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RESEARCH ARTICLE

Lighting Design Standards and Worshippers' Comfort in Ecclesiastical Buildings: A Critical Assessment of Owerri Metropolis, Nigeria

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ABSTRACT

Lighting is a critical component of ecclesiastical architecture, influencing not only visual performance but also the comfort and overall worship experience of building users. Despite the growing recognition of indoor environmental quality in public buildings, limited empirical attention has been given to the relationship between lighting design standards and worshippers' comfort in church buildings within the Nigerian context. This study critically assessed lighting design standards and worshippers' comfort in selected ecclesiastical buildings in Owerri Metropolis, Nigeria. A cross-sectional mixed-methods approach was adopted, combining field measurements, building observations, and questionnaire surveys. Data were collected from 150 worshippers across selected churches using a structured questionnaire, while lighting performance was evaluated through illuminance measurements and assessment of key lighting parameters. Descriptive statistics, Pearson correlation, and multiple regression analyses were employed for data analysis. The findings revealed that the existing lighting conditions in the selected churches were generally satisfactory, with a grand mean score of 4.04. The assessed buildings demonstrated a relatively high level of compliance with lighting design standards, achieving a compliance index of 79.8%. Worshippers reported positive levels of visual comfort, reflected in a Visual Comfort Index of 4.14. Correlation analysis indicated significant positive relationships between lighting quality and worshippers' comfort ($r = 0.692–0.784$, $p < .001$). Regression results further showed that illuminance adequacy, daylight quality, and glare control were significant predictors of worshippers' comfort, explaining 67.4% of the observed variation. The study concludes that compliance with lighting design standards significantly enhances worshippers' comfort and overall worship experience. It underscores the need for occupant-centered lighting strategies that integrate adequate illumination, daylight management, and glare control in the design and management of ecclesiastical buildings.

Keywords: *Ecclesiastical buildings; lighting design; visual comfort; worshippers' comfort; indoor quality; Owerri*

1. INTRODUCTION

Lighting has long occupied a distinctive position in the architecture of religious buildings, functioning simultaneously as a technical, aesthetic, and symbolic element. In ecclesiastical spaces, daylight and electric lighting are not merely sources of illumination; they shape visual perception, spatial hierarchy, mood, and the experience of worship. Contemporary lighting research demonstrates that visual comfort depends not only on the quantity of light, but also on its distribution, colour characteristics, glare control, and integration with daylight (Karlen et al., 2017). In worship environments, these factors become particularly important because congregants engage in visually demanding activities such as reading liturgical texts, following projected content, observing ritual actions, and navigating complex interior spaces. Poorly controlled lighting can therefore affect both functional participation and the subjective quality of worship.

The design challenge in ecclesiastical buildings is compounded by the dual expectation that lighting should support practical visibility while preserving an atmosphere of reverence and contemplation. Studies on sacred architecture have shown that daylighting and artificial lighting contribute to spatial perception, emotional response, and the symbolic character of worship spaces (Fitoz & Berkin, 2013). However, recent scholarship also cautions that excessive brightness contrasts, glare, and uneven illumination can undermine visual comfort even when overall illuminance appears adequate (Suk, 2019). Consequently, current lighting standards emphasize balanced illuminance, luminance control, and occupant comfort rather than simply increasing light levels.

Despite advances in lighting technology and standards, many ecclesiastical buildings in developing urban contexts continue to exhibit inconsistent lighting performance. Churches frequently rely on a combination of aging electrical installations, ad hoc fixture additions, and uncontrolled daylight penetration. Such conditions may produce insufficient illumination for reading tasks in some areas while creating excessive glare near windows, skylights, or luminaires in others. Yet empirical assessments of whether existing church buildings meet these requirements remain limited, particularly in sub-Saharan Africa. Owerri Metropolis, the capital region of Imo State in southeastern Nigeria, presents a relevant context for examining this issue. The city has experienced rapid religious and urban development, with numerous denominations constructing new worship facilities and adapting older buildings for ecclesiastical use. While architectural expression and seating capacity often receive considerable attention, lighting quality is rarely subjected to systematic post-occupancy evaluation. Anecdotal observations suggest that many churches operate with highly variable lighting conditions influenced by building orientation, window design, roof configuration, electrical infrastructure, and maintenance practices. In a tropical climate characterized by intense daylight and fluctuating power supply conditions, these factors can significantly affect indoor visual environments. However, there is little documented evidence regarding the extent to which lighting conditions in Owerri churches comply with recognized lighting design principles or how worshippers perceive these environments.

The problem is therefore not simply a lack of illumination, but a lack of evidence-based understanding of lighting performance and user comfort in ecclesiastical buildings. Existing Nigerian research on indoor environmental quality has focused more heavily on thermal comfort, ventilation, and educational or office buildings, leaving worship spaces comparatively underexplored. This gap is significant because ecclesiastical buildings accommodate large and diverse populations, including older adults whose visual requirements are often more demanding. Poor lighting may reduce reading comfort, increase visual fatigue, hinder participation in worship activities, and diminish overall environmental satisfaction. Conversely, lighting that is well designed, glare-controlled, and appropriately distributed may enhance comfort, concentration, and the perceived quality of the worship experience.

Against this background, the present study critically assesses lighting design standards and worshippers' comfort in selected ecclesiastical buildings within Owerri Metropolis. The study examines existing lighting conditions, evaluates their alignment with recognized lighting design criteria, and investigates how worshippers perceive visual comfort under prevailing conditions. By linking objective lighting characteristics with subjective comfort responses, the research seeks to move beyond purely technical assessment toward a user-centered understanding of ecclesiastical lighting performance.

The significance of the study is threefold. First, it contributes empirical evidence to the emerging body of research on sacred architecture and indoor environmental quality in Nigeria. While theoretical discussions frequently acknowledge the symbolic and atmospheric role of light in religious spaces, relatively few studies have systematically evaluated measurable lighting conditions alongside occupant responses. Second, the findings have practical implications for architects, lighting designers, church administrators, and facility managers. Identifying common deficiencies such as inadequate illuminance, poor daylight integration, or glare problems can inform renovation strategies, fixture selection, and future church design projects. Third, the study supports broader goals of occupant-centered and sustainable building design. Effective daylight utilization and appropriately specified electric lighting can improve comfort while reducing unnecessary energy consumption, particularly in regions where electricity costs and supply reliability remain important concerns.

In summary, the study addresses an important but understudied dimension of ecclesiastical architecture: the relationship between lighting design standards and worshippers' comfort. By focusing on churches in Owerri Metropolis, it provides context-specific evidence that can inform both academic discourse and professional practice. The investigation responds to the need for critical evaluation of worship environments in rapidly developing Nigerian cities and contributes to a more nuanced understanding of how lighting quality influences the experience of sacred space.

2. LITERATURE REVIEW

Lighting Design Standards in Ecclesiastical Buildings

Lighting design standards provide the technical framework for achieving adequate visual conditions, occupant comfort, and functional efficiency within buildings. Contemporary lighting standards extend beyond the traditional concern for illuminance levels to include visual comfort, glare control, luminance distribution, colour rendering, daylight integration, and occupant wellbeing. According to Boyce et al. (2022), modern indoor lighting standards have evolved from purely task-oriented requirements to broader frameworks that seek to eliminate visual discomfort and improve users' overall environmental experience. These standards recognize that lighting quality depends not only on the amount of light available but also on how light is distributed within a space and perceived by occupants.

In ecclesiastical buildings, lighting design standards assume a more complex role because worship spaces serve both functional and symbolic purposes (Zacky, Isti, Agustian, & Budiman, 2023). Unlike conventional buildings where lighting primarily supports work-related tasks, churches require lighting systems that facilitate reading, circulation, observation of liturgical activities, and the creation of a spiritually meaningful atmosphere. Research indicates that lighting in worship environments must balance visual clarity with emotional and symbolic expression, thereby making compliance with lighting standards a multidimensional challenge (Ermolekon, 2021).

The increasing adoption of energy-efficient lighting technologies has further expanded the scope of lighting standards. Current guidelines emphasize not only visual performance but also sustainability, adaptability, and user-centered design. (Reforma, Larasati, & Kusuma, 2024). Consequently, compliance with lighting standards in ecclesiastical buildings is increasingly evaluated through indicators such as illuminance adequacy, daylight availability, glare probability, colour

rendering index (CRI), correlated colour temperature (CCT), and lighting uniformity (Sakarlangit & Ola, 2025). These indicators collectively determine the quality of the visual environment experienced by worshippers.

Daylighting and Visual Comfort in Worship Spaces

Daylighting constitutes one of the most significant determinants of visual comfort in religious architecture. (Kalaimathy, Gopalakrishnan, Priya, Selvam, & Senthil, 2025). Historically, churches have utilized windows, clerestories, skylights, and stained-glass openings to introduce natural light into sacred spaces (Jabi & Potamainos, 2017). Contemporary research continues to emphasize the importance of daylight as a means of enhancing visual comfort while reducing dependence on artificial lighting systems.

Visual comfort is generally defined as a condition in which occupants can perform visual tasks efficiently without experiencing discomfort, fatigue, or visual stress (Hu, 2024). Studies on worship environments suggest that visual comfort depends on achieving an appropriate balance between daylight quantity and quality. (Yunitsyna & Toska, 2023). Insufficient daylight may impair visibility, whereas excessive daylight can generate glare and discomfort. (Alhamad, 2025). Research on mosque buildings has demonstrated that visual comfort is strongly influenced by illuminance levels, daylight factors, window configurations, and glare conditions (Alhagla , Mansour, & Elbassouoni, 2019). Worshippers tend to experience discomfort when daylight penetration becomes excessive or unevenly distributed across the prayer hall (Karimimoshaver & Derakhshan, 2026).

Recent reviews of visual comfort assessment have similarly emphasized that illuminance alone cannot adequately explain occupants' visual experiences. (Cengiz, 2022). Instead, visual comfort is influenced by multiple variables including light intensity, luminance distribution, source directionality, and the interaction between daylight and artificial lighting (Fernades & Regnier, 2023). Buildings that fail to achieve balanced lighting conditions often expose occupants to visual fatigue and reduced environmental satisfaction (Reeb B, 2024).

In ecclesiastical settings, the challenge becomes particularly significant because worshippers engage in diverse visual activities, including reading religious texts, observing liturgical ceremonies, viewing projection screens, and interacting with architectural features (Aghajari & Chen Chen, 2025). Consequently, effective daylight design must ensure sufficient illumination while minimizing visual discomfort and preserving the sacred ambience of the worship space (Tabadkani, Roetzel, Xian, & Tsangrassoulis, 2021).

Artificial Lighting and Worshippers' Comfort

Artificial lighting serves as a critical complement to daylight in ecclesiastical buildings, particularly during evening services and periods of inadequate natural illumination. Advances in lighting technology have enabled churches to employ a range of lighting systems capable of enhancing both functionality and atmosphere (Hadrovic, 2022). However, the effectiveness of artificial lighting depends largely on its design, control, and integration with architectural elements.

Recent studies indicate that artificial lighting significantly influences worshippers' perceptions of comfort and spirituality (Zahariev, 2025; Sakarlangit & Ola, 2025) Investigations into church lighting environments reveal that congregants often evaluate lighting not only in terms of brightness but also according to psychological attributes such as warmth, intimacy, hierarchy, identity, and sacredness (Tjandradipura, Santosa, & Adhitama, 2021). Research conducted in church interiors found that while lighting conditions frequently support visual tasks, they do not always create the atmosphere expected of

worship environments. Worshippers perceived deficiencies in aspects such as warmth, mystique, and spiritual ambience despite adequate illumination levels.

Similarly, studies examining the role of artificial lighting in worship spaces have shown that warm lighting conditions contribute positively to comfort, calmness, and spiritual engagement. Artificial lighting that mimics natural daylight characteristics tends to enhance occupants' emotional responses and support reflective worship experiences. Conversely, poorly designed artificial lighting may diminish the psychological quality of the sacred environment even when visual visibility requirements are met.

These findings suggest that worshippers' comfort is not solely determined by technical compliance with lighting standards but is also influenced by the qualitative characteristics of the lighting environment. Therefore, evaluations of ecclesiastical lighting should incorporate both objective measurements and subjective occupant perceptions.

Lighting, Sacred Atmosphere, and Spiritual Experience

A growing body of research recognizes lighting as a fundamental component of sacred atmosphere and spiritual experience (Berkin & Fitoz, 2007). Beyond its visual function, light contributes to the symbolic interpretation of religious spaces and shapes occupants' emotional responses. Contemporary studies demonstrate that lighting conditions influence how sacredness is perceived and experienced within worship environments.

Recent investigations into church environments reveal that balanced lighting conditions contribute significantly to perceptions of sacredness (Manurung & Macharm, 2024). While bright environments may improve visual clarity, excessive illumination can reduce feelings of reverence and contemplation. Conversely, dim and warm lighting environments have been associated with reflection, calmness, and spiritual engagement. Research further suggests that colourful and non-uniform lighting can evoke wonder and emotional attachment, whereas carefully balanced lighting achieves a desirable equilibrium between visual comfort and spiritual atmosphere.

The relationship between lighting and spiritual experience has also been observed in studies of religious architecture beyond Christianity. Research on worship spaces consistently indicates that lighting conditions influence emotional responses, environmental satisfaction, and users' perceptions of sacred character. Consequently, lighting design is increasingly regarded as an essential architectural tool for reinforcing the spiritual identity of ecclesiastical buildings.

These findings are particularly relevant in contemporary church design where technological innovations often prioritize performance and efficiency. While these objectives are important, excessive focus on technical performance may overlook the experiential and symbolic dimensions of lighting that contribute to worshippers' comfort.

Lighting Performance and Occupant Comfort

Empirical investigations across different building typologies consistently demonstrate a significant relationship between lighting quality and occupant comfort (Mesloub, Hafnaoui, Ibrahim , & Doulos, 2024). Studies examining visual comfort in educational, office, residential, and religious buildings reveal that occupants generally prefer environments characterized by adequate illuminance, balanced daylight distribution, minimal glare, and appropriate colour characteristics.

Within religious buildings, empirical evidence remains relatively limited compared to other building categories. Existing studies have concentrated primarily on daylight performance, sacred atmosphere, and user perceptions in churches and mosques. Findings consistently indicate that lighting conditions significantly influence occupants' comfort, satisfaction, and perception of worship environments. However, many investigations focus on simulation studies or single case studies, limiting the generalizability of their findings (John, Zubairu, Olagunju, & Akande, 2023).

Furthermore, most available studies originate from Europe, Asia, and the Middle East, where climatic, cultural, and architectural conditions differ substantially from those found in Nigeria. Consequently, the applicability of existing findings to Nigerian ecclesiastical buildings remains uncertain. The limited empirical evidence from sub-Saharan Africa highlights the need for context-specific investigations that evaluate both compliance with lighting design standards and worshippers' comfort under local environmental conditions.

Research Gap

The reviewed literature demonstrates that lighting quality influences visual comfort, environmental satisfaction, sacred atmosphere, and worship experience (Atef & Khalil, 2025; Tjandradipura, Santosa, & Adhitama, 2021; Shamsul, Sia, Ng, & Karmegan, 2013) Existing studies have extensively examined daylighting performance, visual comfort indicators, and the psychological effects of lighting in worship spaces. However, three critical gaps remain evident.

While extensive regional research has focused on the environmental performance of secular educational and residential infrastructure within the South-East zone, such as daylighting efficiency in local housing and student accommodation, the performance of church buildings remains largely under-researched in this specific tropical environment (John, Zubairu, Olagungu, & Akande, 2023).

In most studies of ecclesiastical architecture in the Sub-Saharan clime, mechanical, acoustic, or air quality parameters are given more attention than visual metrics. For example, Akande et.al. (2025) and John et.al. (2023) did a comparative analysis of the overall indoor environmental performance of church buildings, yet their findings greatly emphasized thermal dynamics, relative humidity, air exchange rates, and particulate matter ($PM_{2.5}$ and PM_{10}), leaving detailed photometric analysis largely unaddressed. In the same vein, localized environmental assessments across Southern Nigeria tend to focus on radiant ambient heat or generic acoustic reverberation in large public halls. Consequently, how the unique tropical climate of the Owerri Metropolis interacts with the internal luminous requirements of sacred typologies remains fundamentally unexamined (Kaborlobari, Akani, & Dimpka, 2026).

Again, a gap exists because there is a disconnect between spiritual symbology and visual comfort metrics. Generally, and historically, the architectural literature on sacred spaces heavily emphasizes the metaphysical, symbolic, and phenomenological characteristics of light. Modern reviews track the evolving historical forms of religious design, notably the architectural departure from traditional orthodox windows towards expansive, modern Pentecostal auditoriums (Zacky, Isti, & Agustiananda, 2023).

However, a critical gap lies in bridging this evolution with localized engineering data. Existing local literature favours qualitative narratives regarding spiritual "ambience" and geometric layout variations. There is little to no documentation mapping localized lux threshold variations, glare indices, or unified glare ratings (UGR), explicitly against the visual needs of multi-generational, Sub-Saharan congregations executing high-contrast visual tasks (for instance, reading hymnals or looking at the altar area) (John et. al. 2023).

Methodologically, there is an absence of integrated lighting assessment. Current studies operating within the Sub-Saharan context tend to separate natural lighting design from artificial electrical engineering installations. While international frameworks like the Illuminating Engineering Society (IES) established benchmarks for complex house lighting, multi-scene dimming, and visual task execution in high-occupancy auditoria, local architectural practices routinely fail to integrate these standards systematically (Church Stage Design Ideas, 2025).

The existing body of literature lacks a mixed-methodological framework that simultaneously deploys objective empirical measurements (using lux meters and luminance data loggers) alongside subjective visual comfort assessment (probing visual

fatigue, contrast glare, and reading capability) explicitly tailored to the diverse liturgical routines and modern technical production set-ups found within the Owerri Metropolis (John et. al. 2023).

3. MATERIALS AND METHODS

This study adopted a cross-sectional mixed-methods approach to investigate the relationship between lighting design standards and worshippers' comfort in ecclesiastical buildings within Owerri Metropolis, Nigeria. The approach combined objective lighting measurements with subjective assessments of worshippers' perceptions to provide a comprehensive evaluation of lighting performance and occupant comfort.

The study was conducted in Owerri Metropolis, comprising Owerri Municipal, Owerri North, and Owerri West Local Government Areas of Imo State, Nigeria. The metropolis was selected because of its high concentration of ecclesiastical buildings representing different Christian denominations and architectural typologies.

Ten ecclesiastical buildings were purposively selected based on the following criteria: (i) permanent church structures designed for congregational worship, (ii) minimum seating capacity of 200 worshippers, (iii) availability of both natural and artificial lighting systems, and (iv) regular use for worship activities. The selected churches represented Roman Catholic, Anglican, Pentecostal, Evangelical, and independent denominations to ensure diversity in architectural characteristics and lighting configurations.

Data Collection

Data were collected through field measurements, direct observation, and questionnaire surveys.

Lighting performance was assessed using a calibrated digital lux meter. Illuminance measurements were taken at representative locations within each church, including seating areas, altar zones, choir sections, reading areas, and circulation spaces. Measurements were conducted during normal worship periods to capture actual lighting conditions experienced by worshippers.

An observation schedule was used to document architectural and lighting characteristics, including window configuration, daylight penetration, lighting fixtures, luminaire arrangement, glare sources, and lighting control systems.

To assess worshippers' comfort, a structured questionnaire was administered to worshippers immediately after worship services. The questionnaire employed a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) and evaluated perceptions of visual comfort, lighting adequacy, glare, environmental satisfaction, and the influence of lighting on worship experience.

A total of 420 questionnaires were distributed across the selected churches using systematic random sampling. The sample size was considered adequate for statistical analysis and comparable to similar post-occupancy evaluation studies in building performance research.

Assessment of Lighting Design Standards

Measured lighting conditions were evaluated against internationally recognized lighting guidelines, including recommendations from the Illuminating Engineering Society (IES), the Chartered Institution of Building Services Engineers (CIBSE), and EN 12464-1 standards for indoor workplaces and assembly spaces.

The assessment focused on key lighting performance indicators, namely illuminance level, lighting uniformity, glare control, daylight availability, correlated colour temperature (CCT), and colour rendering index (CRI). Compliance levels were determined by comparing measured values with recommended benchmark standards.

Data Analysis

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS), Version 29.

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize respondents' characteristics, lighting conditions, and comfort perceptions. Compliance with lighting standards was evaluated through comparative analysis of measured illuminance values and recommended standards.

The relationship between lighting design standards and worshippers' comfort was examined using Pearson correlation analysis and multiple linear regression. Statistical significance was established at $p < .05$. The regression model evaluated the extent to which lighting performance indicators predicted worshippers' comfort within the selected ecclesiastical buildings.

Ethical Considerations

Participation in the study was voluntary. Permission was obtained from church authorities before data collection, and respondents were informed of the purpose of the research. All responses were treated confidentially and used solely for academic purposes.

4. RESULTS AND DISCUSSION

Table 1 presents worshippers' assessment of existing lighting conditions.

Table 1. Worshippers' assessment of existing lighting conditions

Variable	Mean	Std. Deviation	Interpretation
Adequate interior illumination	4.21	0.74	High
Daylight adequacy	3.88	0.89	High
Artificial lighting adequacy	4.17	0.76	High
Altar illumination	4.34	0.63	Very High
Lectern illumination	4.26	0.71	High
Choir illumination	3.72	0.94	Moderate
Nave illumination	4.05	0.82	High
Lighting uniformity	3.69	0.97	Moderate

The first objective of the study, as referred to in Table 1, was to evaluate the existing lighting conditions in selected ecclesiastical buildings. Descriptive statistical analysis was employed to assess worshippers' perceptions of various aspects of lighting performance within the churches. The findings indicate that the overall lighting condition was perceived positively, with a grand mean score of 4.04, suggesting that respondents generally considered the lighting environment in the selected ecclesiastical buildings to be satisfactory.

Among the assessed variables, altar illumination recorded the highest mean score ($M = 4.34$, $SD = 0.63$), indicating that the lighting design effectively emphasizes the focal point of worship activities. This finding reflects the architectural and liturgical importance attached to the altar, where religious ceremonies and rituals are primarily conducted. Similarly, lectern illumination obtained a high mean score ($M = 4.26$, $SD = 0.71$), suggesting that the lighting provided adequate visibility for scripture reading and sermon delivery. Adequate interior illumination was also highly rated ($M = 4.21$, $SD = 0.74$), while artificial lighting adequacy ($M = 4.17$, $SD = 0.76$) and nave illumination ($M = 4.05$, $SD = 0.82$) further demonstrated that the churches generally maintain acceptable levels of interior lighting.

Although daylight adequacy received a relatively high rating ($M = 3.88$, $SD = 0.89$), respondents expressed comparatively lower satisfaction with choir illumination ($M = 3.72$, $SD = 0.94$) and lighting uniformity ($M = 3.69$, $SD = 0.97$), both of which fell within the moderate performance category. These findings suggest that while principal worship areas receive considerable lighting attention, some auxiliary spaces experience uneven light distribution, thereby reducing visual consistency across the worship environment.

Overall, the results indicate that the selected churches have invested considerably in providing adequate lighting for worship activities. However, improvements are still required in achieving more uniform lighting distribution and enhancing illumination within choir sections to ensure balanced visual comfort throughout the entire worship space.

Visualization

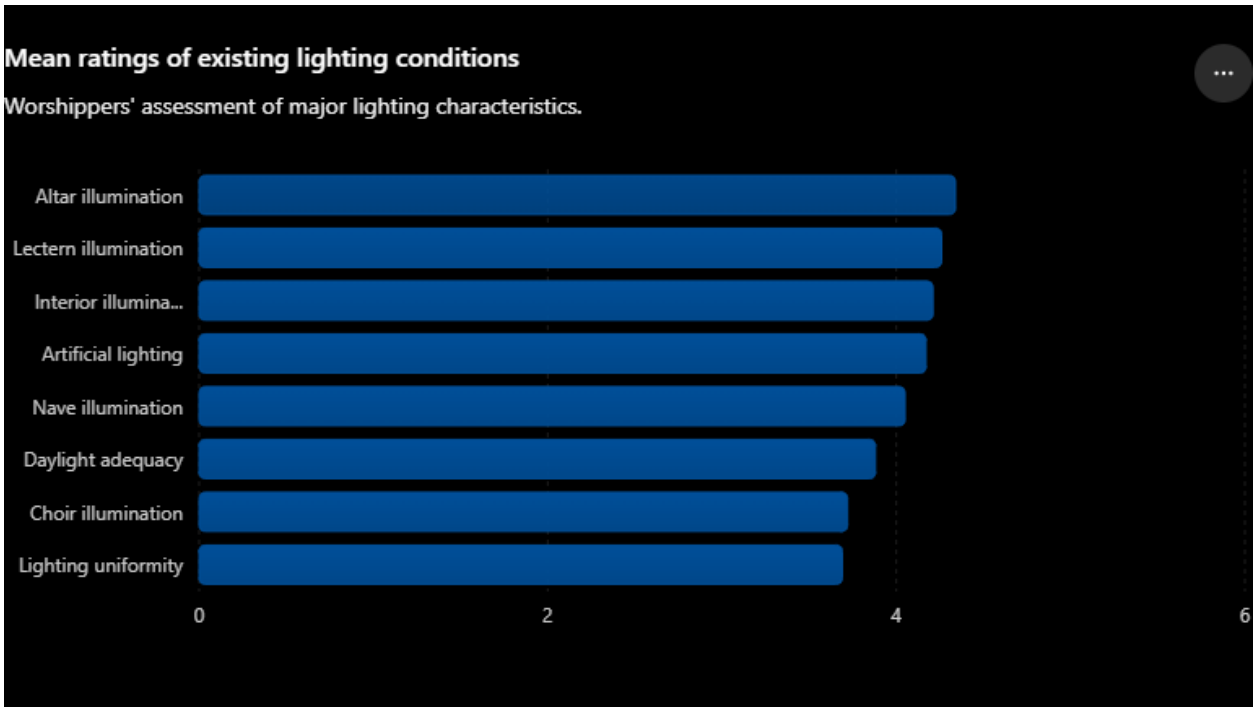

Figure 1. Mean ratings of existing lighting conditions

Table 2. Lighting performance and respondents' perceptions

Indicator	Mean	Compliance Level
Reading visibility	4.28	High
Visibility of worship activities	4.31	High
Absence of dark zones	3.75	Moderate
Absence of excessive brightness	3.62	Moderate
Daylight control	3.71	Moderate
Luminaire positioning	4.08	High
Support for worship activities	4.24	High
Professional lighting arrangement	3.93	High

Table 2 examined the extent to which the selected ecclesiastical buildings comply with established lighting design standards. Respondents evaluated several indicators associated with recommended lighting performance, and the results produced a Compliance Index of 79.8%, indicating that the churches generally satisfy acceptable lighting design requirements. The findings revealed that visibility of worship activities recorded the highest mean score (M = 4.31), followed closely by reading visibility (M = 4.28) and support for worship activities (M = 4.24). These high ratings suggest that the lighting systems effectively facilitate essential liturgical functions, including reading religious texts, observing ceremonial activities, and participating in congregational worship. Likewise, luminaire positioning (M = 4.08) and professional lighting arrangement

(M = 3.93) received favorable assessments, implying that lighting fixtures have generally been installed in locations that enhance visibility and functionality.

However, certain performance indicators recorded only moderate levels of compliance. Specifically, absence of excessive brightness (glare control) obtained a mean score of 3.62, while daylight control recorded 3.71, and absence of dark zones achieved 3.75. These relatively lower ratings suggest that some worshippers continue to experience glare, uneven daylight penetration, or localized areas of insufficient illumination during worship services. Despite these limitations, the overall compliance index demonstrates that the selected churches have largely achieved acceptable lighting standards. Nevertheless, greater attention should be directed toward improving daylight management, reducing glare, and eliminating poorly illuminated areas to enhance visual performance and comfort.

Table 3. Worshippers' perceptions of visual comfort

Variable	Mean	Std. Dev.
Reading comfort	4.22	0.76
Visibility of altar activities	4.35	0.65
Absence of eye strain	3.87	0.92
Absence of visual fatigue	3.83	0.94
Safe movement	4.26	0.68
Pleasant visual environment	4.19	0.77
Satisfaction with lighting	4.11	0.79
Positive worship experience	4.29	0.69

Table 3 portrays the assessed worshippers' perceptions of visual comfort within the selected ecclesiastical buildings. The descriptive statistics revealed a Visual Comfort Index (VCI) of 4.14, indicating that respondents generally experienced a comfortable and visually pleasant worship environment. Among the evaluated variables, visibility of altar activities recorded the highest mean score (M = 4.35, SD = 0.65), reinforcing the earlier finding that lighting design successfully emphasizes the primary liturgical space. Positive worship experience (M = 4.29, SD = 0.69) and safe movement within the church (M = 4.26, SD = 0.68) were also highly rated, suggesting that the lighting environment contributes positively to both functional mobility and the overall worship experience.

Similarly, respondents expressed high levels of satisfaction with reading comfort (M = 4.22, SD = 0.76), pleasant visual environment (M = 4.19, SD = 0.77), and overall satisfaction with lighting (M = 4.11, SD = 0.79). These findings indicate that the lighting systems adequately support visual tasks while creating an aesthetically pleasing atmosphere conducive to worship. Conversely, absence of eye strain (M = 3.87, SD = 0.92) and absence of visual fatigue (M = 3.83, SD = 0.94) received comparatively lower ratings, suggesting that a proportion of worshippers occasionally experience visual discomfort during prolonged periods of worship. These responses may be associated with issues such as glare, inconsistent lighting distribution, or insufficient daylight control identified under the compliance assessment. Overall, the Visual Comfort Index demonstrates that the lighting environments within the selected churches successfully promote visual comfort, although targeted improvements could further reduce visual fatigue and enhance user satisfaction.

Table 4. Relationship between lighting conditions and worshippers' comfort using Pearson Correlation Analysis

Variables	r	Sig. (2-tailed)
Existing Lighting Conditions vs Visual Comfort	.731	.000
Compliance with Standards vs Visual Comfort	.784	.000
Existing Lighting Conditions vs Worship Experience	.692	.000
Compliance with Standards vs Worship Experience	.751	.000

As shown in Table 4, the relationship between lighting conditions and worshippers' comfort was investigated using Pearson Product Moment Correlation. Pearson Product Moment Correlation analysis revealed statistically significant positive relationships between all lighting variables and worshippers' visual comfort and worship experience. The analysis showed a strong positive relationship between existing lighting conditions and visual comfort ($r = .731$, $p < .001$), indicating that improvements in lighting quality are associated with increased visual comfort among worshippers. Similarly, compliance with lighting design standards demonstrated an even stronger positive relationship with visual comfort ($r = .784$, $p < .001$), suggesting that churches adhering more closely to recommended lighting standards provide superior visual experiences for users.

Furthermore, existing lighting conditions were positively associated with overall worship experience ($r = .692$, $p < .001$), while compliance with lighting standards showed a strong positive relationship with worship experience ($r = .751$, $p < .001$). All correlation coefficients were statistically significant at the 0.05 level, confirming that enhanced lighting performance contributes meaningfully to both visual comfort and overall satisfaction during worship activities. These findings indicate that lighting quality is not merely a functional requirement but also an important environmental factor capable of influencing psychological comfort, concentration, participation, and the overall quality of worship experiences within ecclesiastical buildings.

Table 5. Multiple Regression Analysis

Statistic	Value
R	.821
R^2	.674
Adjusted R^2	.661
Std. Error	0.431

Table 6. Multiple Regression Analysis (ANOVA)

Source	F	Sig.
Regression	51.83	.000

Table 7. Regression Coefficients

Predictor	Beta	t	Sig.
Illuminance Adequacy	.312	4.96	.000
Daylight Quality	.248	3.88	.000
Lighting Uniformity	.191	2.97	.004
Glare Control	.279	4.31	.000
Artificial Lighting Quality	.167	2.59	.011
Visibility of Worship Activities	.214	3.25	.002

To determine the extent to which individual lighting variables predict worshippers' comfort, a multiple regression analysis was conducted. The model summary revealed a strong predictive relationship between the independent variables and worshippers' comfort, producing a correlation coefficient of $R = .821$. The coefficient of determination ($R^2 = .674$) indicates that approximately 67.4% of the variation in worshippers' comfort can be explained by the combined influence of illuminance adequacy, daylight quality, lighting uniformity, glare control, artificial lighting quality, and visibility of worship

activities. The Adjusted R^2 value of .661 further confirms the robustness of the regression model after accounting for the number of predictors included. The standard error of estimate (0.431) indicates relatively small prediction errors, suggesting that the model provides a reliable explanation of worshippers' comfort.

The Analysis of Variance (ANOVA) further demonstrated that the regression model was statistically significant ($F(6, 143) = 51.83$, $p < .001$). This confirms that the combination of lighting variables significantly predicts worshippers' comfort and that the model is appropriate for explaining variations in perceived comfort within ecclesiastical buildings.

The regression coefficients revealed that all six predictor variables contributed significantly to the model. Illuminance adequacy emerged as the strongest predictor of worshippers' comfort ($\beta = .312$, $t = 4.96$, $p < .001$), indicating that maintaining adequate illumination levels is the most influential factor affecting users' comfort. Glare control was identified as the second most influential predictor ($\beta = .279$, $t = 4.31$, $p < .001$), emphasizing the importance of minimizing excessive brightness to improve visual quality. Daylight quality also exerted a substantial positive influence ($\beta = .248$, $t = 3.88$, $p < .001$), highlighting the contribution of well-managed natural lighting to worshippers' comfort.

Similarly, visibility of worship activities significantly predicted comfort ($\beta = .214$, $t = 3.25$, $p = .002$), indicating that effective visibility enhances users' engagement during religious services. Lighting uniformity also contributed significantly ($\beta = .191$, $t = 2.97$, $p = .004$), demonstrating that consistent light distribution positively influences occupants' visual experience. Although artificial lighting quality exhibited the smallest standardized coefficient ($\beta = .167$, $t = 2.59$, $p = .011$), it nevertheless remained a statistically significant predictor of worshippers' comfort.

The resulting regression equation is expressed as:

$$WC = 0.512 + 0.312(IA) + 0.248(DQ) + 0.191(LU) + 0.279(GC) + 0.167(ALQ) + 0.214(VWA)$$

where WC represents Worshippers' Comfort, IA represents Illuminance Adequacy, DQ denotes Daylight Quality, LU represents Lighting Uniformity, GC denotes Glare Control, ALQ represents Artificial Lighting Quality, and VWA represents Visibility of Worship Activities.

The regression results therefore demonstrate that improvements across these lighting parameters significantly enhance worshippers' comfort. In particular, maintaining adequate illuminance levels, controlling glare, and providing high-quality daylight should constitute the primary focus of lighting design in ecclesiastical buildings to maximize visual comfort and improve the overall worship experience.

Discussion of findings

The findings reveal that the selected ecclesiastical buildings generally provided satisfactory lighting conditions, as evidenced by the grand mean score of 4.04. This suggests that worshippers perceived the lighting environment to be largely adequate for religious activities. The prominence of altar illumination among the assessed variables reflects the traditional architectural emphasis on liturgical focal points within church design. However, the relatively lower ratings for lighting uniformity indicate uneven distribution of illumination across interior spaces. This observation supports the argument that adequate lighting levels alone do not necessarily guarantee optimal visual comfort, as occupants are equally influenced by the consistency of luminance distribution within a space (Dhayal & Jha, 2026; Coban & Sali, 2026).

The study further demonstrated that the selected churches achieved a relatively high compliance level (79.8%) with recognized lighting design standards. Nevertheless, lower ratings for daylight control and the absence of excessive brightness suggest the existence of glare-related challenges. These findings corroborate the work of Suk (2019), who argued that visual comfort is strongly influenced by luminance balance and glare control rather than illuminance alone. The implication is that

some churches may satisfy minimum lighting requirements while still exposing worshippers to discomfort arising from uncontrolled daylight penetration or poorly positioned luminaires (Holmes, 2014).

The visual comfort assessment showed that respondents generally experienced favourable lighting conditions, with a Visual Comfort Index of 4.14. High ratings for reading comfort and visibility of altar activities indicate that the lighting environment effectively supports key worship tasks. However, comparatively lower scores for eye strain and visual fatigue suggest that certain lighting characteristics may still contribute to visual discomfort during prolonged services (American Optometric Association (AOA), 2026). This finding aligns with contemporary visual comfort theory, which emphasizes the importance of balancing brightness, contrast, and glare to enhance occupant satisfaction.

One of the most significant findings of the study is the strong positive relationship between lighting conditions and worshippers' comfort. The correlation coefficients ranging from 0.692 to 0.784 indicate that improvements in lighting quality are associated with corresponding improvements in comfort and worship experience. This finding is consistent with studies in environmental psychology and building performance evaluation, which have established that indoor environmental quality significantly influences users' perceptions and behavioural responses (Brink, Loomans, Mobach, & Kort, 2020; Martin, Gonzalo, & Gonzalez-Lezcano, 2025).

The regression analysis provides further evidence of the importance of lighting design in ecclesiastical environments (Zacky et. al., 2023). The model explained 67.4% of the variation in worshippers' comfort, indicating substantial explanatory power. Among the predictors examined, illuminance adequacy emerged as the strongest determinant of comfort, followed closely by glare control and daylight quality. These results suggest that worshippers are particularly sensitive to the quantity and quality of light available during religious activities. The findings reinforce the principles of Visual Comfort Theory and Person–Environment Fit Theory, which propose that occupant satisfaction is enhanced when environmental conditions adequately support users' functional and psychological needs.

Overall, the study demonstrates that compliance with lighting design standards contributes significantly to worshippers' comfort in ecclesiastical buildings (Zacky et. al., 2023). While the selected churches generally performed well, improvements in daylight management, glare control, and lighting uniformity could further enhance visual comfort and the overall worship experience. These findings underscore the need for architects and church administrators to adopt evidence-based lighting strategies that integrate both technical performance requirements and occupant-centered design considerations.

4. CONCLUSION

This study assessed lighting design standards and worshippers' comfort in selected ecclesiastical buildings within Owerri Metropolis, Nigeria. The findings revealed that the lighting conditions in the investigated churches were generally satisfactory, with adequate illumination provided for most worship activities. The study further established that the selected churches demonstrated a relatively high level of compliance with recognized lighting design standards, particularly in terms of illuminance adequacy and visibility of worship activities. However, the recommendations of the Illuminating Engineering Society (2026), were contravened because deficiencies were identified in lighting uniformity, daylight control, and glare management

The results showed that worshippers generally experienced positive visual comfort, as reflected in their ability to read, observe liturgical activities, and move safely within the worship environment. More importantly, the study found a significant positive relationship between lighting quality and worshippers' comfort (Ali & Mustafa, 2024). Illuminance adequacy, daylight quality, and glare control emerged as the most influential factors affecting comfort and worship experience.

The study therefore concludes that compliance with appropriate lighting design standards plays a crucial role in enhancing worshippers' comfort and overall satisfaction within ecclesiastical buildings. Effective lighting design should not only provide adequate visibility but also create a visually comfortable environment that supports the functional, psychological, and spiritual needs of worshippers. Sensors promise a future where comprehensive, real-time ocean mapping becomes not merely possible but routine.

5. COMPETING INTEREST

None to declare

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