Spatial Distribution of Telecommunication Masts and Its Effects on Human Health in Kaduna Metropolis: A Cross-Sectional Study

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***Abstract*—This study examines the spatial distribution of telecommunication masts and their effects on human health in Kaduna Metropolis. Using GPS field surveys, 57 telecommunication masts were identified and mapped across the 172 km² study area. A cross-sectional survey of 384 residents assessed health symptom prevalence and residents' perceived associations between mast proximity and health outcomes. Results revealed that 55.6% of residents live within 100 meters of masts, with 43.1% experiencing multiple-mast exposure. Self-reported health symptom prevalence reached 77.1%, dominated by sleep disturbances (50.7%), frequent headaches (43.1%), and fatigue (27.8%). Household symptom clustering affected 42.4% of respondents, suggesting possible shared environmental exposures. Regarding perceived associations, 32.7% of residents believed symptoms were mast-related, while 41.0% remained neutral and 26.4% rejected the association. The study demonstrates that spatial distribution of masts creates concentrated exposure zones where residents experience substantial health concerns, though causal attribution remains contested. The findings underscore the need for health-protective infrastructure siting in future telecommunications planning.**

***Index Terms*—telecommunication masts, spatial distribution, health symptoms, electromagnetic field exposure, public health, Kaduna Metropolis**

I. INTRODUCTION

Rapid expansion of telecommunications infrastructure globally has transformed urban landscapes (Andrews, 2014; Rappaport et al., 2013; Stallings, 2019) while simultaneously raising public health concerns regarding potential adverse effects of electromagnetic field (EMF) exposure (Kesari & Kumar, 2020). Nigeria's telecommunications sector has experienced unprecedented growth, with networks expanding to serve increasing demand for mobile connectivity in urban centers (GSMA Intelligence, 2022; Okunoye & Oyeniran, 2020). Kaduna Metropolis, as a major Nigerian urban center, has witnessed substantial telecommunication mast deployment without comprehensive assessment of spatial distribution patterns or health implications for resident populations (Emmanuel, 2021; Suleiman, 2016).

The World Health Organization and International Commission on Non-Ionizing Radiation Protection (ICNIRP) acknowledge that while scientific evidence regarding health effects of low-level EMF exposure remains contested, public health concerns persist (ICNIRP, 2020). Understanding spatial patterns of telecommunication infrastructure deployment and documenting residents' health experiences and perceptions provides essential baseline data for evidence-based telecommunications planning and public health policy (ITU, 2019).

This study addresses three specific research objectives: (1) identifying telecommunication mast locations in Kaduna Metropolis, (2) determining prevalence of self-reported health symptoms among proximity-exposed residents, and (3) examining residents' perceived associations between mast proximity and health outcomes. These objectives collectively contribute to understanding whether and how spatial distribution of infrastructure affects human health in Nigerian urban contexts.

The study population comprises 1,126,000 residents across 172 km² of Kaduna Metropolis, with 384 respondents selected through stratified random sampling across 23 wards. The research employs mixed-methods approach integrating spatial data collection (GPS surveys of mast locations) with health survey methodology (questionnaire administration assessing symptoms and perceptions).

1.1. Study Area

Kaduna Metropolis comprises four Local Government Areas (Kaduna North, Kaduna South, Chikun, and Igabi) with total area of 172 km² and population of 1,126,000 residents based on 2006 census projections (NPC, 2009). The study area encompasses diverse urban, peri-urban, and rural zones with varying degrees of development intensity and infrastructure provision (Ezeamaka, 2020). The metropolis serves as a major commercial, administrative, and transportation hub in northern Nigeria (Akpu, 2012).

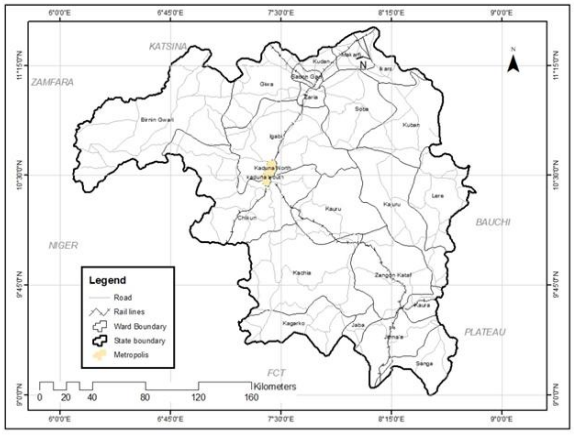

Figure 1: Kaduna State Showing Kaduna Metropolis

Source: Kaduna Polytechnic Department of Cartography and GIS Map Library (2025)

II. METHODOLOGY

Telecommunication mast locations were identified through field GPS survey conducted from January to March 2025. A total of 57 masts operated by major telecommunications companies (MTN, Airtel, Glo, 9Mobile) and co-location facilities were located and mapped using handheld GPS devices (Garmin eTrex with ±5-meter accuracy). Mast attributes including operator, type (monopole, lattice, rooftop), height, and coordinates were recorded in standardized database.

Spatial data were georeferenced using UTM Zone 32N projection and imported into ArcGIS Pro for mapping and analysis. Masts were classified by operator, location (ward and LGA), and type to characterize the spatial and organizational dimensions of network deployment.

A cross-sectional health survey was administered to 384 residents selected through stratified random sampling by ward (23 wards proportionally represented). Sample size was calculated using Taro Yamane formula with 95% confidence level and 5% margin of error, yielding n = 384 from estimated population of 1,126,000. The questionnaire comprised four sections: (A) respondent demographics and residential exposure characteristics; (B) awareness and perception of masts; (C) exposure duration and patterns; and (D) health experiences and perceived associations with mast proximity.

Respondents were asked whether they experienced health inconvenience in the preceding 12 months and, if affirmative, which specific symptoms from a list of eight: frequent headaches, dizziness, fatigue, trouble sleeping, memory/concentration problems, ringing in ears, skin irritation, or none of the above. Perceived association between symptoms and mast proximity was assessed using five-point Likert scale: strongly agree, agree, neutral, disagree, strongly disagree. Additional questions assessed whether symptoms were more noticeable when physically close to masts and whether other household members experienced similar symptoms.

2.1. DATA ANALYSIS

Descriptive statistics (frequencies, percentages, means, standard deviations) characterized respondent demographics, mast locations, and health symptom prevalence. Cross-tabulation examined relationships between spatial proximity variables (distance from nearest mast, multiple mast exposure, hours daily within 100m) and health outcomes. Chi-square tests assessed statistical associations between categorical variables ($p < 0.05$ indicating significance).

III. RESULTS AND DISCUSSION

Telecommunication Mast Identification and Spatial Distribution

Field GPS survey identified 57 telecommunication masts distributed across Kaduna Metropolis. Infrastructure ownership showed MTN dominance with 20 masts (35.1%), followed by Glo with 16 masts (28.1%), Airtel with 11 masts (19.3%), 9Mobile with 6 masts (10.5%), and co-located facilities with 4 masts (7.0%) as shown in Fig2 below. The concentration of ownership among three major operators reflects Nigeria's competitive telecommunications market structure (Aderoju, Oluwaseun, & Akinbile, 2014; Godswill, Nwankwo, & Okonkwo, 2016). Mast types

included 28 monopoles (49.1%), 18 lattice towers (31.6%), and 11 rooftop installations (19.3%). The predominance of monopole structures reflects modern deployment preferences due to aesthetic considerations and reduced land-use conflicts.

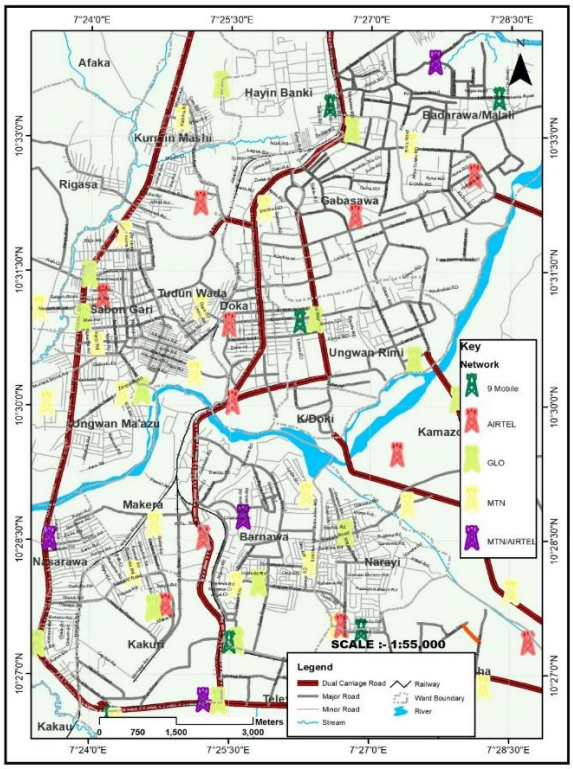

Figure 2 Location of Telecommunication masts in the Study Area

Source: Author's Work, 2025

Spatial distribution analysis revealed pronounced concentration in urban core wards (Sabon Gari, T/Wada, Kabala West, Barnawa, Narayi, Kakuri) with sparse deployment in peripheral areas (Afaka, Rigasa, Kamazou) (Akpu, 2012). This clustering pattern reflects market-driven deployment prioritizing areas with high user density and commercial viability.

The study documents substantial spatial proximity of residents to telecommunication masts in Kaduna Metropolis, with 55.6% living within 100 meters of infrastructure and 43.1% experiencing multiple-mast exposure (Dalil, Abdulkadir, & Hassan, 2016; Nisu, 2018).

These exposure patterns create conditions for potential electromagnetic field exposure in a significant proportion of the urban population.

Prevalence of Self-Reported Health Symptoms

The study found 77.1% (n=296) of respondents reported experiencing health inconvenience in the preceding 12 months, while only 22.9% (n=88) reported no health issues. Among symptomatic individuals Fig 3 shows symptom distribution: trouble sleeping 50.7% (n=195), frequent headaches 43.1% (n=165), fatigue 27.8% (n=107), ringing in ears 27.1% (n=104), memory or concentration problems 19.4% (n=75), dizziness 13.9% (n=53), and skin irritation 8.3% (n=32).

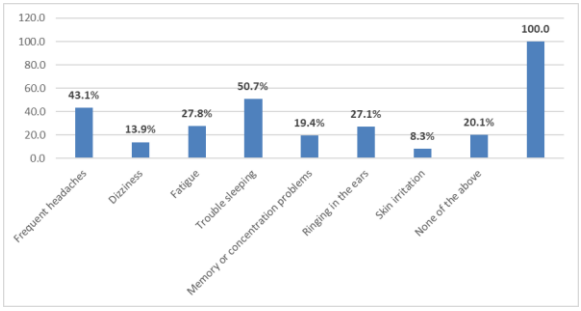

Figure 3: Symptoms Experienced by Respondent

Source: Authors' Work, 2025

The temporal pattern of symptoms showed 49.3% (n=189) experiencing symptoms "sometimes," 29.9% (n=115) "rarely," and 20.8% (n=80) "frequently." The predominance of regular symptom occurrence (70.1% experiencing symptoms with some regularity) suggests persistent rather than transient health concerns shown in Fig 4.

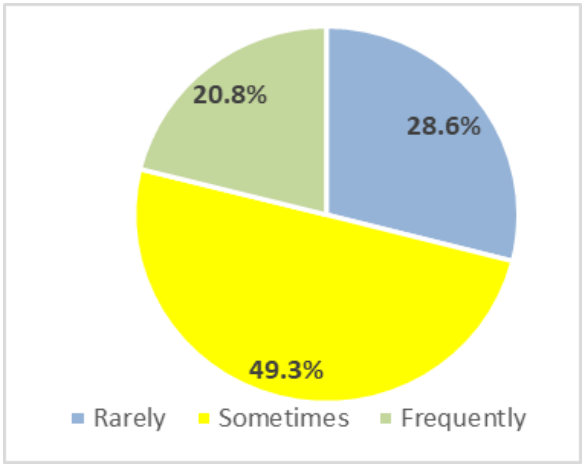

Figure 4: Occurrence of Symptoms by Respondent

Source: Authors' Work, 2025

Healthcare-seeking behavior revealed only 42.4% (n=163) of symptomatic individuals sought medical attention, while 57.6% (n=221) did not consult

healthcare providers. Among those consulting healthcare providers, only 29.2% (n=112) reported that providers suggested environmental factors as possible symptom causes, while 62.5% (n=240) received no such attribution. Household symptom clustering was reported by 42.4% (n=163) of respondents whose other household members complained of similar symptoms, 39.6% (n=152) reported no household clustering, and 18.1% (n=69) were unsure shown in Table 1.

Table 1 Medical Attention, and House Symptoms Reported

Variable	Medical Attention		Household symptoms reported	
Response	Freq	(%)	Freq	(%)
Yes	163	43.2	163	43.2
No	214	56.8	145	38.5
Not sure			69	18.3
Total	377	100	377	100

Source: Authors' Work, 2025

The low rate of healthcare provider environmental attribution (29.2%) suggests either limited awareness among medical practitioners regarding potential EMF effects or clinical judgment that symptoms have alternative etiologist. The 57.6% of symptomatic individuals not seeking medical care may reflect normalization of symptoms, cost barriers, or attribution to environmental sources believed beyond medical intervention.

The household symptom clustering (42.4%) provides epidemiological evidence consistent with shared environmental exposure, though alternative explanations including genetic predisposition, common lifestyle factors, dietary patterns, and psychosocial influences cannot be excluded without more rigorous investigation.

Perceived Association Between Proximity and Symptoms

Responses to belief in symptom-mast relationship showed considerable variation: 16.0% (n=61) "strongly agreed," 16.7% (n=65) "agreed," 41.0% (n=157) remained "neutral," 11.8% (n=45) "disagreed," and 14.6% (n=56) "strongly disagreed" that symptoms were mast-related as shown in Fig 5. Cumulatively, 32.7% believed symptoms mast-related, while 26.4% rejected this association, with 41.0% expressing uncertainty.

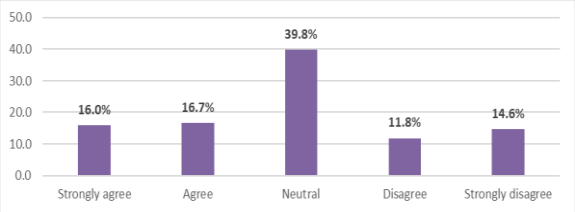

Figure 5: Health Symptoms Are Related to Telecommunication Mast Exposure

Source: Authors' Work, 2025

When asked if symptoms were more noticeable when physically close to masts, 26.4% (n=101) responded "yes," 35.4% (n=136) said "no," and 38.2% (n=147) were "not sure."

The substantial uncertainty proportion (38.2%) combined with those reporting proximity-related exacerbation (26.4%) totals 64.6%, suggesting majority of respondents either experience or cannot exclude distance-dependent symptom patterns shown in Fig 6.

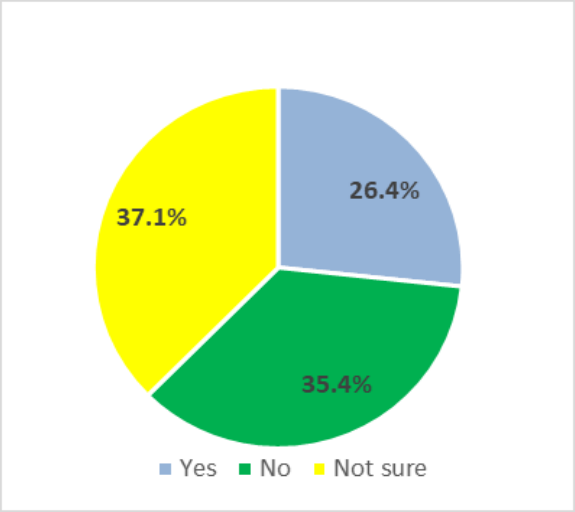

Figure 6: Closer Proximity Symptoms of Telecommunication Mast Exposure

Source: Authors' Work, 2025

Regarding general health implications of masts, figure 7 shows that 62.5% (n=240) believed implications were negative (Alhassan & Adeniran, 2021), 26.4% (n=101) were unsure, and only 11.1% (n=43) perceived positive implications (likely reflecting connectivity benefits).

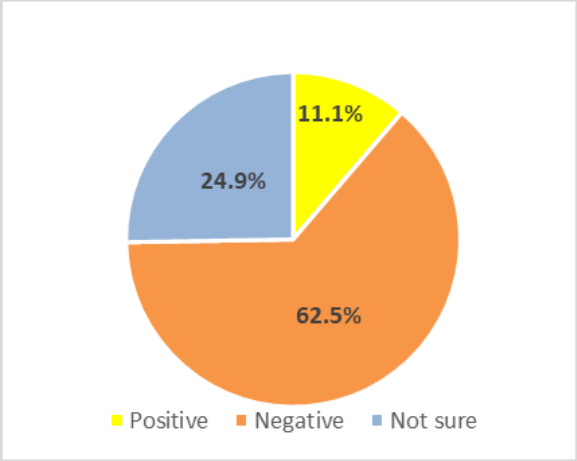

Figure 7: Health Implication of Telecommunication Mast Exposure

Source: Authors' Work, 2025

The perception-reality gap evident in results merits careful consideration. While 77.8% of all respondents believe masts harmful to health, only 32.7% attribute their own symptoms to mast proximity, suggesting distinction between general health concerns about masts and personal symptom attribution. The 41.0% expressing neutrality regarding symptom-mast relationship indicates substantial uncertainty despite experiencing symptoms, possibly reflecting awareness of contested scientific evidence or acknowledgment of alternative symptom causes.

IV. CONCLUSION

This study documents that spatial distribution of telecommunication masts in Kaduna Metropolis creates substantial proximity exposure for majority of residents, with 55.6% living within 100 meters of infrastructure. The high prevalence of self-reported health symptoms (77.1%) combined with pronounced household symptom clustering (42.4%) raises public health concerns warranting systematic investigation. However, the perception-reality gap, where general health concerns exceed personal symptom attribution, suggests that while residents experience substantial symptoms, they remain uncertain whether mast proximity represents actual etiology. This uncertainty reflects broader scientific debate regarding low-level EMF health effects, with current evidence remaining contested among researchers and health organizations.

The findings underscore three critical needs: (1) objective health assessment using clinical measures beyond self-report, (2) rigorous exposure assessment using dosimetric measurements rather than proximity proxies, and (3) longitudinal studies enabling temporal relationship determination between exposure changes and health outcomes. From public health perspective, the high symptom prevalence and widespread health concern, regardless of causal attribution, warrant enhanced environmental health capacity in primary care, improved health communication regarding mast placement, and health-protective considerations in future telecommunications infrastructure planning (Godswill et al., 2016; Njih & Achebe, 2015).

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