

ORIGINAL ARTICLE

## Road Traffic Noise Exposure Near a Hospital and Implications for Environmental Health Protection in Pekanbaru, Indonesia

Muchammad Zaenal Muttaqin<sup>1</sup>, Handika Fajryan Bayoangin Harahap<sup>1</sup>, Abdul Kudus Zaini<sup>1</sup>

<sup>1</sup> Civil Engineering, Universitas Islam Riau, Indonesia

Corresponding author: Muchammad Zaenal Muttaqin; email: [muchzaenalmuttaqin@eng.uir.ac.id](mailto:muchzaenalmuttaqin@eng.uir.ac.id)

**Submitted:**

November 11,  
2025

**Accepted:**

December 15,  
2025

**Published:**

December 31,  
2025

### Abstract

**Background:** Road traffic noise is a recognized environmental health stressor and may compromise comfort, recovery, and staff performance in noise-sensitive hospital environments. **Objective:** To quantify road traffic noise exposure near a hospital in Pekanbaru, Indonesia, assess compliance with the national benchmark for hospital areas, and examine its association with traffic density. **Method:** An observational field study was conducted in the hospital corridor from 7:00 am to 8:00 pm. Environmental noise was measured using a sound level meter and summarized as equivalent metrics, also estimated using the Bina Marga approach and the Ministry of Environment method. Traffic volume and speed were observed and converted to density ( $k = q/v$ ). Noise levels were compared with the 55 dB(A) benchmark for hospital areas, and multiple linear regression was used to explore associations between traffic indicators and noise. **Results:** Traffic density ranged from 255.8 to 508.6 pcu/km, with a peak of 508.6 pcu/km. Noise estimates ranged from 40.84 to 45.52 dB(A) (Bina Marga) and 51.7 dB(A) (Ministry method). All values were below 55 dB(A), indicating compliance. The regression model showed a moderate relationship between traffic indicators and noise ( $R^2 = 0.37$ ). **Discussion:** Benchmark compliance does not eliminate potential cumulative impacts on vulnerable patients and staff, particularly during peak traffic. The modest explained variance indicates that non-traffic factors (e.g., vehicle mix, horn use, road surface, and meteorology) likely contribute to exposure. **Conclusion:** Traffic noise near the studied hospital met the Indonesian standard; however, quiet-zone management and monitoring are recommended to strengthen environmental health protection in hospital areas.

**Keywords:** environmental health, hospital environment, regulatory compliance, road traffic, traffic noise exposure

### INTRODUCTION

Environmental noise is increasingly recognized as a non-communicable disease risk factor and a pervasive environmental health stressor in

rapidly urbanizing settings. Road traffic is the dominant source in most cities, and chronic exposure has been associated with sleep disturbance, psychological stress responses,

impaired cognitive performance, and elevated cardiometabolic and cardiovascular risk through neuroendocrine and autonomic pathways [1, 2]. These impacts may be amplified in noise-sensitive receptors such as hospitals, where rest, recovery, and low-stimulation conditions are clinically important, and where staff performance and communication safety can be affected by intermittent high-noise events.

Hospitals require a controlled acoustic environment to protect vulnerable patients, support therapeutic rest, and maintain safe clinical operations. Noise control in hospital surroundings is therefore not only an environmental quality issue but also a public health protection measure. Many jurisdictions, including Indonesia, specify benchmark limits for environmental noise by land use, with stricter thresholds for sensitive facilities such as hospitals [3]. However, compliance with a regulatory threshold does not necessarily imply absence of health-relevant exposure because noise is variable across time (e.g., peak-hour surges), influenced by vehicle mix and behavioral sources (e.g., horn use), and may still impose cumulative burdens on sensitive populations [4].

Evidence on traffic-related noise exposure around healthcare facilities remains uneven across low- and middle-income contexts, including Indonesia. While studies from large metropolitan areas often report exceedances and substantial variability, fewer investigations have documented hospital-adjacent exposure in peri-urban or district corridors where intercity traffic, heavy vehicles, and mixed road functions may coexist [5]. This gap is salient for Riau Province, where hospitals can be located near major transport corridors linking urban centers and industrial areas. RSUD Minas, situated in the

Pekanbaru region and adjacent to a high-activity road corridor, provides a relevant case to characterize real-world exposure patterns and to inform local environmental health protection and land-use management [6].

This study aims to quantify road traffic noise exposure near a hospital in Pekanbaru, Indonesia, assess compliance with the Indonesian benchmark for hospital areas, and examine the association between traffic density (derived from observed flow and speed) and measured/estimated noise levels [3,7]. By integrating field-based noise monitoring with traffic observation and regression-based association analysis, the study contributes evidence for prioritizing interventions such as quiet-zone management, traffic calming and access control, and routine monitoring in hospital surroundings [8].



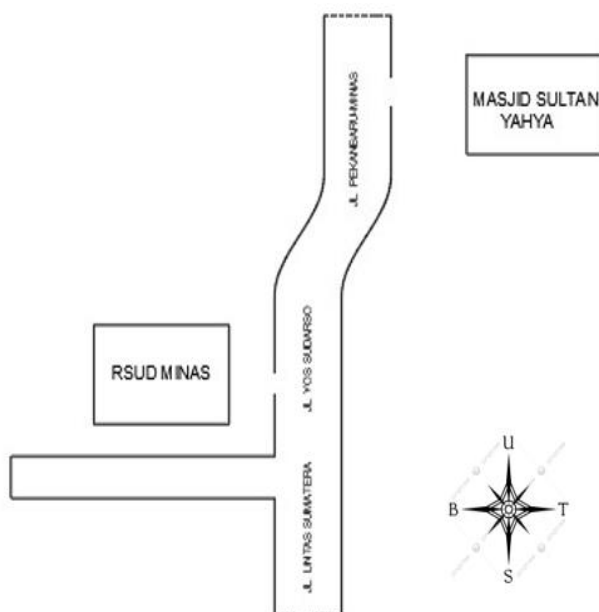
**Figure 1.** Study area and noise measurement points near the hospital corridor

## METHOD

### Study design and setting

This study employed an observational field design combining environmental noise monitoring and traffic observation around a hospital-adjacent road corridor in Pekanbaru, Indonesia [9]. This research is located on Jl. Cross Sumatra, Pekanbaru-Duri, District Minas, Siak

Regency. The total population in the Minas sub-district area is 31,188 people. The Sumatra Cross Road, Pekanbaru-Duri is a type of arterial road because it connects the provincial capital with the district capital. The volume of traffic along this road is classified as having high density because it is often passed by heavy vehicles that cause noise. Measurements were conducted during daytime operating hours (07:00 am – 08:00 pm) to capture typical outpatient and visitor activity periods and peak traffic conditions [10]. Noise and traffic were recorded at predefined roadside points representing the hospital frontage and adjacent approach segments. Each measurement point was selected to minimize obstructions and reflect dominant traffic exposure while maintaining safe placement for observers [11]. Basic site descriptors were documented for each point, including proximity to the carriageway, surrounding land use, presence of vegetation or barriers, and notable intermittent sources (e.g., horn use, idling vehicles) [11].



**Figure 2.** Study location

### Noise measurement protocol

Environmental noise was measured using a calibrated sound level meter (SLM) configured for A-weighting and time-weighting consistent with environmental noise assessment practice [12]. At each session, the SLM microphone was positioned on a tripod at approximately 1.2–1.5 m above ground level and oriented toward the roadway, avoiding reflective surfaces where feasible (e.g., walls or large façades) [12]. For each observation session, noise was recorded for 10 minutes with readings taken at 5-second intervals, and field notes documented meteorological conditions and unusual acoustic events (sirens, construction, traffic disruptions) to support interpretability and sensitivity checks [13].

Noise data were summarized into equivalent continuous sound level metrics (LAeq/Leq) over each 10-minute interval using energy averaging (equivalent level concept) [12]. In addition, the dataset supported estimation of noise indices using two Indonesian approaches commonly referenced in practice: (i) a Bina Marga-based procedure generating a predicted noise level index (reported as PNL) from traffic characteristics, and (ii) an assessment approach aligned with the Indonesian environmental authority's framework for environmental noise evaluation [14, 15]. Where multiple metrics were available for the same session, they were retained as separate outcome variables to allow comparative interpretation across methods [12].

### Traffic data collection and derived indicators

Traffic data were collected concurrently with noise monitoring for the same 10-minute sessions. Observers recorded traffic volume as the number of vehicles passing the point,

disaggregated by major vehicle classes where feasible (e.g., motorcycles, light vehicles, heavy vehicles) [16]. Traffic speed was obtained using a field procedure consistent with road traffic observation practice (e.g., fixed-distance travel-time method or equivalent spot-speed procedure recorded in the study log) [16].

Traffic flow variables were expressed as (1) **Traffic volume (q)**: number of vehicles per unit time (vehicles/hour), converted from 10-minute counts. Where required, volumes were converted into passenger car units (PCU) using equivalency factors consistent with Indonesian traffic engineering practice [16]; (2) **Mean speed (v)**: average observed speed during the session (km/h) [16], and (3) **Traffic density (k)**: derived indicator representing traffic concentration, calculated using the fundamental relationship:

$$k = \frac{v}{q}$$

where 'k' is density (PCU/km), 'q' is flow (PCU/hour), and 'v' is mean speed (km/hour) [17]. Density was used as the primary exposure determinant because it reflects congestion-related conditions that may elevate noise through engine load, acceleration-deceleration cycles, and increased horn use [18].

### Regulatory benchmark/standard

Noise levels were evaluated against the Indonesian environmental noise benchmark for hospital areas (55 dB(A)), which is used as a reference limit for sensitive land use [19]. Compliance status was defined a priori as "compliant" when session-based LAeq/Leq (or corresponding reported metric) did not exceed 55 dB(A) [19]. This benchmark served as the primary reference for interpreting environmental health acceptability in hospital surroundings and

informing environmental health protection measures [19].

### Statistical analysis

Analyses were conducted in three stages. First, descriptive statistics were produced for noise metrics (LAeq/Leq and/or estimated indices) and traffic indicators (q, v, k) by measurement point and time block [20]. Second, compliance with the 55 dB(A) benchmark was assessed by comparing session-based noise levels to the standard and summarizing the proportion of compliant sessions [19].

Third, association analysis was performed using multiple linear regression. The dependent variable was environmental noise level (analyzed separately for each available noise metric), and independent variables included traffic density (primary predictor) and supporting indicators such as traffic volume and mean speed [21]. Model specification followed:

$$\text{Noise} = a + b. \text{Density} + c. \text{Volume} + d. \text{Speed} + \epsilon$$

Model fit was reported using the coefficient of determination ( $R^2$ ). Statistical significance was evaluated at a two-sided alpha level of 0.05 when p-values were available, and standard regression diagnostics were used to assess linearity, multicollinearity, and influential observations [21].

### Quality control

Quality assurance procedures included (i) instrument preparation and verification (settings, battery status, and calibration checks where available), (ii) standardized placement of the SLM (height and orientation) and consistent session duration (10 minutes) with fixed sampling interval (5 seconds), and (iii) observer training to harmonize traffic classification, counting rules,

and speed measurement procedures [12, 16]. Field logs were used to document contextual factors (weather, unusual events) to support sensitivity checks and transparent interpretation [13]. Data entry was double-checked for completeness and consistency, and out-of-range values were verified against field notes [20].

### Ethical considerations

No ethical clearance for this study. This study involved environmental measurements and roadside observations and did not collect personal identifiers or patient-level data. Institutional permission for site access and measurement activities was obtained from relevant authorities. As no human subjects were enrolled and no identifiable information was collected, formal informed consent was not required; nevertheless, the study adhered to principles of minimal disruption to hospital operations and safety of research personnel [22].

## RESULTS

### Traffic characteristics (volume, speed, and density)

**Table 1.** Traffic indicators by time block/day (time window 07:00 am – 08:00 pm)

Observation grouping	Traffic density (PCU/km)	Notes
Peak period session	508.6	Highest observed density session
Off-peak period session	255.8	Lowest observed density session
Overall range across sessions	255.8–508.6	Range of observed densities

Traffic conditions varied across the daytime observation window (07:00 am –08:00 pm). The derived traffic density ( $k = q/v$ ) ranged from 255.8 to 508.6 PCU/km, with a peak density of

508.6 PCU/km and a minimum of 255.8 PCU/km. Density values were computed from concurrently observed traffic flow and mean speed using the fundamental flow–speed–density relationship [17].

### Noise levels and compliance with hospital noise standard

Across measurement sessions, estimated noise levels using the Bina Marga approach (reported as PNL) ranged from 40.84 to 45.52 dB(A). Using the environmental authority method aligned with the Indonesian framework (Ministry of Environment approach), the estimated noise level was 51.7 dB(A). All reported noise values were evaluated against the Indonesian benchmark for hospital areas (55 dB(A)) [3] and were classified as compliant ( $\leq 55$  dB(A)).

**Table 2.** Noise metrics by time block/day and compliance status (time window 07:00 am – 08:00 pm)

Observation grouping	Noise metric	Value (dB(A))	Status
Lowest-noise session	Bina Marga (PNL)	<b>40.84</b>	Compliant
Highest-noise session	Bina Marga (PNL)	<b>45.52</b>	Compliant
Overall range across sessions	Bina Marga (PNL)	<b>40.84–45.52</b>	Compliant
Method-based estimate	Ministry approach	<b>51.7</b>	Compliant

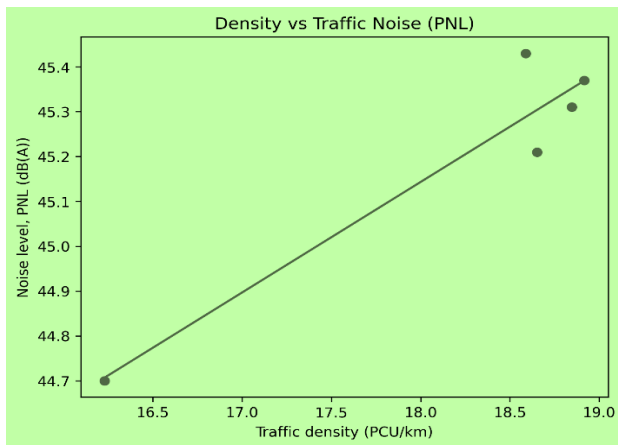
### Association between traffic indicators and noise

Multiple linear regression was used to examine the relationship between traffic indicators (with density as the primary predictor) and noise metrics [21]. The model showed a positive

association between traffic density and noise levels, with  $R^2 = 0.37$ , indicating that the included traffic indicators explained 37% of the variability in the modeled noise outcome. The formulas that have been produced are,

$$Y = 84,392 + 0,003X1 - 0,774X2 + \epsilon$$

X1 is volume and X2 is vehicle speed.



**Figure 3.** Scatter plot of traffic density versus noise level with fitted regression line

## DISCUSSION

### Summary of key findings

Traffic conditions during daytime operations (07:00 am – 08:00 pm) showed marked variability, reflected by a wide range of derived traffic density values. Across sessions, estimated noise levels computed using both a Bina Marga based approach and an environmental authority method remained below the Indonesian benchmark of 55 dB(A) for hospital areas. Association analysis further indicated that higher traffic density was accompanied by higher noise levels, with traffic indicators explaining a moderate share of noise variability ( $R^2 = 0.37$ ) under a multiple linear regression framework. Collectively, the results depict a hospital-adjacent environment that is compliant with the applicable standard yet exhibits traffic-driven

temporal dynamics that remain relevant to environmental health protection and management [3, 21, 22].

### Public health interpretation in a hospital zone

Environmental noise is widely recognized as a public health stressor, with evidence linking chronic exposure to sleep disturbance, stress related outcomes, and cardiometabolic and cardiovascular risk pathways through neuroendocrine and autonomic mechanisms [1, 2, 9]. Hospitals represent a particularly sensitive receptor: patients may be physiologically and psychologically more vulnerable to stressors, and the acoustic environment can influence comfort, rest, and recovery. For staff, intermittent noise can interfere with communication, increase cognitive load, and contribute to fatigue, which may affect safety-sensitive tasks [1, 4].

Within this context, the central interpretive point is that regulatory compliance is necessary but not sufficient for optimal protection. The Indonesian hospital area benchmark (55 dB(A)) provides a threshold for acceptability, but it does not fully address exposure characteristics that matter for health and service quality, including (i) recurrent exposure during peak activity windows, (ii) short-duration high-noise events (e.g., horn bursts, heavy-vehicle acceleration), and (iii) cumulative exposure across work shifts and patient stays [3], [1]. Equivalent continuous sound levels ( $LA_{eq}/Leq$ ) and method-based indices are appropriate for benchmarking and comparisons, yet they can under-represent transient peaks that drive annoyance and acute stress responses, especially in sensitive environments [7, 12].

The moderate  $R^2$  (0.37) also supports a public health relevant interpretation: traffic density and

related indicators explain an important portion of noise variability, but a substantial fraction remains attributable to contextual factors that influence both emission and propagation. These likely include vehicle mix (notably heavy vehicles and motorcycles), driving behavior (horn use, acceleration/deceleration cycles), road surface conditions, and meteorology factors frequently highlighted in the environmental noise literature as determinants of exposure heterogeneity [7, 18]. Consequently, maintaining a hospital environment that is “quiet-enough” requires management attention not only to average levels but also to peak events and modifiable local contributors.

### **Comparison with previous studies**

The observed pattern noise levels meeting the applicable hospital area benchmark while still showing measurable coupling with traffic conditions aligns with several strands of prior research. Systematic reviews indicate that noise in and around hospitals is common, can be variable across time, and is often influenced by both external sources (traffic) and internal operational sources [4]. Studies focusing on hospital surroundings have reported that exposure levels depend strongly on road hierarchy, traffic intensity, the proportion of heavy vehicles, distance of road building, and urban form, with some hospital corridors experiencing exceedances and others remaining below regulatory thresholds [4, 5].

Where higher exposures have been reported, they commonly occur in dense metropolitan settings with continuous congestion, close building setbacks, and high heavy-vehicle or mixed-traffic shares. Under such conditions, equivalent metrics may approach or exceed common guideline values, and temporal

variability can be pronounced [5]. In contrast, in peri-urban or district contexts, where traffic may be intense during certain windows but less continuous average levels may remain within standards, consistent with the present findings [5]. Differences may also reflect enforcement contexts (e.g., horn restriction adherence) and the presence/absence of effective buffers (vegetation, setbacks, barriers).

Methodological differences also contribute to variation across studies. Some investigations rely on 24-hour monitoring and day night metrics, while others focus on daytime operational windows that align with key hospital activity periods. The choice of metric (LAeq vs other indices), measurement duration, and the spatial distribution of monitoring points can shift the reported exposure profile. Standardized measurement and reporting approaches such as those outlined in ISO guidance and sound level meter specifications help improve comparability, but local contextual factors remain dominant drivers of cross study differences [7, 12]. Finally, the moderate explanatory power of traffic-only models is consistent with the broader traffic noise prediction literature, where non-traffic determinants are frequently needed to improve model performance [18].

### **Policy implications for environmental health protection**

The findings support a preventive, management-oriented approach to protecting hospital environments from traffic related noise. First, establishing a quiet hospital zone is a low-regret intervention: it targets avoidable noise sources (horn use, unnecessary idling) and sets expectations for drivers and facility users. Such zones are consistent with public health-oriented noise management approaches and can be

operationalized through signage, enforcement coordination, and community engagement [1, 8].

Second, traffic management around hospital frontage can reduce noise generating driving patterns. Practical measures include improving access circulation to minimize stop-and-go conditions, managing curbside drop off/pick up operations, and organizing parking entry/exit flows to prevent queue spillback onto the main corridor. Where appropriate, speed moderation strategies can reduce acceleration noise and improve safety; these should be designed to preserve emergency access and avoid unintended congestion that could increase noise [16, 18].

Third, buffering and site design are relevant where space allows. Vegetated buffers, landscaped setbacks, and modest barrier elements can provide incremental attenuation and can be integrated with broader hospital environmental quality objectives. The feasibility and effectiveness of these measures are site-dependent (available right of way, building orientation, and microtopography), and should be assessed as part of facility management and urban design planning [7, 8].

Fourth, the results point to the value of routine monitoring and governance integration. Because traffic patterns and land use conditions can evolve quickly, periodic reassessment of noise conditions around hospitals can serve as an early warning system. Embedding noise monitoring within local environmental health programs and facility management plans aligns with contemporary approaches to managing environmental exposures in sensitive land-use contexts [1, 11]. In this regard, "meeting the standard" should be treated as an ongoing

performance condition rather than a one-time compliance outcome.

## **CONCLUSION**

Road traffic noise exposure measured near the hospital corridor in Pekanbaru complied with the Indonesian environmental noise benchmark for hospital areas, indicating that minimum regulatory protection was achieved during the observation period. Nonetheless, the observed coupling between traffic conditions and noise underscores that exposure remains dynamic and may affect acoustic comfort in a noise-sensitive healthcare environment. From a public health perspective, compliance should be treated as a baseline, while preventive management should prioritize reducing avoidable peaks and sustaining a restorative setting for patients and safe working conditions for staff through routine control measures and periodic reassessment.

## **RECOMMENDATIONS**

Based on the findings of this study, the following recommendations are provided for future researchers: conduct extended measurements, including nighttime periods and weekend profiles, to capture full exposure relevant to inpatient recovery; perform spatial mapping of noise levels around the hospital (multiple points and distance gradients) to identify micro-hotspots and prioritize interventions; undertake a follow-up health and service impact study (patient sleep/annoyance and staff fatigue/stress indicators) under appropriate ethical protocols to strengthen public health decision-making.

## **ACKNOWLEDGEMENTS**

The authors thank the management of RSUD Minas for permitting site access and facilitating measurement logistics in the hospital

environment. We also acknowledge the field survey team for conducting noise and traffic observations, and local stakeholders who supported coordination and safety during data collection near the hospital frontage. This study received no external funding. The authors declare no competing interests.

## REFERENCES

- [1] World Health Organization Regional Office for Europe. Environmental noise guidelines for the European Region. Copenhagen: WHO Regional Office for Europe; 2018.
- [2] Basner M, McGuire S. WHO environmental noise guidelines for the European Region: a systematic review on environmental noise and effects on sleep. *Int J Environ Res Public Health*. 2018;15(3):519. doi:10.3390/ijerph15030519.
- [3] Menteri Negara Lingkungan Hidup Republik Indonesia. Keputusan Menteri Negara Lingkungan Hidup Nomor 48 Tahun 1996 tentang Baku Tingkat Kebisingan. Jakarta: Kementerian Negara Lingkungan Hidup; 1996.
- [4] de Lima Andrade E, Zannin PHT. Environmental noise in hospitals: a systematic review. *Environ Sci Pollut Res Int*. 2021;28(16):19629–19642. doi:10.1007/s11356-021-13211-2.
- [5] Montes-González D, Barrigón-Morillas JM, Gómez Escobar V, Vílchez-Gómez R, Rey-Gozalo G, Atanasio-Moraga P, et al. Environmental noise around hospital areas: a case study. *Environments*. 2019;6(4):41. doi:10.3390/environments6040041.
- [6] Muttaqin MZ, JJ W. Pengaruh aktivitas lalu lintas terhadap kebisingan pada wilayah rumah sakit di Kota Pekanbaru (studi kasus: RS Awal Bros Panam). *J Teknol dan Inov Ind (JTII)*. 2021;2(2):Article 31. doi:10.23960/jtii.v2i2.31.
- [7] International Electrotechnical Commission. IEC 61672-1:2013. Electroacoustics—Sound level meters—Part 1: Specifications. Geneva: IEC; 2013.
- [8] International Organization for Standardization. ISO 1996-2:2017. Acoustics—Description, measurement and assessment of environmental noise—Part 2: Determination of sound pressure levels. Geneva: ISO; 2017.
- [9] Direktorat Jenderal Bina Marga. Pd T-10-2004-B: Prediksi kebisingan akibat lalu lintas. Jakarta: Departemen Perumahan dan Prasarana Wilayah; 2004.
- [10] Wallis R, Harris E, Lee H, Davies W, Astin F. Environmental noise levels in hospital settings: a rapid review of measurement techniques and implementation in hospital settings. *Noise Health*. 2019;21(102):200–216. doi:10.4103/nah.NAH\_19\_18.
- [11] Smith MG, Croy I, Persson Wayne K, Basner M. Environmental noise and effects on sleep: an update to the WHO systematic review and meta-analysis. *Environ Health Perspect*. 2022;130(7):076001. doi:10.1289/EHP10197.
- [12] Hao G, Persson Wayne K, Ögren M, Pyko A, de Faire U, Barregard L, et al. Associations of road traffic noise with cardiovascular diseases and mortality: longitudinal results from UK Biobank and meta-analysis. *Environ Res*. 2022;209:113129. doi:10.1016/j.envres.2022.113129.
- [13] Münzel T, Sørensen M, Daiber A. Transportation noise pollution and cardiovascular health. *Circ Res*. 2024;134(4):e66–e92. doi:10.1161/CIRCRESAHA.123.323584.
- [14] van Kamp I, Simon S, Notley H, Baliatsas C, van Kempen E. Evidence relating to environmental noise exposure and annoyance, sleep disturbance, cardiovascular and metabolic health outcomes in the context of IGCB(N): a scoping review of new evidence. *Int J Environ Res Public Health*. 2020;17(9):3016. doi:10.3390/ijerph17093016.
- [15] Naim F, Nasir NHM. Road traffic noise annoyance and cardiovascular disease risk in population: a case series study in Kota Bharu, Malaysia. *Kesmas (Indonesian J Public Health)*. 2024;19(1).
- [16] Lin X, Chen C-Y. Research on the performance, measurement, and influencing factors of the acoustic environment in hospital buildings. *Appl Sci*. 2024;14(16):7219. doi:10.3390/app14167219.
- [17] Van Renterghem T. Towards explaining the positive effect of vegetation on the perception of environmental noise. *Urban For Urban Green*. 2019;40:133–144. doi:10.1016/j.ufug.2018.03.007.

- [18] Ow LF, Ghosh S. Urban cities and road traffic noise: reduction through vegetation. *Appl Acoust.* 2017;120:15–20. doi:10.1016/j.apacoust.2017.01.005.
- [19] Roustaei N. Application and interpretation of linear-regression analysis. *Mehdi Ophthalmol J.* 2024.
- [20] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *PLoS Med.* 2007;4(10):e296. doi:10.1371/journal.pmed.0040296.
- [21] Verhaeghe N, Vandenbulcke B, Lelie M, Annemans L, Simoens S, et al. Cost-effectiveness of strategies addressing environmental noise: a systematic literature review. *Int J Environ Res Public Health.* 2025;22(5):803. doi:10.3390/ijerph22050803.
- [22] Jeanette V, Lemson J, Lanting C, van den Boogaard M, van der Hoeven J. Reduction of sound levels in the intermediate care unit: effectiveness of architectural redesign and a multicomponent bundle. *J Crit Care.* 2024;82:154001. doi:10.1016/j.jcrc.2024.154001.
- [23] Tahvili A, Waite J, Astin F, et al. Noise and sound in the intensive care unit: a cohort study. *Sci Rep.* 2025;15(1):10858. doi:10.1038/s41598-025-94365-8.
- [24] Pershagen G, Pyko A, Aasvang GM, Ögren M, Tiittanen P, Lanki T, et al. Road traffic noise and incident ischemic heart disease, myocardial infarction, and stroke: a systematic review and meta-analysis. *Environ Epidemiol.* 2025;9(3):e400. doi:10.1097/EE9.0000000000000400.
- [25] Khan D, Burdzik R. Noise and vibration as environmental impacts of transportation: comprehensive review. *Transp Res Interdiscip Perspect.* 2025; (Article in Press/available online).
- [26] Jones L, Barnett A, Vagenas D. Linear regression reporting practices for health researchers: a cross-sectional meta-research study. *PLoS One.* 2025;20(3):e0305150. doi:10.1371/journal.pone.0305150.
- [27] Louis M, Grabill N, Strom P, Gibson B. Leading through noise: operating room noise challenges for staff and leadership techniques to ensure optimal operational performance. *Cureus.* 2024;16:e69569. doi:10.7759/cureus.69569.
- [28] Ginting GKR, Indiarjo S. Lingkungan, Perilaku Personal Hygiene, dan Pemakaian APD Terhadap Kejadian Leptospirosis. *Higeia J Public Heal Res Dev* 2022; 6: 236–250.