The Role of Thermal Comfort in Worship Engagement within ECWA (Evangelical Church Winning All) Church Buildings, Abuja

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Abstract. Thermal comfort has emerged as a critical factor influencing human concentration, productivity, and engagement in indoor environments globally, particularly within public and religious buildings located in tropical climates. In recent years, growing attention has been directed toward how indoor environmental quality affects occupants' behavioural responses and participation levels. Despite this growing discourse, limited empirical research has examined the relationship between thermal comfort and worship engagement in church buildings in Nigeria. This study investigates the role of indoor thermal comfort in shaping worship engagement within selected ECWA (Evangelical Church Winning All) church buildings in Abuja, Nigeria, while exploring sustainable passive cooling strategies suitable for tropical worship spaces. A mixed-method research approach was adopted, combining quantitative surveys of worshippers, qualitative behavioural observations, and environmental measurements across five ECWA worship centres. Findings indicate that indoor temperatures ranged from 28.2°C to 36.3°C, with a mean of 33.17°C, exceeding recommended thermal comfort thresholds, while relative humidity averaged 25.75%. Statistical analysis revealed significant negative relationships between indicators of thermal discomfort—such as fidgeting ($\tau = -0.455$), use of personal cooling devices ($\tau = -0.352$), solar radiation exposure ($\tau = -0.474$), and congregants leaving the worship space ($\tau = -0.467$)—and worship engagement levels. These results demonstrate that thermal discomfort significantly reduces attention, participation, and overall engagement during worship services. The study concludes that improving thermal comfort through passive cooling strategies—including enhanced natural ventilation, improved building orientation, shading devices, and thermally efficient materials—can significantly enhance worship engagement while reducing dependence on energy-intensive mechanical cooling systems. The findings provide practical design guidance for architects, church administrators, and policymakers seeking to create sustainable and spiritually conducive worship environments.

Keywords: Thermal comfort; Worship engagement; Passive cooling; Sustainable church design; ECWA churches; Abuja.

1.0 Introduction

Globally, thermal comfort has become a central concern in the design and operation of buildings due to its direct influence on occupants' health, productivity, and behavioural responses (Park et al., 2022; Zhang et al., 2020). According to ASHRAE Standard 55 (2020), thermal comfort is defined as "that condition of mind which expresses satisfaction with the thermal environment," and is determined by air temperature, relative humidity, air velocity, mean radiant temperature, clothing insulation, and metabolic activity. Contemporary studies across offices, schools, healthcare facilities, and assembly buildings consistently demonstrate that poor thermal conditions negatively affect concentration, task performance, and user satisfaction (Wargocki & Wyon, 2017; Cao et al., 2022).

In tropical regions—particularly across Sub-Saharan Africa—achieving acceptable indoor thermal comfort remains a persistent challenge due to high ambient temperatures, intense solar radiation, rapid urbanisation, and limited application of climate-responsive design strategies (Adekunle et al., 2021; Omoniyi & Ojo, 2023). Nigeria, located within the tropical belt, experiences prolonged hot seasons with outdoor temperatures frequently exceeding established comfort thresholds (Adebayo et al., 2020). Consequently, many public buildings rely heavily on mechanical cooling systems, which are often energy-intensive, economically burdensome, and environmentally unsustainable (Ogunbiyi et al., 2022).

Places of worship constitute a unique building typology where thermal comfort is particularly critical. Unlike offices or classrooms, worship spaces demand prolonged physical stillness, emotional engagement, and sustained attention during religious services (Deuble & de Dear, 2014; Attard et al., 2021). Thermal discomfort in such environments often manifests through restlessness, fatigue, reduced concentration, and premature exit behaviour, thereby undermining worship engagement and spiritual immersion (Park et al., 2022). Despite these implications, empirical research on thermal comfort in religious buildings—especially within African contexts—remains limited.

In Nigeria, studies on church architecture have predominantly focused on acoustics, aesthetics, spatial organisation, and symbolism, with minimal emphasis on environmental performance and indoor thermal comfort (Oluigbo & Ojo, 2018; Omoniyi & Ojo, 2023). ECWA church buildings in Abuja are no exception, as many were constructed without adequate consideration of climate-responsive design principles, resulting in excessive heat accumulation, poor ventilation, and increased dependence on mechanical cooling systems.

This study addresses this gap by evaluating indoor thermal conditions in selected ECWA church buildings in Abuja and examining how these conditions influence worship engagement. Specifically, the study seeks to:

(i) assess the thermal comfort conditions within selected worship centres;

(ii) examine the behavioural and engagement responses of worshippers to these conditions; and

(iii) propose sustainable passive cooling strategies suitable for church buildings in tropical climates.

2.0 Literature Review

Thermal Comfort in the Built Environment

Thermal comfort research has evolved considerably over the past five decades, with early analytical models such as Fanger's Predicted Mean Vote (PMV) forming the foundation of modern comfort standards. However, recent research increasingly emphasises adaptive thermal comfort theory, which accounts for occupants' behavioural, physiological, and psychological adjustments—particularly in naturally ventilated buildings (Nicol et al., 2012; Kim et al., 2021). In tropical climates, adaptive models suggest that occupants can tolerate higher indoor temperatures when supported by adequate airflow, shading devices, and contextual adaptation (Cao et al., 2022).

Recent empirical studies across Africa and Asia indicate that indoor temperatures above 30 °C frequently result in thermal discomfort, reduced cognitive performance, and increased adaptive behaviours such as posture adjustment, fanning, and movement (Ogunbiyi et al., 2022; Park et al., 2022). A recent study of historic churches in southern Europe reported that inadequate ventilation and high thermal mass significantly influenced occupants' comfort perception during summer services, leading to shortened service attendance and reduced satisfaction (Lucchi et al., 2018).

2.2 Thermal Comfort, Behaviour, and Engagement in Worship Spaces

Thermal comfort strongly influences occupants' behavioural responses, which directly affect engagement levels in indoor environments (Frontczak & Wargocki, 2011; Kim et al., 2021). In worship settings, engagement is typically expressed through attentiveness, participation in singing and prayers, and sustained presence throughout services (Attard et al., 2021). Recent studies conducted in parish churches in Malta (Attard et al., 2021) and Nigerian worship spaces at Ahmadu Bello University, Zaria (Yusuf et al., 2024) demonstrate that thermal discomfort results in observable behaviours such as seat shifting, clothing adjustment, handheld fan usage, and premature exit, all of which negatively affect worship immersion.

Architectural design variables—including ceiling height, window placement, building orientation, roof configuration, and seating density—mediate the relationship between thermal comfort and worship engagement (Szokolay, 2014; Adekunle et al., 2021). Worship spaces that incorporate effective cross-ventilation, shaded openings, elevated roof profiles, and appropriate orientation consistently report higher thermal satisfaction and improved congregational engagement.

2.3 Passive Cooling Strategies and Energy Use in Church Buildings

Passive cooling strategies are widely recognised as effective means of enhancing indoor thermal comfort while reducing building energy consumption (Santamouris et al., 2017; Ogunbiyi et al., 2022). Common strategies include natural ventilation, solar shading, thermal mass optimisation, reflective roofing, evaporative cooling, and appropriate building orientation. Recent studies in tropical climates show that assembly buildings—including churches—integrating passive design strategies record significantly lower cooling energy demand compared to those relying predominantly on mechanical air-conditioning systems (Adekunle et al., 2021; Omoniyi & Ojo, 2023).

Despite growing empirical evidence, many Nigerian churches continue to rely heavily on mechanical cooling due to limited awareness of passive alternatives, retrofit challenges, and congregational comfort expectations (Oluigbo & Ojo, 2018; Ogunbiyi et al., 2022). This underscores a critical research gap on how passive cooling strategies can simultaneously improve thermal comfort, reduce energy use, and enhance worship engagement in Nigerian church buildings.

2.4 Study Location

This study was conducted in Abuja, Nigeria, the country's capital, located in the North-Central region. Abuja spans an area of 1,769 square kilometers and lies approximately between latitude 8.9476° N and longitude 7.3576° E. The city serves as an administrative and religious hub, featuring diverse architectural styles and varying environmental conditions that influence thermal comfort in worship spaces.

The research focused on five ECWA churches, each situated within one of Abuja's five District Church Councils (DCCs). These churches were selected based on their seating capacity (minimum of 500 worshippers), spatial orientation, and ventilation strategies to provide a representative sample for studying thermal comfort and worship engagement.

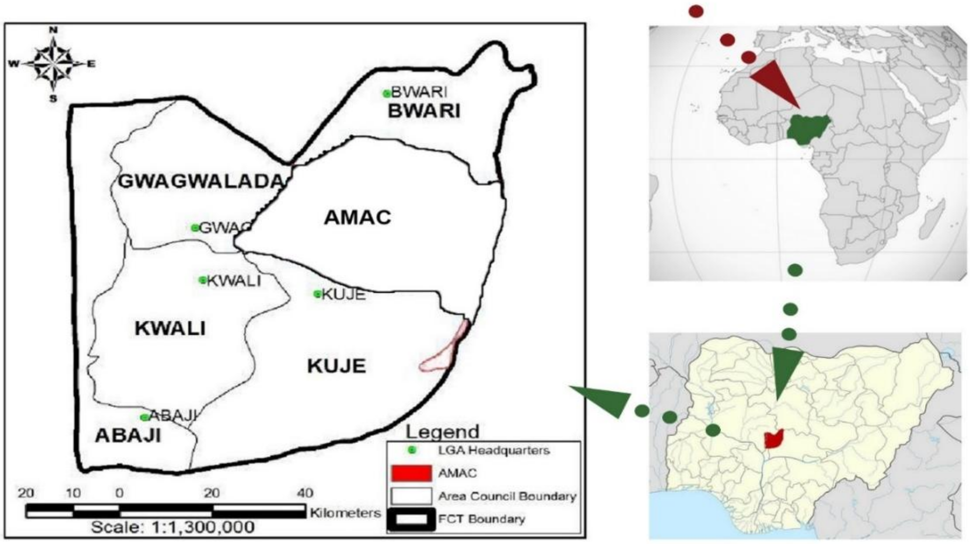

Figure 1: Location map showing the locations the District Churches in Abuja the Federal Capital Territory of Nigeria.
Source: OpenStreetMap contributors. (2025). Map of Abuja, Nigeria

3.0 Methodology

3.1 Research Design

This study adopts a mixed-method research approach within a descriptive and exploratory design to assess the impact of thermal comfort on worship engagement in selected ECWA church buildings in Abuja.

3.2 Study Area and Location

The study was conducted in Abuja, Nigeria's Federal Capital Territory, characterized by a tropical savannah climate with high temperatures and seasonal variability. Five ECWA churches were selected across the city's District Church Councils (DCCs). Each church has a minimum seating capacity of 500 worshippers and exhibits distinct architectural and ventilation characteristics.

3.3 Data Collection Methods

Data were collected using three complementary methods:
Quantitative surveys administered to 150 worshippers (30 per church) selected through random sampling.
Qualitative behavioural observations conducted during live worship services.
Environmental measurements using digital thermometers, hygrometers, anemometers, and solar radiation meters.
Measurements were taken at three intervals: before service, during peak worship, and after service.

3.4 Method of Analysis

Survey data were analysed using descriptive statistics and Kendall's tau-b correlation tests to examine relationships between thermal comfort indicators and worship engagement.

Observational data were analysed thematically, while environmental measurements were compared against ASHRAE Standard 55 comfort benchmarks.

4.0 Results and Discussion

4.1 Introduction to Results

This section presents the findings of the study in line with the research objectives and methodological framework. Results are organized into four main parts: (i) socio-demographic characteristics of respondents, (ii) indoor thermal conditions across the selected ECWA churches, (iii) worshippers' behavioural responses and engagement levels, and (iv) statistical tests of the hypothesised relationships between thermal comfort and worship engagement. For confidentiality, the five churches are coded as Church A, Church B, Church C, Church D, and Church E.

4.2 Socio-Demographic Characteristics of Respondents

A total of 154 worshippers participated in the survey as shown above in table 4.1, with at least 30 respondents drawn from each church. Respondents represented a mix of age groups, gender, and worship attendance frequency, ensuring a broad representation of regular church users. The majority of respondents attended weekly services and typically remained in the worship space for durations exceeding 90 minutes, making them suitable evaluators of indoor thermal conditions.

Table 4.1: Demography Information of Respondents

Variable	*Frequency*	*Percentage*
Gender		
Male	110	71.4
Female	43	27.9
Prefer not to say	1	0.6
Age group		
Under 18	7	4.5
18-29	60	39
30-39	63	40.9
40-49	15	9.7
50-59	6	3.9
60 and above	3	1.9
How often do you attend service at this worship centre		
Weekly		
Bi-weekly		
Monthly	115	74.7
Occasionally	11	7.1
	5	3.2

	23	14.9
Which service do you usually attend		
Morning service		
Afternoon service	123	57.8
Evening service	26	12.2
Special events	27	12.6
	37	17.4

Source: Author's fieldwork (2025)

4.3 Indoor Thermal Conditions Across the Selected Churches

Environmental measurements revealed notable variations in thermal conditions across the five ECWA churches as shown in figure 4.1, 4.2 and 4.3 respectively. Indoor temperatures ranged from 28.2°C to 36.3°C, with peak values generally recorded during the mid-service period when occupancy density was highest. Churches with east–west orientations (Churches B and D) consistently recorded higher indoor temperatures and solar radiation levels compared to north–south oriented churches (Churches A and C). Relative humidity levels across all churches remained low, averaging 25.75%, indicative of dry indoor conditions.

Temporal analysis showed that temperatures increased from pre-service to peak worship periods before declining slightly post-service, confirming the influence of occupant density and limited ventilation during active worship sessions.

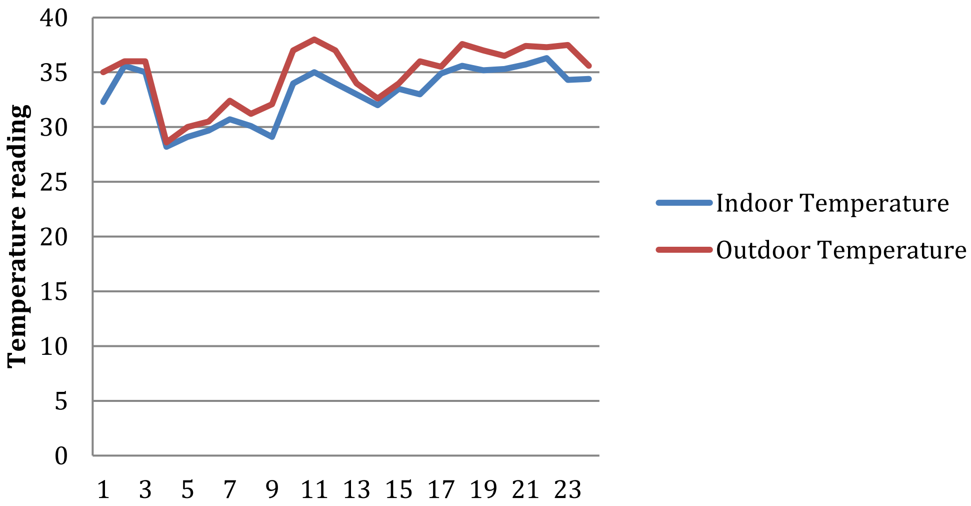

Figure 4.1: Graph of temperature reading at the selected ECWA Worship Centres Under Study

Source: Author's fieldwork (2025)

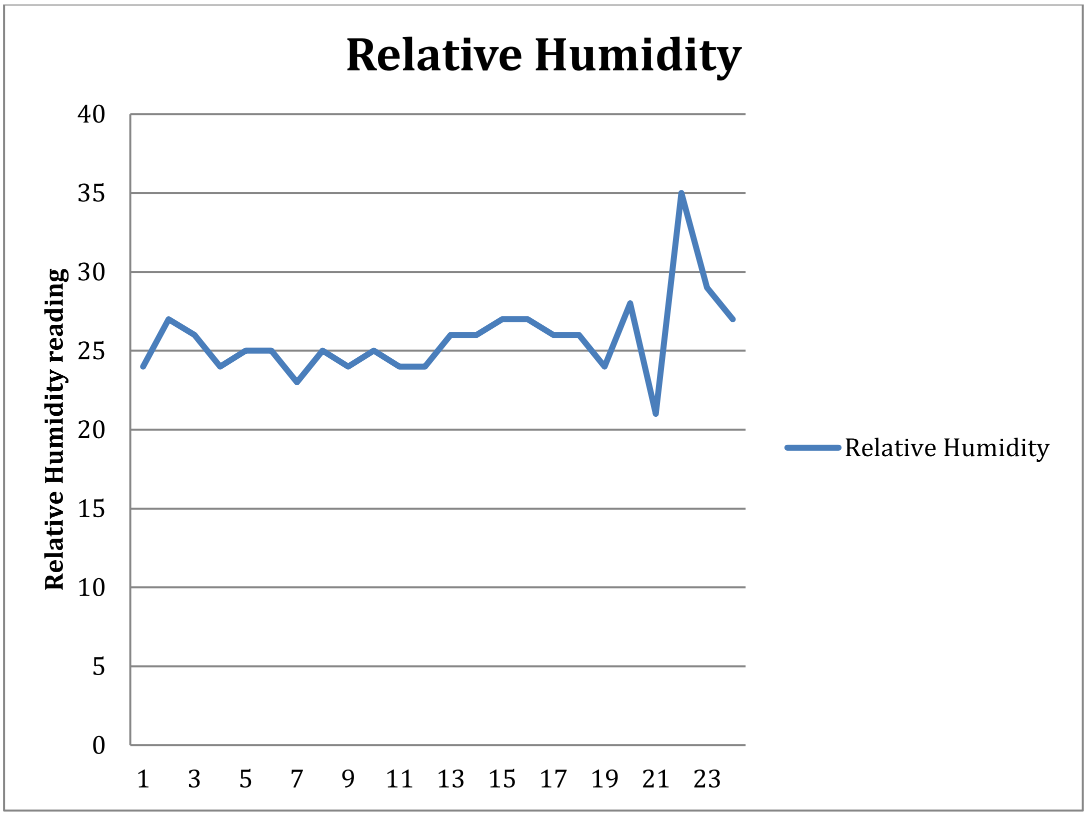

Figure 4.2: Graph of relative humidity reading at the selected ECWA Worship Centres Under Study
Source: Author's fieldwork (2025)

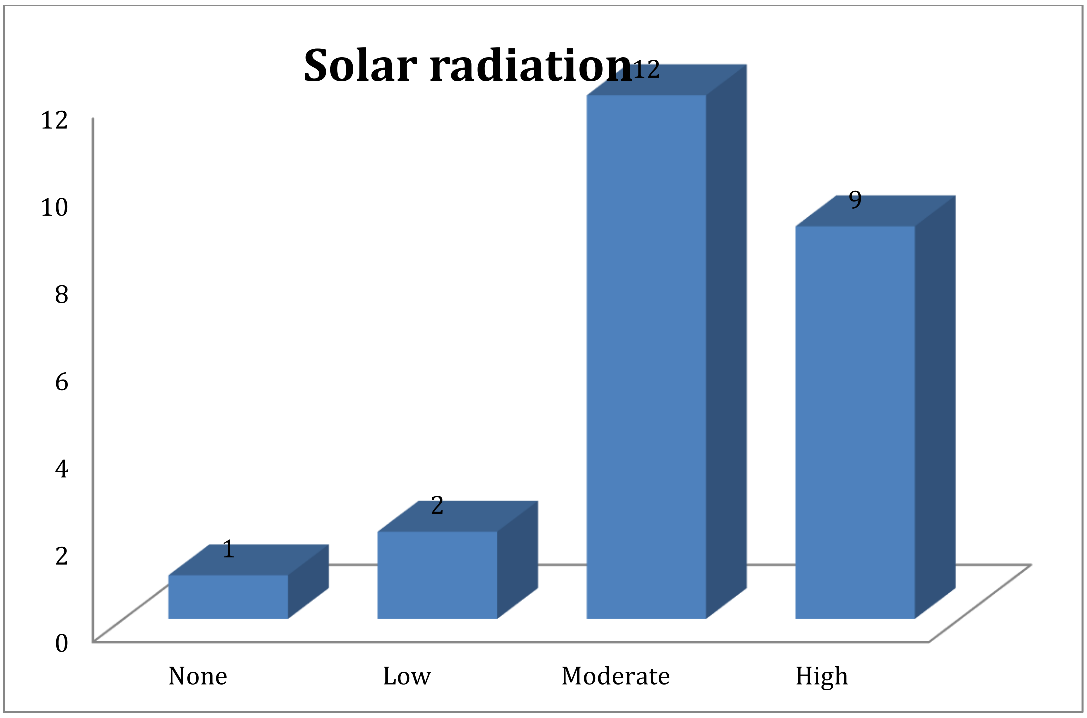

Figure 4: Graph of Solar radiation at the selected ECWA Worship Centres Under Study
Source: Author's fieldwork (2025)

4.4 Behavioral Responses and Worship Engagement

Observable behavioral responses as shown in figure4.2 below includes fanning, seat movement, clothing adjustment, and temporary exit from the worship space—were more frequent in churches with higher indoor temperatures and limited cross-ventilation. Church E, which incorporated larger operable windows and higher ceiling volumes, recorded fewer discomfort-related behaviours and higher reported engagement levels.

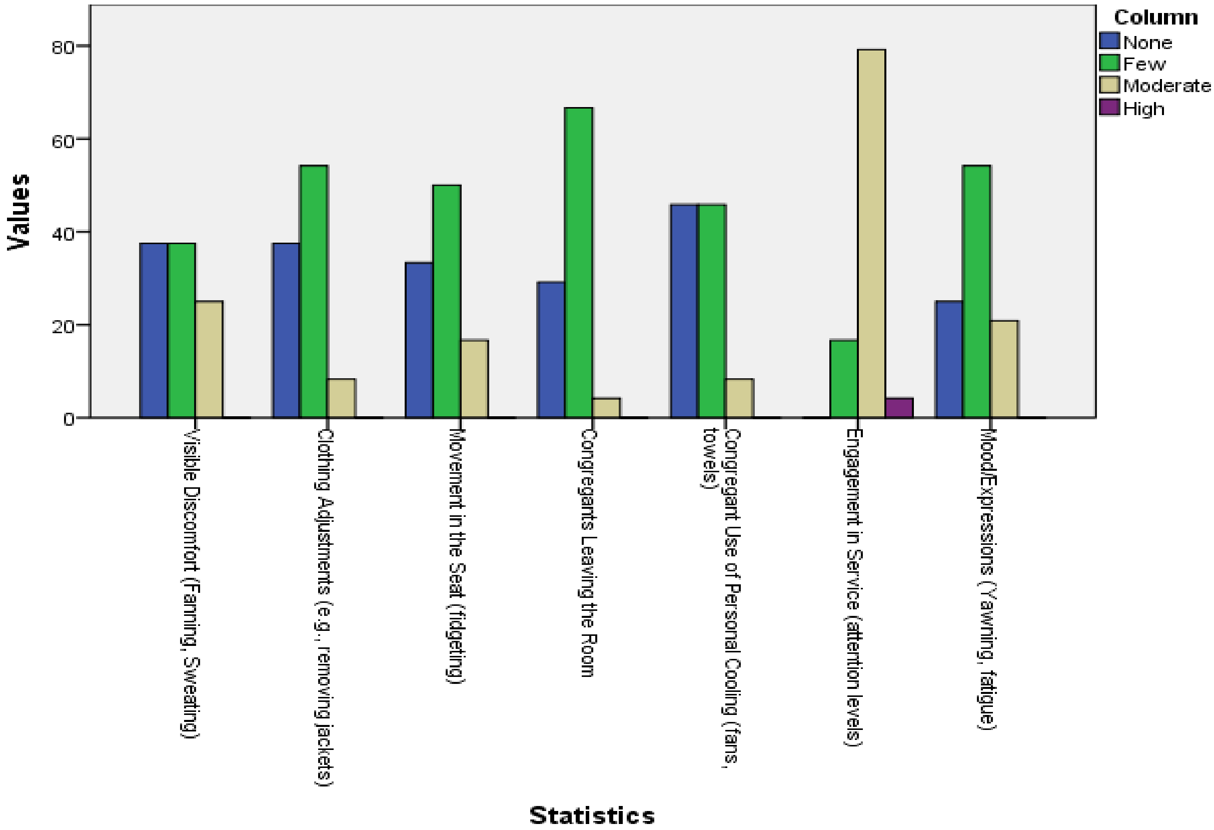

Figure 4.2: Multiple bar chart of congregant responses and worship engagement

Source: Field Survey, 2025

4.5 Test of Hypotheses

To test the hypothesis that thermal comfort significantly influences worship engagement, Kendall’s tau-b correlation analysis was conducted. Results indicate significant negative relationships between thermal discomfort indicators and engagement levels, including fidgeting ($\tau = -0.455$), congregants leaving the room ($\tau = -0.467$), use of personal cooling devices ($\tau = -0.352$), and solar radiation exposure ($\tau = -0.474$). These findings confirm that increased thermal discomfort corresponds with reduced attention and participation during worship services, leading to the rejection of the null hypothesis as shown in table 4.2.

Table 4.2: Correlation between the engagement in service and the indoor thermal comfort

			Overall Thermal Comfort Level	Engagement in Service (attention levels)
Kendall's tau_b	Overall Thermal Comfort Level	Corr. Coeff	1.000	.374
		Sig. (2-tailed)	.	.064
		N	24	24
	Engagement in Service (attention levels)	Corr. Coeff	.374	1.000
		Sig. (2-tailed)	.064	.
		N	24	24
	Indoor Temperature (°C)	Corr. Coeff	**-.393***	-.049
		Sig. (2-tailed)	**.022**	.777
		N	**24**	24
	Outdoor Temperature (°C)	Corr. Coeff	**-.513****	-.227
		Sig. (2-tailed)	**.003**	.190
		N	**24**	24
	Relative Humidity (%)	Corr. Coeff	.131	.065
		Sig. (2-tailed)	.469	.719
		N	24	24
	Solar Radiation (Direct sunlight)	Corr. Coeff	**-.486***	**-.474***
		Sig. (2-tailed)	**.013**	**.016**
		N	**24**	**24**
	Weather Conditions	Corr. Coeff	**.485***	.229
		Sig. (2-tailed)	**.018**	.264
		N	**24**	24

Source: Author's fieldwork (2025)

4.6 Discussion

The findings of this study reinforce existing global evidence that indoor thermal comfort is a key determinant of occupants' behavioural responses and engagement levels in public buildings. The recorded indoor temperature range (28.2°C–36.3°C) exceeds the comfort thresholds recommended by ASHRAE Standard 55, particularly for sedentary activities such as worship. Similar temperature-related discomfort has been reported in parish churches in Malta (2021) and heritage churches in southern Spain (Malaga and Seville), where inadequate ventilation and high solar heat gains were identified as primary contributors to reduced occupant comfort.

The observed negative relationship between solar radiation and worship engagement ($\tau = -0.474$) aligns with findings from the 2018 Spanish study, which demonstrated that east–west oriented church buildings experienced higher afternoon heat loads and reduced occupant satisfaction. In the present study, churches with east–west orientations recorded higher indoor temperatures and more frequent discomfort-related behaviours, confirming the influence of spatial orientation on thermal performance.

Behavioural responses such as fidgeting, clothing adjustment, and congregants leaving the worship space mirror adaptive actions documented in the ABU Zaria (2024) study on Nigerian worship environments. These behaviours signify attempts by occupants to restore thermal balance, often at the expense of sustained attention and spiritual immersion. Church buildings that incorporated passive design features—such as higher ceilings, larger operable windows, and cross-ventilation—demonstrated improved comfort and engagement outcomes, supporting the adaptive thermal comfort theory.

The findings further highlight the limitations of reliance on mechanical cooling systems alone. Despite the presence of fans and air conditioners in some churches, discomfort persisted due to uneven air distribution and high operational loads. This reinforces the argument that sustainable passive cooling strategies offer a more effective and energy-efficient pathway for enhancing comfort and engagement in worship spaces.

5.0 Conclusion

This study highlights the significant impact of indoor thermal comfort on worship engagement in ECWA church buildings in Abuja. Findings reveal that many worship spaces suffer from excessive heat, poor ventilation, and high solar radiation exposure, leading to thermal discomfort, reduced concentration, and lower engagement levels among congregants. The analysis of indoor temperatures (ranging from 28.2°C to 36.3°C), relative humidity (mean of 25.75%), and airflow conditions confirms that many churches do not meet recommended thermal comfort standards.

The study further establishes a negative correlation between thermal discomfort indicators (e.g., excessive fidgeting, clothing adjustments, use of personal cooling devices) and worship engagement. Statistical analysis shows that as thermal discomfort increases, congregants are more likely to leave the service, experience fatigue, and struggle to focus, ultimately affecting their overall spiritual experience. Given that mechanical cooling systems alone have proven ineffective and unsustainable, the research underscores the need for passive cooling strategies such as natural ventilation, optimized building orientation, shading devices, and thermally efficient materials.

To create a sustainable and thermally comfortable worship environment, ECWA church buildings must adopt climate-responsive architectural designs that reduce heat buildup and reliance on energy-intensive cooling systems. Implementing these solutions will not only enhance the physical comfort of worshippers but also promote better engagement, participation, and overall spiritual fulfillment.

By integrating sustainable passive cooling strategies, church administrators, architects, and policymakers can transform ECWA churches into environmentally friendly, energy-efficient worship Centres that support both congregational well-being and sustainability goals.

6.0 Recommendations

Based on the findings of this study, it is evident that thermal discomfort in ECWA church buildings negatively impacts worship engagement, primarily due to poor ventilation, high temperatures, and excessive reliance on mechanical cooling systems. To address these challenges and enhance thermal comfort, the following recommendations are made:

1. Enhance cross-ventilation by positioning windows and openings on opposite walls, install clerestory windows or louvers at high levels to allow warm air to escape, and prioritize operable windows for adjustable airflow based on weather conditions.
2. Orient church buildings along the north-south axis to minimize solar radiation exposure, position entrances and windows to harness prevailing winds, and arrange seating to maximize airflow while avoiding direct heat sources.
3. Incorporate extended roof overhangs, canopies, and external shading elements like adjustable louvers or fins to regulate sunlight penetration, and plant trees around churches to provide natural shading and cool the surrounding microclimate.
4. Use high-reflectivity roofing materials such as cool roofs or clay tiles, construct walls with high thermal mass materials like compressed earth blocks, and improve ceiling insulation with polystyrene or fiberglass panels to reduce heat transfer and maintain stable indoor temperatures.
5. Introduce evaporative cooling features such as ponds or fountains near entrances, utilize porous building materials that retain moisture for natural cooling, and install low-energy evaporative coolers during dry seasons to balance indoor humidity and temperature.
6. Integrate solar-powered ventilation fans where mechanical cooling is needed, combine natural ventilation with low-energy ceiling fans in hybrid systems, and incorporate passive downdraft evaporative cooling towers to naturally cool incoming air while reducing electricity consumption.
7. Schedule services during cooler hours, encourage flexible dressing codes suited to thermal conditions, and implement retractable partitions or flexible seating arrangements that allow congregants to adjust their positions for improved personal comfort.

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