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Spatiotemporal Assessment of Environmental Noise Exposure and Associated Health Effects around Religious Centers in Abeokuta, Nigeria

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ABSTRACT

Environmental noise pollution from religious activities has emerged as a pressing environmental health concern in rapidly urbanizing Nigerian cities. This study assessed noise levels from selected churches and mosques in Abeokuta and examined the associated health effects among nearby residents. A cross-sectional design combining environmental noise monitoring and questionnaire surveys was adopted. Twenty religious centers (15 churches, 5 mosques) were sampled, and 200 residents participated. Noise levels were measured with a calibrated sound level meter during morning, afternoon, and evening/night periods. Data were analyzed using descriptive statistics, independent samples t-test, one-way ANOVA, and Pearson correlation. Mean environmental noise across all centers was 85.48 ± 9.03 dB (A), exceeding World Health Organization and NESREA residential limits. Churches recorded significantly higher noise levels than mosques ($t = 4.62$, $p = .001$). Noise intensity varied across time, with evening/night worship activities producing the highest levels, $F(2, 57) = 8.47$, $p = .002$. Commonly reported health complaints included headache (51.7%), annoyance (45.0%), insomnia (43.3%), and lack of concentration (45.0%). Correlation analysis revealed strong positive associations between noise exposure and headache ($r = .71$, $p < .01$) as well as sleep disturbance ($r = .64$, $p < .01$).

The findings demonstrate that religious noise constitutes a significant environmental health challenge in Abeokuta. Stricter enforcement of noise regulations and adoption of sustainable control measures are recommended to protect residential communities from adverse health impacts.

Keywords: Environmental Noise Pollution, Religious Centers, Noise Exposure, Public Health, Urban Environmental Management

INTRODUCTION

Environmental noise pollution has become a major public health concern, particularly in rapidly urbanizing cities where human activities increasingly generate excessive and unwanted sound. Prolonged exposure to high noise levels has been linked to several adverse health outcomes, including hearing impairment, sleep disturbance, stress, reduced cognitive performance, and cardiovascular disorders (Hammer *et al.*, 2014; Münzel *et al.*, 2024). Recognizing these risks, the World Health Organization (WHO) recommends that residential outdoor noise levels should not exceed 55 dB(A) during the daytime and 40 dB(A) at night in order to minimize harmful health effects (WHO, 2018). Despite these guidelines, environmental noise remains a growing challenge in many developing countries where urban growth and weak regulatory enforcement contribute to increasing exposure levels.

Environmental noise originates from multiple sources such as transportation systems, industrial activities, commercial operations, construction work, and social gatherings. In many Nigerian cities, religious activities have also emerged as important contributors to urban noise pollution due to the widespread use of amplified loudspeakers, musical instruments, and prolonged worship programmes. Churches and mosques are central to the social and spiritual life of communities; however, their increasing concentration within residential neighbourhoods has intensified concerns over noise exposure and its effects on nearby residents.

Previous studies in Nigeria have reported elevated noise levels associated with worship activities. For instance, Ikibe and Adekogbe (2020) recorded church noise levels exceeding 90 dB(A) in southwestern Nigeria, while Udeh *et al.* (2023) observed similarly high levels during religious activities in Port Harcourt. Ayanugo *et al.* (2024) further reported increased prevalence of headache, annoyance, sleep disturbance, and stress among residents living close to worship centres. These findings suggest that prolonged exposure to religious noise may negatively affect the health and quality of life of surrounding populations.

Although the National Environmental Standards and Regulations Enforcement Agency (NESREA) has established environmental noise regulations in Nigeria, enforcement remains limited in many urban centres. In Abeokuta, rapid urban expansion, mixed land use, and the growing number of religious centres within residential areas have heightened environmental noise concerns. Worship activities involving high-powered loudspeaker systems, night vigils, and outdoor programmes frequently expose nearby residents to elevated noise levels.

Existing studies on environmental noise in Nigeria have focused largely on traffic and industrial sources, with comparatively limited attention given to noise generated by religious centres and its associated health implications. In addition, few studies have combined environmental noise measurements with statistical assessment of residents' health experiences. This gap limits evidence-based interventions aimed at managing religious noise pollution in urban communities.

This study is anchored in Environmental Stress Theory, as developed by Stokols (1978), which explains that prolonged exposure to environmental stressors such as excessive noise can trigger physiological and psychological responses that adversely affect human health and well-being. The theory was further elaborated by Evans and Cohen (1987), who

emphasized that chronic exposure to environmental stressors can lead to adverse physiological, psychological, and behavioural outcomes. Environmental Stress Theory therefore provides a suitable framework for understanding the potential health effects associated with prolonged exposure to environmental noise generated by religious activities.

Against this background, this study assessed environmental noise levels generated by selected religious centres within Abeokuta metropolis and examined associated health effects among nearby residents. Specifically, the study compared noise levels between churches and mosques, evaluated temporal variations in noise intensity across worship periods, and examined relationships between environmental noise exposure and selected health outcomes. The findings are expected to contribute to environmental health research and support policies aimed at improving urban noise management in rapidly growing Nigerian cities.

MATERIALS AND METHODS

Study Area

The study was conducted in Abeokuta, the capital city of Ogun State, southwestern Nigeria. Abeokuta is located between latitude 7°05′N and 7°20′N and longitude 3°17′E and 3°28′E. The city occupies a land area of approximately 879 km² and lies within the tropical rainforest zone of Nigeria. It experiences a tropical wet-and-dry climate characterized by two distinct seasons: the rainy season, which extends from March to October, and the dry season, which lasts from November to February.

The area has a mean annual temperature ranging from 26°C to 28°C, with relative humidity varying between 70% and 95% depending on the season. The average annual rainfall ranges from approximately 1,000 mm to 1,300 mm, creating favourable environmental conditions for human settlement and economic activities.

Abeokuta has an estimated population of over 700,000 residents. Rapid urbanization, increasing population density, and mixed land-use development have resulted in the proximity of residential buildings, commercial establishments, educational institutions, and places of worship. Consequently, numerous churches and mosques are located within residential neighbourhoods, making environmental noise from religious activities an important public health concern.

The major occupations of the inhabitants include civil service, trading, agriculture, transportation, artisanship, teaching, and other small- and medium-scale business enterprises.

Research Design

A cross-sectional environmental health assessment design was adopted for this study. The study combined environmental noise measurements with a questionnaire-based assessment to evaluate the effects of environmental noise generated by religious centres on the health and well-being of nearby residents. This design enabled the simultaneous collection of objective noise data and subjective information on respondents' perception of noise exposure and its associated health effects.

Study Population

The study population comprised residents, traders, worshippers, and workers located within a 500 m radius of the selected religious centres in Abeokuta metropolis. These individuals were considered appropriate for the study because of their regular exposure to environmental noise generated during religious activities. A total of 200 respondents participated in the study.

Sampling Technique

A multistage sampling technique was employed in selecting the study participants. In the first stage, twenty religious centres, comprising fifteen churches and five mosques, were purposively selected across major residential districts within Abeokuta metropolis. The selection was based on the intensity of worship activities, level of sound amplification, accessibility, and frequency of reported noise complaints.

In the second stage, respondents were selected using simple random sampling from residents and other eligible individuals living or working within a 500 m radius of the selected religious centres. Geographic coordinates of all sampled religious centres were obtained using a handheld Global Positioning System (GPS) receiver to facilitate spatial referencing and mapping of the sampling locations.

Noise Measurement Procedure

Environmental noise levels were measured using a calibrated digital Sound Level Meter (Extech 407730, Extech Instruments, USA). The instrument was configured using the A-weighting frequency network and slow response mode in accordance with World Health Organization environmental noise assessment guidelines. Noise monitoring was conducted during three periods of the day: morning (06:00–09:00 h), afternoon (12:00–15:00 h), and evening/night (18:00–22:00 h), covering both weekdays and weekends. Measurements were obtained at worship halls, entrance points, outdoor congregation areas, and nearby residential zones surrounding the selected religious centres. At each sampling location, measurements were taken at approximately 1.5 m above ground level and at a reasonable distance from major reflective surfaces to minimize interference. Three consecutive noise level readings were taken at each sampling location during each monitoring period, and the arithmetic mean of the three readings was calculated to obtain a representative environmental noise level for subsequent analysis.

Questionnaire Administration and Health Assessment

Structured questionnaires were administered to collect data on respondents' socio-demographic characteristics, perception of environmental noise, duration of exposure, and self-reported health effects associated with noise exposure. The health indicators assessed included headache, sleep disturbance, irritation, stress, hearing discomfort, and reduced concentration.

The questionnaire items were developed from previous environmental health studies and reviewed for content validity before administration. A pilot survey was conducted among a small group of respondents outside the study locations to assess clarity, consistency, and suitability of the instrument. Necessary modifications were made before the final field administration.

Informed Consent

Participation in the study was voluntary, and informed consent was obtained from all respondents before data collection commenced. Participants were adequately informed about the objectives and procedures of the study, and their right to decline participation or withdraw from the study at any stage without any adverse consequences was emphasized. Confidentiality and anonymity of the information provided were assured, and no personal identifiers were included in the analysis or reporting of the findings. Environmental noise measurements were conducted without disrupting worship activities or normal community operations.

Statistical Analysis

Data obtained from noise measurements and questionnaire surveys were analyzed using IBM SPSS Statistics version 25. Descriptive statistics, including mean, standard deviation, frequencies, percentages, minimum values, and maximum values, were used to summarize environmental noise levels and respondents' socio-demographic characteristics.

An independent-samples t-test was used to determine differences in environmental noise levels between churches and mosques, while one-way Analysis of Variance (ANOVA) was employed to examine temporal variations in noise levels across monitoring periods. Pearson Product-Moment Correlation analysis was used to assess relationships between environmental noise exposure and reported health outcomes. Statistical significance was determined at $p < 0.05$ using a 95% confidence level.

RESULTS AND DISCUSSION

Ambient Noise Levels around Religious Centres

Environmental noise levels recorded across the selected religious centres are presented in Table 1. The results showed substantial variation in noise intensity among the sampled worship centres. Mean noise levels ranged from 69.77 ± 3.69 dB(A) at Isolu Central Mosque (SP19) to 100.82 ± 3.23 dB(A) at Redeemed Christian Fellowship (SP12), with an overall mean of 85.48 ± 9.03 dB(A).

Among the churches sampled, Redeemed Christian Fellowship (SP12), Four Square Gospel Church (SP6), Baptist Student Fellowship (SP3), and Father's House (SP13) recorded the highest mean noise levels, all exceeding 93 dB(A). In contrast, mosques generally recorded lower values, with Isolu Central Mosque (SP19) and FUNAAB Mosque (SP18) showing mean noise levels below 72 dB(A).

The highest recorded noise level during the study was 109.1 dB(A) at Redeemed Christian Fellowship (SP12), while the lowest value of 63.9 dB(A) was observed at FUNAAB Mosque (SP18). Overall, most measured noise levels exceeded the residential exposure limits recommended by the World Health Organization (WHO) and the National Environmental Standards and Regulations Enforcement Agency (NESREA), indicating widespread environmental noise pollution within the study area.

Table 1: Environmental Noise Levels Recorded at Selected Religious Centers

Religious Center	Code	Mean ± SD dB(A)	Minimum [dB(A)]	Maximum[dB(A)]
Reigning City Int'l Church	SP1	91.8 ± 1.04	90.2	93.4
RCCG Jesus Dynasty	SP2	81.09 ± 2.26	77.5	85.3
Baptist Student Fellowship	SP3	94.23 ± 4.03	89.4	104.1
Divine Height Bible Church	SP4	90.36 ± 2.66	85.7	93.4
RCCG Jesus Inspiration	SP5	86.5 ± 5.86	75.8	95.2
Four Square Gospel Church	SP6	94.82 ± 4.04	84.4	98.2
Victory Life Bible Church	SP7	80.62 ± 7.42	70.9	101.2
Living Faith Church	SP8	81.91 ± 3.48	75.1	85.6
Glory House Church	SP9	81.2 ± 2.25	78.1	87.1
New Covenant Apostolic Christ Church	SP10	89.44 ± 6.31	82.7	104.1
MFM Christian Fellowship	SP11	85.1 ± 1.21	82.9	86.7
Redeemed Christian Fellowship	SP12	100.82 ± 3.23	96.3	109.1
Fathers House	SP13	93.75 ± 5.01	83.4	99.2
Mountain of Fire and Miracle Ministries	SP14	88.47 ± 4.28	82.4	98.1
Christ Apostolic Church	SP15	89.92 ± 3.67	83.2	94.5
Abans Central Mosque	SP16	72.45 ± 4.03	67.4	83.4
AL-HUSNA Mosque	SP17	85.51 ± 4.79	77.8	93.4
FUNAAB Mosque	SP18	71.95 ± 4.91	63.9	79.1
Isolu Central Mosque	SP19	69.77 ± 3.69	65.1	76.2
NASFAT Mosque	SP20	79.98 ± 5.79	76.3	98.1
Overall Mean		85.48 ± 9.03	63.9	109.1

An independent samples *t*-test was conducted to compare the mean environmental noise levels between churches and mosques. The results are presented in Table 2.

Table 2: Independent Samples t-test Comparing Churches and Mosques

Group	N	Mean dB (A).	SD	T	P
Churches	15	88.9	6.5	4.62	.001*
Mosques	5	75.9	6.3		

*Significant at $p < .05$

The independent-samples t-test showed a statistically significant difference in environmental noise levels between churches and mosques ($t = 4.62$, $p = .001$). Churches recorded higher mean noise levels than mosques, reflecting the greater use of amplified musical instruments, loudspeakers, and prolonged worship activities.

Temporal Variation in Environmental Noise Levels

Temporal variations in environmental noise levels across the monitoring periods are presented in Table 3. Mean noise levels increased progressively from morning to evening/night periods, indicating variation in worship-related acoustic activities over time.

The morning period recorded the lowest mean environmental noise level of 76.8 ± 4.3 dB(A), while higher values were observed during the afternoon period (82.5 ± 5.1 dB(A)). The

highest mean noise level was recorded during evening/night worship activities at 91.7 ± 6.4 dB (A).

One-way Analysis of Variance (ANOVA) revealed a statistically significant variation in environmental noise levels across the monitoring periods, $F(2, 57) = 8.47$, $p = .002$. A Tukey post hoc test further indicated that the evening/night period recorded significantly higher noise levels compared with the morning period ($p < .05$). However, the differences between morning and afternoon periods, as well as between afternoon and evening/night periods, were not statistically significant.

The elevated evening/night noise levels were associated with intensified worship activities such as amplified preaching, congregational singing, drumming, revival programmes, and night vigils commonly observed in several churches within the study area.

Table 3: Temporal Variation in Environmental Noise Levels across Monitoring Periods

Monitoring Period/Source of Variation	Mean dB(A)	SD	df	F	P
Morning	76.8	4.3			
Afternoon	82.5	5.1			
Evening/Night	91.7	6.4			
Between Groups			2	8.47	.002*
Within Groups			57		

*Significant at $p < .05$

Table 4: Tukey Post Hoc Multiple Comparison Test for Monitoring Periods

Comparison	Mean Difference dB(A)	p-value	Remark
Morning vs Afternoon	-5.7	.081	Not Significant
Morning vs Evening/Night	-14.9	.001*	Significant
Afternoon vs Evening/Night	-9.2	.063	Not Significant

*Significant at $p < .05$

Perceived Health Problems Associated with Environmental Noise Exposure

Respondents reported varying degrees of physiological and psychological effects associated with environmental noise exposure from religious activities within the study area. The perceived health problems are presented in Table 4 and Figure 1.

Headache, annoyance/irritation, insomnia, and lack of concentration were the most frequently reported health complaints. More than half of the respondents (51.7%) reported always experiencing headaches, while 45.0% indicated persistent annoyance/irritation and lack of concentration. Similarly, 43.3% reported always experiencing insomnia, suggesting possible disruption of sleep quality due to environmental noise exposure.

A considerable proportion of respondents also reported occasional hearing impairment (38.3%), insomnia (38.3%), and impaired performance (33.3%). In contrast, depression/stress appeared to be the least frequently reported condition, as 71.7% of respondents indicated that they did not experience depression or stress related to environmental noise exposure.

Overall, the findings indicate that prolonged exposure to elevated environmental noise may contribute to non-auditory health effects such as headache, sleep disturbance, annoyance, and reduced concentration among nearby residents.

Table 5: Perceived Problems Associated with Environmental Noise Exposure

Problem	Always (%)	Sometimes (%)	Not at all (%)
Hearing Impairment	23.3	38.3	38.3
Headache	51.7	33.3	15.0
Annoyance/Irritation	45.0	35.0	20.0
Nervousness	20.0	35.0	45.0
Insomnia	43.3	38.3	18.3
Lack of concentration	45.0	40.0	15.0
Depression/Stress	8.3	20.0	71.7
Impaired performance	15.0	33.3	51.7

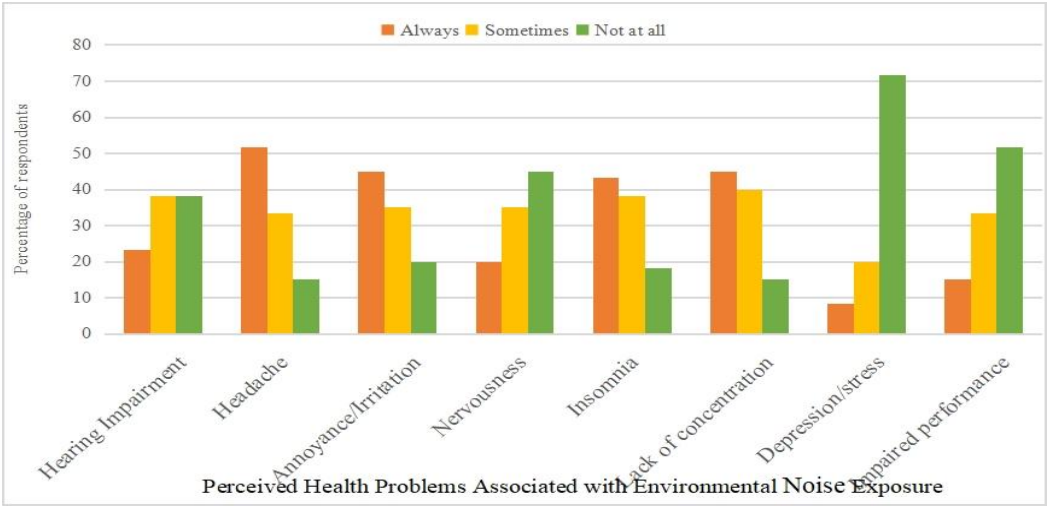

Figure 1: Percentage Distribution of Respondents According to Perceived Health Problems Associated with Environmental Noise Exposure

Correlation between Environmental Noise Exposure and Health Outcomes

Pearson Product-Moment Correlation analysis was conducted to examine the relationship between environmental noise exposure and selected self-reported health outcomes among respondents residing around the sampled religious centres. The results are presented in Table 5.

Environmental noise level showed strong positive correlations with headache ($r = .71$, $p < .01$) and sleep disturbance ($r = .64$, $p < .01$), indicating that higher noise exposure was associated with increased occurrence of these health complaints. Moderate positive relationships were also observed between noise exposure and irritation ($r = .58$, $p < .05$) and stress-related symptoms ($r = .61$, $p < .01$).

Headache further demonstrated significant positive associations with sleep disturbance ($r = .52$, $p < .05$), irritation ($r = .46$, $p < .05$), and stress ($r = .49$, $p < .05$). Similarly, sleep disturbance showed a significant relationship with stress ($r = .57$, $p < .01$), suggesting possible interrelationships among the reported non-auditory health effects.

Overall, the findings indicate that prolonged exposure to elevated environmental noise from religious activities may contribute to adverse physiological and psychological health outcomes among exposed populations in the study area.

Table 6: Pearson Correlation Matrix between Environmental Noise Exposure and Selected Health Outcomes

Variable	Noise Level	Headache	Sleep Disturbance	Irritation	Stress
Noise Level	1	.71**	.64**	.58*	.61**
Headache		1	.52*	.46*	.49*
Sleep Disturbance			1	.43*	.57**
Irritation				1	.48*
Stress					1

**Correlation significant at $p < .01$
*Correlation significant at $p < .05$

Discussion

This study assessed environmental noise levels generated by religious centres in Abeokuta and examined associated health implications among nearby residents. The findings revealed that most worship centres recorded noise levels above the residential limits recommended by the World Health Organization (WHO, 2018) and the National Environmental Standards and Regulations Enforcement Agency (NESREA, 2015). The overall mean noise level of 85.48 ± 9.03 dB(A), with peak values exceeding 100 dB(A), indicates substantial environmental noise exposure within the study area. These findings support previous studies conducted in Nigeria that identified religious activities as important contributors to urban environmental noise pollution (Eseroghene, 2019; Ikibe & Adekogbe, 2020; Udeh *et al.*, 2023).

The significant differences observed between churches and mosques suggest that worship practices strongly influence environmental noise intensity. Churches, particularly Pentecostal denominations, generally recorded higher noise levels due to the extensive use of amplified loudspeakers, musical instruments, drumming, and prolonged worship activities. Similar observations were reported by Ikibe and Adekogbe (2020) in southwestern Nigeria and by Sackey *et al.* (2024) in Ghana, where Pentecostal worship centres were identified as major sources of excessive environmental noise. In contrast, mosques generally recorded lower noise levels, likely due to shorter worship duration and relatively lower dependence on amplified musical instruments. These findings indicate that acoustic characteristics and worship patterns are important determinants of environmental noise exposure within religious settings.

Temporal variation in environmental noise levels further showed that evening and night worship activities generated the highest noise exposure. The significant increase in evening/night noise levels was associated with revival programmes, night vigils, amplified preaching, congregational singing, and extended worship sessions. This finding is important because prolonged nighttime noise exposure has been associated with sleep disturbance, stress, and other adverse health outcomes (Halperin, 2014; Zaman *et al.*, 2022). Similar patterns have also been reported in studies conducted in Indonesia and Brazil (Silva & Cabral, 2011; Kango *et al.*, 2025). The exceedance of recommended night time noise limits within residential communities therefore

suggests potential disruption of residential comfort and public health concerns among exposed populations.

The health complaints reported by respondents, particularly headache, insomnia, annoyance, and reduced concentration, are consistent with Environmental Stress Theory developed by Stokols (1978), which explains that prolonged exposure to environmental stressors such as excessive noise may trigger physiological and psychological responses. The strong positive correlations observed between environmental noise exposure, headache, and sleep disturbance further suggest that increasing noise exposure may contribute to non-auditory health effects among nearby residents. These findings are consistent with previous studies linking chronic environmental noise exposure to sleep disturbance, reduced cognitive performance, and psychological stress (Basner *et al.*, 2014; Hahad *et al.*, 2019; Chen *et al.*, 2023).

From a policy perspective, the findings highlight the need for improved enforcement of environmental noise regulations in urban residential areas. Although NESREA has established permissible environmental noise limits in Nigeria, enforcement remains weak in many communities. Practical measures such as routine noise monitoring, enforcement of decibel limits, soundproofing of worship facilities, and improved urban zoning regulations could help reduce environmental noise exposure from religious activities. Community-based awareness programmes may also encourage voluntary compliance and promote environmental responsibility among religious institutions.

CONCLUSION

This study has demonstrated that environmental noise generated by religious centres in Abeokuta constitutes a significant environmental health concern. The recorded mean environmental noise level of 85.48 ± 9.03 dB(A), with peak values above 100 dB(A), exceeded the residential exposure limits recommended by the World Health Organization (WHO) and NESREA. Churches generally recorded higher environmental noise levels than mosques, while evening and night worship activities produced the highest levels of environmental noise exposure.

The study further showed that residents exposed to elevated environmental noise frequently reported health complaints such as headache, insomnia, annoyance, and reduced concentration. Significant positive relationships between environmental noise exposure and selected health outcomes suggest that prolonged exposure to excessive religious noise may contribute to adverse physiological and psychological effects among nearby residents.

Overall, the findings support growing evidence that religious noise pollution constitutes an emerging environmental health concern within rapidly urbanizing cities. By integrating environmental noise measurement with self-reported health outcomes, this study provides useful empirical evidence to support environmental management strategies aimed at reducing excessive noise exposure within residential communities.

Based on these findings, stricter enforcement of environmental noise regulations should be prioritized within urban residential communities. Regulatory agencies should strengthen routine environmental noise monitoring and ensure compliance with permissible decibel limits. Worship centres should also be encouraged to adopt soundproofing measures and regulate the use of high-powered loudspeaker systems, particularly during nighttime worship activities.

Urban planning authorities should consider zoning measures capable of reducing conflicts between high-intensity worship activities and residential land use. In addition, public awareness programmes are necessary to promote environmental responsibility and encourage voluntary compliance with environmental noise regulations among religious institutions.

Overall, the study contributes to existing environmental health research by demonstrating the relationship between religious noise exposure and associated health effects within an urban Nigerian setting. The findings provide useful evidence for policymakers, urban planners, environmental regulators, and public health authorities seeking to develop sustainable strategies for environmental noise management in rapidly growing cities.

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