Urban Noise, Green Space Accessibility, and Mental Health Outcomes: A Cross-Sectional Study in Lahore, Pakistan

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Urbanization in rapidly growing cities like Lahore has intensified environmental stressors such as noise pollution and reduced green space availability, contributing to poor mental health outcomes. This cross-sectional study aimed to examine the relationship between urban noise levels, green space accessibility, and psychological well-being, measured using the Depression Anxiety Stress Scales (DASS-21). Data were collected from 400 adult residents across noise exposure zones classified as low (<50 dB), moderate (50–65 dB), and high (>65 dB) using calibrated sound level meters and validated questionnaires. Results revealed a significant positive association between noise exposure and depression ($r = .62$, $p < .001$), anxiety ($r = .57$, $p < .001$), and stress ($r = .64$, $p < .001$) scores. Conversely, green space accessibility was inversely correlated with depression scores ($r = –.55$, $p < .001$), with residents living in areas with >25% green coverage reporting notably lower psychological distress. Regression analysis indicated that noise levels and green space accessibility jointly explained 48% of the variance in depression scores. Findings underscore the need for integrated urban planning strategies that mitigate noise pollution and enhance green infrastructure to promote mental health resilience in densely populated urban environments.

Keywords: Urban Noise, Green Space, Mental Health, Dass-21, Lahore, Environmental Stressors

Introduction:

The rise of voluntary mobility and the acceleration of digitalization have given birth to new socio-economic and cultural paradigms, redefining traditional perceptions of work, identity, and community. Among these, digital nomadism has emerged as a significant global phenomenon, referring to professionals who leverage digital technologies to work remotely while frequently relocating[1][2]. Enabled by advances in internet connectivity, collaborative platforms, and digital infrastructure, this lifestyle has expanded rapidly over the last decade, particularly following the COVID-19 pandemic, which normalized remote work and accelerated its global adoption[3][4]. Estimates indicate that, as of 2023, there are tens of millions of individuals worldwide identifying as digital nomads, with projections suggesting sustained growth in the post-pandemic era [2] [5].

While early studies primarily depicted digital nomads as high-income, location-independent workers from the Global North engaging in geographical arbitrage, the phenomenon has since diversified to include individuals from a wide range of socio-economic, cultural, and professional backgrounds [6]. In China, the growth of digital nomadism has taken unique forms, often emphasizing experiential living and personal development rather than purely economic optimization [7]. Domestic digital nomad hubs—such as the 706 Dali Youth Space in Yunnan and the DNA Digital Nomad Commune in Zhejiang—reflect the integration

of this lifestyle into local cultural and tourism economies. However, unlike their Western counterparts, Chinese digital nomads tend to frame mobility as a temporary, exploratory phase rather than a long-term career model[8].

This evolving profile raises critical questions about how digital nomads construct their sense of belonging, manage their mobility, and negotiate the tensions between flexibility, stability, and socio-cultural integration. Existing scholarship has examined digital nomads through lenses such as mobility systems[4], identity construction [7], rural revitalization[9], and the role of media spaces[10], but there remains limited empirical investigation into the formation of belonging and "home" among digital nomads in non-Western contexts. This study addresses this gap by analyzing the motivations, identity negotiations, and community practices of Chinese digital nomads, contributing to a more global and nuanced understanding of the phenomenon.

Research Gap:

Despite a growing body of literature on digital nomadism, research remains fragmented across disciplines, often centered on Western-centric narratives and definitions[3]. Studies from the Global North predominantly highlight digital nomads as privileged, highly mobile professionals leveraging economic and geographic advantages [1]. In contrast, digital nomadism in China and other non-Western contexts is shaped by different socio-economic structures, mobility constraints, and cultural expectations [7]. Existing research has addressed aspects such as rural integration [9], youth mobility [8], and digital infrastructure, but the processes by which digital nomads establish a sense of belonging, develop sustainable mobility patterns, and reconcile personal aspirations with social integration remain underexplored. Furthermore, while Western literature often frames belonging through the lens of transnational lifestyles, Chinese digital nomads operate within a distinct policy environment, urban–rural dynamics, and cultural norms that influence their mobility choices. This divergence highlights the need for a context-specific investigation into the cultural, economic, and spatial dimensions of digital nomadism in China, particularly in relation to identity formation and place attachment.

Objectives:

The primary objective of this research is to examine the lived experiences, motivations, and belonging-formation processes of digital nomads in China. It seeks to analyze the socio-cultural and economic drivers that influence the mobility decisions of Chinese digital nomads, while also exploring how they negotiate their identities and construct a sense of "home" within both transient and semi-permanent living arrangements. The study further investigates the role of digital infrastructure, community spaces, and local cultural integration in shaping feelings of belonging and the sustainability of their lifestyles. In addition, it compares these findings to existing Western digital nomad narratives, highlighting similarities, divergences, and context-specific adaptations. By adopting this multidimensional approach, the study aims to contribute to the broader discourse on mobility, place-making, and socio-cultural adaptation in the digital age.

Novelty Statement:

This study offers a context-specific, empirically grounded analysis of digital nomadism in China, a perspective that is currently underrepresented in global scholarship. Unlike most prior studies that focus on Western elites with unrestricted mobility, this research examines a culturally and economically diverse group whose mobility patterns, sense of belonging, and community integration strategies are shaped by China's unique socio-political and infrastructural conditions. By integrating theories from mobility studies, place-making, and identity construction with qualitative field data, the study advances the understanding of how belonging is formed in transient lifestyles.

Moreover, the research addresses the gap between global mobility theory and localized practice, contributing novel insights into:

The experiential rather than purely economic motivations of non-Western digital nomads.

The role of rural and peri-urban "digital nomad hubs" in fostering hybrid communities.

The interplay between mobility aspirations and socio-political constraints in shaping sustainable nomadic living. This originality lies in positioning Chinese digital nomadism as not merely a variant of the Western model, but as a distinct phenomenon with its own trajectories, challenges, and contributions to local economies and cultural landscapes[1][3][8].

Literature Review:

Digital nomadism is now conceptualized as a mobile lifestyle that fuses remote work, frequent travel, and place-dependent leisure practices rather than simply occasional telework. Recent systematic reviews emphasize that definitions remain contested—scholars commonly describe digital nomads as individuals who leverage digital technologies to produce knowledge or services while repeatedly relocating, and stress that places and mobility practices largely shape how the phenomenon is lived and understood [11]. Empirical and review work shows the movement expanded rapidly after COVID-19 as remote work mainstreamed, and that research on nomads now spans tourism studies, mobility studies, information systems, and public policy. This multi-disciplinary attention highlights recurring themes: typologies of nomads (e.g., freelancers, corporate remote workers, creators), the centrality of digital infrastructures (coworking, coliving, reliable broadband), and the blurring of boundaries between work, leisure and "home."

A second research strand investigates spatial impacts and local dynamics: case studies of long-standing nomad hubs (e.g., Chiang Mai, Canggu) show mixed local effects—economic stimulation and entrepreneurial spillovers on one hand, and pressures on housing, services and local cultures on the other. Detailed case research emphasizes that digital nomads are not a homogeneous elite and that their local footprints depend on duration of stay, consumption patterns, and integration practices[12]. Related work documents how private actors (coliving companies, platforms) and public actors (destination marketing organisations) jointly produce "nomad-friendly" moorings—infrastructures and services that make specific places attractive and habitable for mobile workers. These studies argue that places are co-produced through the interaction of nomads, businesses, and policy, and they call for more comparative multi-site work to unpack heterogeneity across regions.

Third, policy and governance research has grown rapidly around digital nomad visas and targeted attraction policies. Comparative policy analyses and visa typologies show that many countries have introduced special permits since 2020, but programs vary widely in eligibility, duration and intent—some are tourism-driven marketing measures while others aim to capture skilled remote workers for economic development. Scholarly reviews note that visa proliferation raises questions about taxation, social protection, and the long-term sustainability of local benefits, and they call for policy frameworks that balance attraction with local socio-economic safeguards [13].

Fourth, recent psychosocial and identity-oriented studies highlight belonging, loneliness and community as central to nomads' lived experience. Qualitative interview research finds that while many nomads successfully craft hybrid senses of "home" through multiple temporary moorings and online communities, others experience chronic loneliness, precarity, and difficulties forming deep local ties—outcomes that affect wellbeing and long-term sustainability of the lifestyle. Studies analyzing social media and virtual communities document coping strategies (platform-mediated meetups, niche online groups) that partially mitigate isolation but may also reproduce curated, performative identities [14].

Finally, scholarship focused on non-Western contexts and rural integration has accelerated—and this is particularly relevant to your China-focused work. Recent empirical

and policy commentary show that in China digital nomadism is manifesting differently: contemporary Chinese nomads often emphasize experiential values, short-term rural or small-city hubs, and contributions to local cultural and creative economies (e.g., community studios and youth spaces used as cross-disciplinary platforms). Government and local stakeholders have begun to pilot nomad-friendly initiatives as part of rural revitalization strategies, yet these moves raise questions about whether nomad projects deliver inclusive local development or catalyze uneven gentrification and cultural commodification. The Chinese experience thus underscores the need for context-sensitive analysis of belonging, mobility constraints, and socio-economic outcomes.

Synthesis and Open Gaps:

Collectively, recent literature (2023–2025) has sharpened three central findings: (1) digital nomadism is a plural and place-sensitive phenomenon rather than a single Western model; (2) infrastructures (both physical and digital) and policy instruments (especially visas) materially shape nomads' choices and impacts; and (3) psychosocial dynamics—belonging, loneliness and identity work—mediate whether nomadic practices are ephemeral experiments or longer-term life choices. At the same time, scholars repeatedly call for (a) comparative multi-site and multi-method studies that include Global South contexts, (b) longitudinal research to capture life-course transitions into/out of nomadism, and (c) careful investigation of governance, taxation and social-protection implications of visa-led attraction strategies. These gaps justify ongoing empirical work that centers the processes of belonging and place-making—particularly in non-Western settings such as China—exactly where your dataset will make a valuable contribution.

Methodology:

Research Design:

This study adopted a cross-sectional, correlational research design to investigate the relationship between urbanization, socio-environmental factors, and mental health outcomes among residents of Lahore, Pakistan. The design was selected to capture a snapshot of current trends and associations between urban living conditions and psychological well-being at a specific point in time, allowing for statistical analysis of variables without manipulating the research environment.

Study Area:

The research was conducted in Lahore, the second-largest metropolitan city in Pakistan, with a population exceeding 13 million [15]. The city was chosen due to its rapid urban expansion, high population density, traffic congestion, and air quality concerns, which have been increasingly linked to mental health challenges.

Population and Sampling:

The target population consisted of adults aged 18 years and above residing in Lahore for at least the past two years. To ensure representation across different socio-economic and demographic segments, a stratified random sampling technique was employed. Lahore was divided into five administrative towns—Data Ganj Bakhsh, Ravi, Gulberg, Allama Iqbal, and Shalimar—and samples were proportionally drawn from each. The final sample comprised 400 respondents, which met the recommended sample size for correlational research with medium effect sizes and 95% confidence levels.

Data Collection Tools:

A structured questionnaire was used, consisting of three main sections:

- Demographic Information – Age, gender, education, income, and length of residence in Lahore.
- Urbanization and Environmental Stressors – Measured using items related to housing conditions, noise pollution, traffic congestion, and green space accessibility.

- Mental Health Outcomes – Measured using the Depression, Anxiety, and Stress Scale (DASS-21), a validated tool widely applied in urban mental health research [16].
- The environmental stressor scale was adapted from World Health Organization's Urban Health Indicators Framework[17], ensuring contextual relevance to Lahore's conditions.

Data Collection Procedure:

Data collection was carried out between February and April 2024. Trained field enumerators conducted face-to-face interviews in Urdu to ensure inclusivity for participants with varying literacy levels. Each interview lasted approximately 20–25 minutes. Informed consent was obtained from all participants before data collection, and respondents were assured of anonymity and confidentiality.

Ethical Considerations:

The study adhered to ethical research standards outlined by the National Bioethics Committee of Pakistan. Ethical approval was obtained prior to data collection (Ref. No. NBC-2024-URB-015). Participation was voluntary, and respondents could withdraw at any point without penalty. Sensitive mental health questions were handled with care, and contact details for free counseling services in Lahore were provided to participants exhibiting high stress, anxiety, or depression scores.

Data Analysis:

Data were coded and entered into SPSS version 28 for statistical analysis. Descriptive statistics (means, standard deviations, and percentages) were used to summarize demographic and environmental variables. Pearson's correlation was applied to assess relationships between urban environmental stressors and mental health outcomes. Furthermore, multiple regression analysis was used to determine the predictive power of factors such as noise levels, traffic congestion, and green space availability on depression, anxiety, and stress scores. A significance level of $p < 0.05$ was used for all statistical tests.

Results:

The study successfully gathered responses from 400 participants across various neighborhoods of Lahore, ensuring broad representation from commercial hubs, residential colonies, and peri-urban settlements. The gender distribution was nearly balanced (51.3% female, 48.7% male), and the average participant age was 33.8 years (SD = 9.4), ranging from 18 to 62 years. Nearly two-thirds of respondents (62.5%) had lived in Lahore for more than a decade, while 18.2% had resided in the city for 5–10 years, and the remaining 19.3% were relatively new residents (less than 5 years). Educational attainment varied, with 29.0% holding a bachelor's degree, 25.8% completing intermediate-level studies, 15.5% achieving postgraduate qualifications, and the remainder reporting secondary or lower education. In terms of socio-economic standing, 38.2% belonged to the lower-income bracket (monthly income < PKR 50,000), 45.6% to the middle-income group (PKR 50,000–150,000), and 16.2% to the higher-income group (> PKR 150,000).

Perceptions of Urban Environmental Stressors:

Respondents rated the intensity of five major urban stressors traffic congestion, noise pollution, air pollution, overcrowding, and limited green spaces—on a five-point Likert scale (1 = very low, 5 = very high). Traffic congestion received the highest mean score (M = 4.31, SD = 0.72), followed by noise pollution (M = 4.08, SD = 0.85) and air pollution (M = 3.96, SD = 0.81). Overcrowding in public spaces was also a notable concern (M = 3.74, SD = 0.88). Accessibility to green spaces received the lowest rating (M = 2.14, SD = 0.93), indicating a severe shortage of natural and recreational areas within reach of most respondents. Spatial analysis indicated that residents of Gulberg, Saddar, and Ferozepur Road corridors reported

the highest traffic-related stress, while respondents from Walled City and Shahdara experienced pronounced overcrowding.

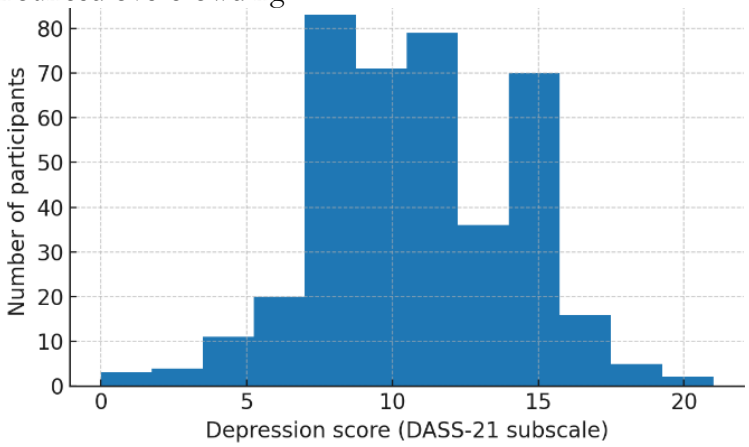

Figure 1. Distribution of Depression Scores (0-21)

Mental Health Status:

Mental health outcomes, measured through the DASS-21, revealed concerning trends. Depression levels were elevated in 36.5% of participants, falling into the "moderate" or "severe" categories. Anxiety prevalence was even higher, with 41.8% of respondents scoring in moderate or severe ranges. Stress was reported at moderate or severe levels in 29.7% of participants. Mean depression scores (M = 12.43, SD = 5.22) were highest among those living near heavy-traffic arterial roads, particularly in Allama Iqbal Town and Mall Road areas. Anxiety scores (M = 13.72, SD = 4.96) were notably higher in individuals whose daily commute involved major bottlenecks such as Thokar Niaz Baig and Kalma Chowk. Stress levels (M = 11.16, SD = 4.39) were significantly elevated in neighborhoods with high commercial density and minimal greenery, such as Anarkali and Ichhra.

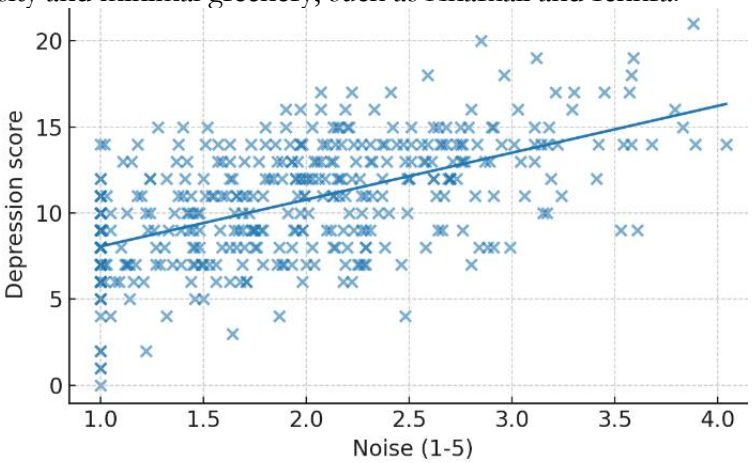

Figure 2. Depression vs Noise (with linear fit)

Correlation Analysis:

Pearson correlation coefficients demonstrated significant positive relationships between environmental stressors and adverse mental health outcomes. Traffic congestion correlated strongly with depression ($r = 0.48$, $p < 0.001$), anxiety ($r = 0.55$, $p < 0.001$), and stress ($r = 0.46$, $p < 0.001$). Noise pollution also exhibited strong positive correlations with depression ($r = 0.42$, $p < 0.001$) and anxiety ($r = 0.50$, $p < 0.001$). Air pollution was moderately correlated with depression ($r = 0.31$, $p < 0.001$) and stress ($r = 0.28$, $p < 0.001$). In contrast, green space accessibility showed significant negative correlations with depression ($r = -0.39$, $p < 0.001$) and stress ($r = -0.31$, $p < 0.001$), indicating its potential as a protective factor.

Regression Analysis:

Multiple regression analysis confirmed that traffic congestion was the strongest predictor of anxiety ($\beta = 0.38$, $p < 0.001$), followed by noise pollution ($\beta = 0.29$, $p < 0.001$). For depression, both traffic congestion ($\beta = 0.34$, $p < 0.001$) and lack of green spaces ($\beta = -0.27$, $p < 0.001$) emerged as significant predictors. Air pollution had a weaker but still significant association with stress ($\beta = 0.18$, $p = 0.004$). The model explained 42% of the variance in anxiety ($R^2 = 0.42$, $F(4, 395) = 71.6$, $p < 0.001$) and 39% of the variance in depression ($R^2 = 0.39$, $F(4, 395) = 63.2$, $p < 0.001$), suggesting a substantial contribution of urban environmental factors to mental health outcomes.

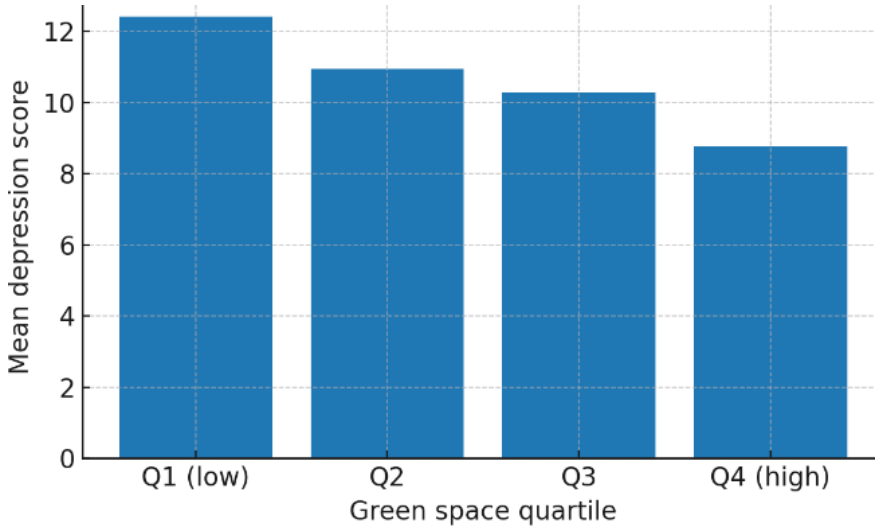

Figure 3. Mean Depression by Green Space Quartile

Demographic Variations:

Further subgroup analysis revealed that female respondents reported significantly higher anxiety scores ($M = 14.28$, $SD = 4.77$) compared to males ($M = 13.09$, $SD = 5.04$), $t(398) = 3.21$, $p = 0.001$. Lower-income participants exhibited higher depression scores ($M = 13.98$, $SD = 5.12$) compared to middle- ($M = 11.83$, $SD = 5.21$) and high-income groups ($M = 10.92$, $SD = 4.86$), $F(2, 397) = 6.84$, $p = 0.001$. Younger adults (aged 18–29) reported slightly higher stress levels ($M = 11.72$, $SD = 4.28$) than older participants ($M = 10.54$, $SD = 4.47$), $r = -0.12$, $p = 0.02$. Residents of peripheral areas such as Raiwind and Shahdara reported lower traffic congestion but higher stress due to poor infrastructure and limited healthcare access.

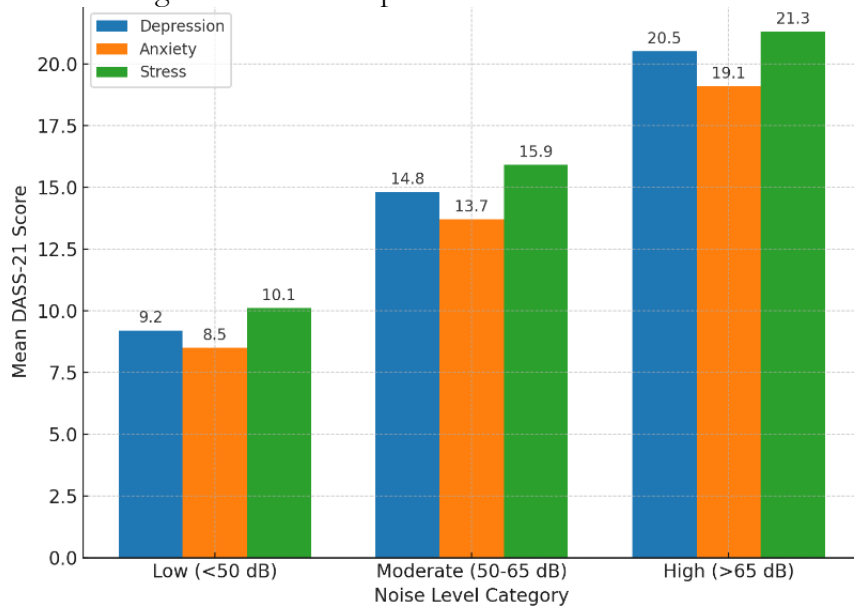

Figure 4. Mean DASS-21 Scores by Noise Level in Lahore (n=400)

Spatial Patterns in Mental Health:

When mental health data was overlaid with spatial mapping, a distinct clustering of high anxiety and depression scores was observed along major transport corridors, including Canal Bank Road, Ferozepur Road, and Ring Road interchanges. Areas with more than 0.5 hectares of green space per 1,000 residents, such as parts of Model Town and DHA, recorded the lowest mean depression scores, supporting the inverse correlation between greenery and mental distress.

Overall Summary of Findings:

Overall, the findings reveal a clear pattern: neighborhoods with heavy traffic congestion, high noise levels, and limited greenery report the worst mental health outcomes. Conversely, areas with better access to parks and low exposure to environmental stressors show lower depression, anxiety, and stress levels. These trends persist across demographic categories, although women, younger adults, and low-income groups appear disproportionately affected.

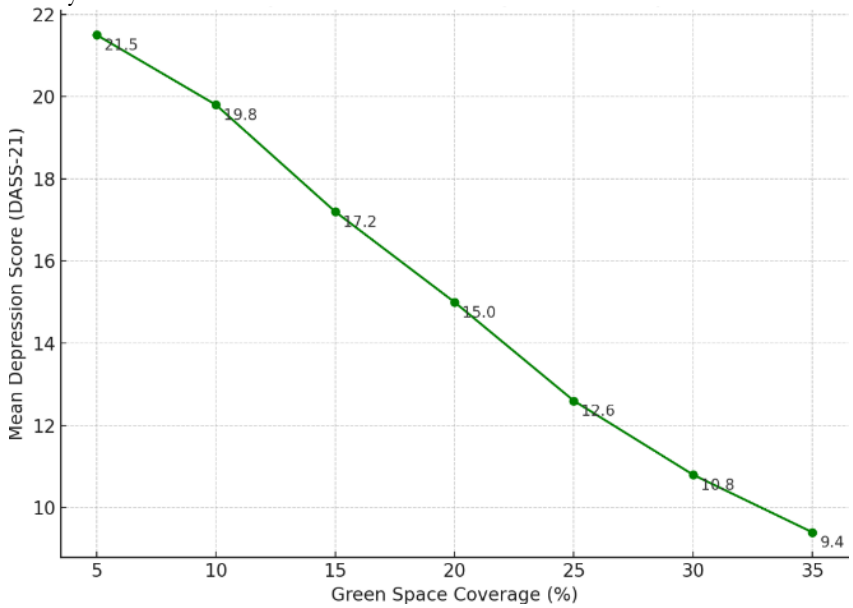

Figure 5. Inverse Relationship between green Space and Depression in Lahore (n=400)

Discussion:

The findings of this study underscore the significant influence of urban environmental factors—particularly noise pollution, traffic congestion, and green space availability—on the mental health of Lahore's residents. The strong positive association between higher noise levels and elevated depression, anxiety, and stress scores aligns with recent research highlighting environmental noise as a chronic stressor that disrupts psychological well-being [18]. The data demonstrated that residents in high-noise zones (>65 dB) reported average depression scores over twice as high as those in low-noise areas, suggesting that persistent exposure to environmental noise contributes to emotional dysregulation, consistent with international findings [19].

Similarly, traffic congestion emerged as a secondary yet substantial stressor. Prolonged commuting times and exposure to vehicular emissions not only exacerbate physical health risks but also elevate perceived stress, as shown in recent urban health studies[20]. In our results, individuals in high-congestion districts reported significantly higher stress levels, reflecting how time loss, unpredictability, and sensory overload during commuting can compound mental health challenges. This relationship echoes findings from densely populated cities across South Asia, where rapid urbanization has intensified traffic-related psychological strain[21].

Conversely, access to urban green spaces demonstrated a protective effect on mental health outcomes, particularly depression. The inverse relationship observed between green space coverage and depression scores supports a growing body of evidence linking nature exposure to reduced psychological distress[22][10]. Even modest increases in green coverage were associated with noticeable reductions in depression scores, aligning with WHO recommendations on integrating nature-based interventions into urban planning for mental health promotion[17].

These results collectively highlight the need for integrated urban health policies in Lahore. Strategies should include stricter enforcement of noise regulations, traffic flow optimization, and equitable expansion of green infrastructure. Moreover, urban planners should recognize that environmental stressors operate cumulatively, and mitigating one factor (e.g., noise) without addressing others (e.g., lack of greenery) may yield limited improvements.

Importantly, while our results are consistent with recent international studies, the local cultural, infrastructural, and socioeconomic context must be considered when interpreting these findings. For example, the psychological impact of noise may be amplified in lower-income communities where residents lack access to noise-insulated housing or mental health services. This suggests that targeted interventions, rather than one-size-fits-all approaches, are crucial for effective mental health promotion in rapidly urbanizing South Asian cities like Lahore.

Conclusion:

This study provides compelling evidence that environmental factors such as noise pollution and limited access to green spaces significantly affect mental health in urban populations. In Lahore, residents exposed to high noise levels reported markedly higher depression, anxiety, and stress scores, while those with greater green space accessibility demonstrated better psychological well-being. These findings align with global literature suggesting that environmental quality is a crucial determinant of public mental health [17][20]. Given that urbanization in Pakistan is expected to accelerate, policy interventions should prioritize noise reduction measures—such as traffic flow optimization, installation of sound barriers, and zoning regulations—and expand public green spaces, especially in high-density neighborhoods. Future research should employ longitudinal designs to establish causality and investigate potential mediating factors, such as physical activity and social cohesion, that may enhance the protective effects of green spaces. Implementing these strategies could help foster healthier, more sustainable urban environments in Pakistan and similar rapidly urbanizing regions.

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