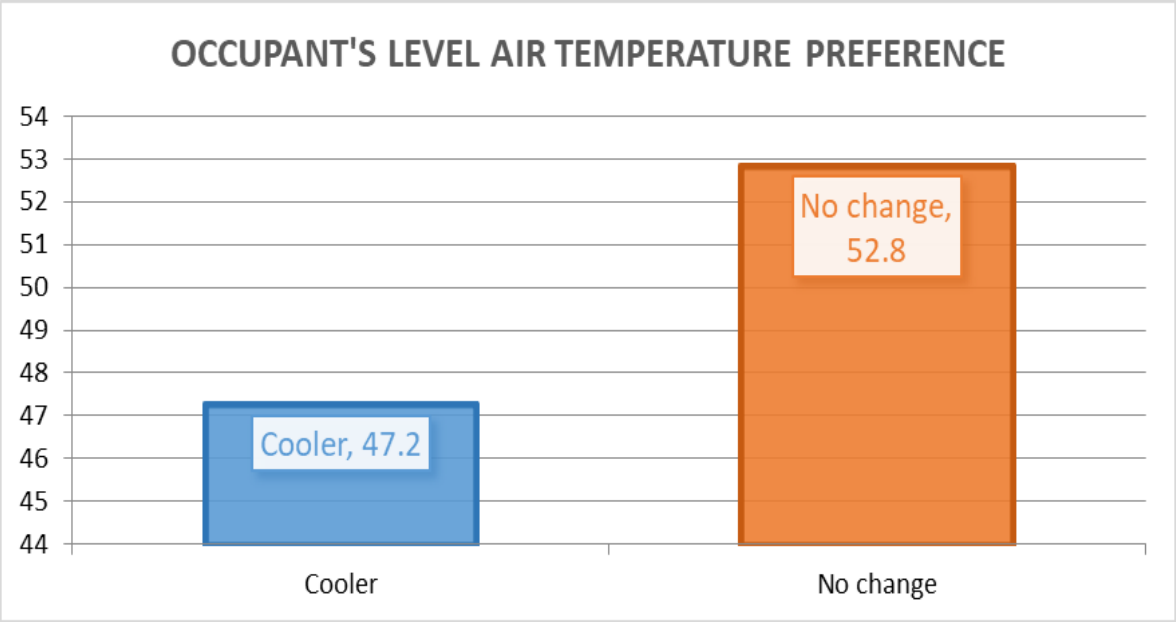
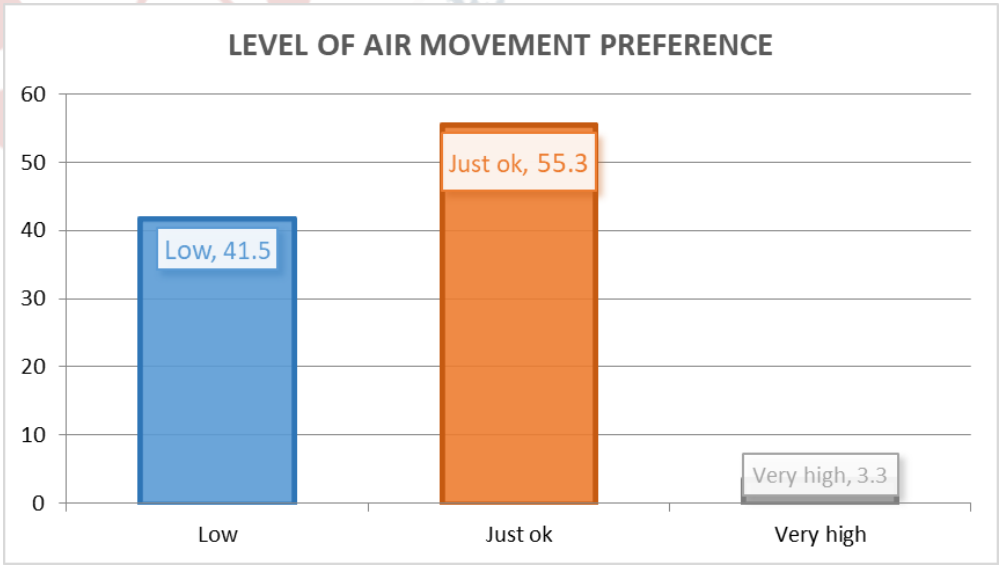


Figure 9. Analysis of aggregated data of Level of Air Temperature Preference in Living Rooms
Source: Fieldwork (2024)

The Figure 4.6 presented the finding revealed that more than a half of the respondents preferred 'No change condition', representing valid percent of 52.8%, a slightly less than a half of the respondents representing valid percent of 47.8%, preferred 'cooler' condition. The difference in occupant's level of air temperature preference could be caused by an individual thermal expectation at time of day, and non-thermal factors such clothing insulation, age, life style and dress code (Vellei et al., 2018; Shahzad et al., 2018; Amarya et al., 2018; Sanchez-Gonzalez, 2015).

4.7. Analysis of aggregated data of Level of Air Movement Preference in Living Rooms

Figure 10 illustrated the valid percent of the occupants' responses to levels of air movement sensation across selected naturally ventilated living rooms in the ESHDC high-density estates. The valid percent of 55.3%, a two-third of occupants sampled responded 'Just ok' to the question 'How do you feel air movement now in this living room?', and the valid percent of 41.5%, less than a third of occupants voted 'Low', and less than a tenth of sampled occupants okayed 'very high', representing the valid percent of 3.3%.



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Volume 13, Issue 04, April 2026

Figure 10. Analysis of aggregated data of Level of Air Movement Preference in the Living Rooms
Source: Fieldwork (2024)

4.8. Analysis of aggregated data of Level of Relative Humidity Preference in the Living Rooms

The Figure 11 indicated the outcomes, and thus showed levels of relative humidity preference of the respondents' answer to the question – 'How do you prefer or desire humidity condition in this living room now?'- The majority of respondents representing the valid percent of 73.2% expressed desire for 'No change' or neutral condition, and a sizeable portion of the respondents representing valid percent of 26.8% expressed desire for 'Dry' condition. The implication - An insignificant difference in the level of relative humidity sensation among occupants of living rooms. This finding thus reconfirmed results of past studies that relative humidity has a negligible effect on thermal comfort (Humphrey et al., 2016; Nicol et al., 2014; Charamlampopoulos, 2017).

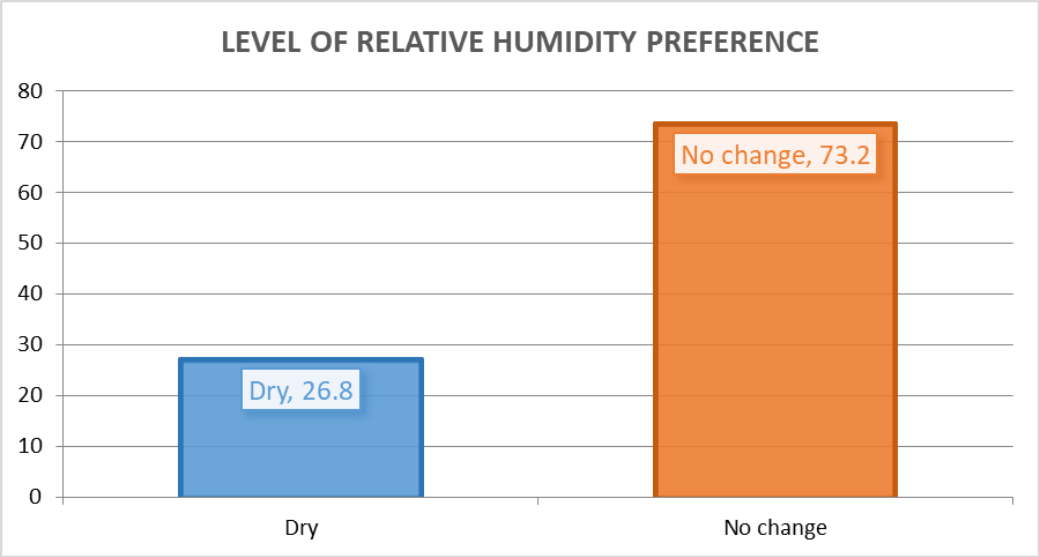


Figure 11. Analysis of aggregated data of Level of Relative Humidity Preference in the Living Rooms
Source: Fieldwork (2024)

4.9. Test of Hypothesis

This study examined the relationship between ageing and clothing insulation in the naturally ventilated living rooms within the ESHDC high-density estates. The key variables considered were:

1. Occupant's Age (OA)
2. Type of Cloth Insulation (TCI)
3. Number of Persons in House (NPH)
4. Type Of Activity (TOA)
5. Level of Air Temperature Preference (LATP)
6. Level of Air Movement Preference (LAMP)
7. Level of Relative Humidity Preference (LRHP)

The crux of the study is to ascertain the relationship between ageing and clothing insulation for the purpose of improving environment quality for the quality of life for all the age cadres in naturally ventilated living rooms within ESHDC high-density estates. Ageing relates to thermal comfort which is closely associated with these variables - Number of Persons in House (NPH) and Type of Activity (TOA) – are measured interval scale variables - thus the Pearson Product-Moment Correlation tool was employed to assess their magnitudes and relationships. Additionally, the environment quality can also be measured by using thermal preference scale to assess - Level of Air Temperature Preference (LATP), Level of Air Movement Preference (LAMP) and Level of Relative Humidity Preference (LRHP). These variables are of ordinal scale, hence the Spearman Rho Correlational tool was applied for assessing the magnitudes and directions of their relationships.

Test of hypothesis Ho1- There is no significant relationship between Occupant's Age (OA) with Type of Cloth Insulation (TCI). The first variable measuring Occupant's Age - Type of Cloth Insulation (TCI) was paired in bivariate tests against the variables assessing thermal comfort: 1. Type of Cloth Insulation (TCI), 2. Type of Activity (TOA), 3. Number of Persons in House (NPH)

Table 4. Result of Pearson Product-Moment Correlations of OA, TCI & NPH

		Type of Cloth Insulation (TCI)	Type of Activity (TOA)	Number of Persons in House (NPH)
Occupant's	Pearson Correlation	-.026	-.381**	-.197*

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Volume 13, Issue 04, April 2026

Age (OA)	Sig. (2-tailed)	.772	.000	.030
	N	123	123	123

Source: Fieldwork, (2024)

The results presented in the Table 4 show that correlation between OA and TCI yielded a Pearson coefficient of –0.026 with a significance value (p-value) of 0.772. This indicates an extreme weak and statistically non-significant negative relationship with type of cloth insulation occupants preferred to put on in while staying in their living in the evenings. This finding confirmed that preferred clothing insulation was an adaptive response to the prevailing thermal conditions in living rooms in the evenings rather than restrictions due to occupant's age.

Furthermore, the correlation between OA and TOA resulted in a coefficient of –0.381, with a p-value of 0.000. This also represents a moderate and statistically significant negative relationship, indicating that the nature or level of activity performed indoors can influence the type of cloth insulation. Similarly, the correlation of OA and NPH yielded a coefficient value of – 0.197 with a significance value (p-value) of 0.030. This outcome shows a weak and statistically non-significant negative relationship with the type of cloth insulation a person preferred to wear. This goes on to suggest that ageing has little or no relationship with the number of persons in house, but NPH can impact the indoor thermal conditions as the result of increased body metabolism and activity levels following the increase in number of persons or intensity of activity at the material time.

Test of Hypothesis Ho2: 'There is no significant relationship between Thermal Satisfaction and Environmental Quality (EQ)'.

The first variable measuring Environmental Quality: Thermal Satisfaction (TS) paired in the bivariate tests against variables assessing the environmental quality: 1. Temperature Preference (LATP), 2. Level of Air Movement Preference (LAMP), 3. Level of Relative Humidity Preference (LRHP). The results are presented in the Table 4.2.

Table 5. Results of Spearman Rho Correlations of LATP, LAMP & LRHP

		Level of Air Temperature Preference (LATP)	Level of Air Movement Preference (LAMP)	Level of Relative Humidity Preference (LRHP)
Thermal Satisfaction (TS)	Spearman Rho Correlation	0.626**	0.565**	0.446
	Sig. (2-tailed)	.000	.000	.000
	N	123	123	123

Source: Fieldwork, (2024)

The set of results presented in the Table 5 indicated the correlations of TS with LATP, LAMP and LRHP. The variables involved are all ordinal scale variables, therefore the Spearman Rho Correlation Analysis tool was deployed. The correlation between TS and LATP resulted in the coefficient value of 0.626, with significance value (p-value) of 0.000, implying that there was a statistically significant positive relationship between thermal satisfaction and level of air temperature preference. A similar result was obtained from the correlation between TS and LAMP, resulted in a coefficient of 0.565, with a p-value of 0.000, implying existence of a positive correlation between TS and LAMP that was statistically significant. In the same vein, the correlation between TS and LRHP was very good as the coefficient of 0.446 with the p-value of 0.000 indicated a strong significant relationship. These findings strongly suggest that the level of thermal satisfaction is strongly relates to the environment quality, which in turn determines thermal preference, ultimately the thermal satisfaction of occupants in the naturally ventilate rooms within the warm-humid tropical climate.

IV. CONCLUSION AND RECOMMENDATIONS

This study examined the relationship between the age/ageing and clothing insulation in naturally ventilated living rooms across dense residential estates developed by Enugu State Housing Development Corporation (ESHDC) in Enugu Metropolis. Findings indicated that there was no significant relationship between the occupant's age and the type of cloth insulation in the naturally ventilated living rooms in the warm-humid tropical region, and thus, contradicting the assertion that aged people prefer layered cloth to keep warmer. The preference to light clothes like tee shirts or long-sleeve shirts by a majority of respondents in the area of study is an adaptive strategy to achieve thermal satisfaction, and to reduce heat stress of higher thermal environment caused by the nature of warm-humid tropical climate. In furtherance of this investigation, the Spearman Rho Correlation analysis performed to examine the relationship between thermal satisfaction and environmental quality. The results indicated strong and positive correlations with environmental variables, which further implies that both age/ageing and type of cloth insulation have an affinity with the climate types. Inhabitants of cold regions prefer thick

clothing to keep warmer whereas those of the hot-humid regions prefer light clothing to allow in more air to accelerate sweat evaporation. This finding thus aligned with the position of past studies that the climate is a key factor influencing adaptations globally - choice of clothing, dress code, and shelters as well.

Recommendations

Drawing from study's findings and review of related literature, the following recommendations proposed to ensure environment quality for a good quality of life and thermal satisfaction of residents of ESHDC high-density estates within the Metropolis:

1. Promote an active population – A healthy community supporting increased productivity
2. Provision of a quality environment – Good quality of life and thermal satisfaction
3. Quality of life – Implies access to affordable health and social care services - longevity.
4. Eliminates poverty and reduces disability and dependence among the aged people.
5. Advance economic empowerment of the progressive ageing community.

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