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Research article

The Relationship between Exposure to Train Noise and Blood Pressure in Housewives in Gaharu Subdistrict, East Medan

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Abstract

Noise from train activity is an environmental health issue that requires attention, especially for communities living near railway lines. Noise exposure can be associated with health problems, including increased blood pressure. This study aims to determine the relationship between noise levels and blood pressure in housewives in residential areas along the railway line in Gaharu Village, East Medan District, Medan City. This study used a quantitative analytical design with a cross-sectional approach. The study sample consisted of 89 housewives selected using a purposive sampling technique. Noise levels were measured using a sound level meter, while blood pressure was measured in the respondents. Data were analyzed univariately and bivariately using the Chi-Square test. The results showed that the average noise level in respondents' homes reached 62.97 dB, with the lowest value being 41 dB and the highest being 89 dB. A total of 63 houses (70.8%) had noise levels above 55 dB, while 26 houses (29.2%) had noise levels ≤55 dB. Based on blood pressure measurements, 48 respondents (53.9%) had blood pressure ≥140/90 mmHg. In the group of houses with noise levels above 55 dB, there were 43 respondents (68.3%) with blood pressure ≥140/90 mmHg. Meanwhile, in the group of houses with noise levels ≤55 dB, there were 5 respondents (19.2%) with blood pressure in the same category. The results of the Chi-Square test showed a significant relationship between noise levels and blood pressure (p=0.001; PR=3.55; 95% CI: 1.586–7.843). These results indicate that respondents who live in houses with noise levels above 55 dB have a higher prevalence of blood pressure ≥140/90 mmHg compared to respondents in the noise group ≤55 dB. These findings are important for environmental health, as most of the homes studied had noise levels exceeding the 55 dB threshold used in the study. This situation suggests the need for attention to the environmental quality of residential areas near railway lines. However, because this study used a cross-sectional approach, the results represent statistical associations and do not prove causality. The study also did not assess the effectiveness of noise control measures or specific health interventions. Therefore, the results can serve as a basis for further environmental assessments and monitoring of the cardiovascular health of communities living near railway lines

Keywords: *Noise, Blood Pressure, Environmental Health, Housewives, Trains.*

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Introduction

Hypertension remains a widespread health problem. The WHO (2025) reports that by 2024, approximately 1.4 billion adults aged 30–79 years will be living with hypertension worldwide. Two-thirds of these will live in low- and middle-income countries. Furthermore, approximately 600 million adults are unaware that they have hypertension[1]. This high figure highlights the importance of identifying and controlling blood pressure, including addressing environmental factors that can potentially impact cardiovascular health.

In Indonesia, hypertension remains a public health problem. The 2023 Indonesian Health Survey reported that the prevalence of hypertension among residents aged 18 years and older in North Sumatra reached 4.7%, or 31,588 people, based on doctor's diagnosis, while the prevalence of hypertension reached 25.4%, or approximately 29,989 people[2] based on blood pressure measurements. Medan also recorded a relatively high number of hypertension

sufferers, at 7,174 people[3]. This situation highlights the need to pay attention to various factors that can be related to blood pressure, including environmental factors in the community.

One environmental factor that can impact health is transportation noise. Noise does not always cause disturbance, but high-intensity and repeated exposure can reduce comfort and potentially impact public health[4].The WHO (2011) explains that noise can be associated with sleep disturbances, cardiovascular disorders, reduced performance, and hearing loss. In Europe, more than 113 million people are chronically exposed to transportation noise at levels above 55 dB(A), which is estimated to result in the loss of approximately 1.3 million healthy life years annually. In addition, approximately 40% of the European Union population is exposed to noise above 55 dB(A), 20% are exposed to noise above 65 dB(A) during the day, and more than 30% are exposed to noise above 55 dB(A) at night[5].

Transportation noise has different exposure characteristics depending on its source. On railway lines, noise can increase when a train passes and decrease after it leaves the area, so exposure can occur over a repeated period. This pattern differs from noise, which occurs relatively continuously. Repeated exposure has the potential to disrupt comfort and trigger physiological stress responses, which could theoretically be related to changes in blood pressure. However, the intensity and duration of exposure experienced by each person can vary, depending on the location of the home, the condition of the building, and daily activities. Therefore, railway noise needs to be assessed based on the environmental characteristics and conditions of the community living near the railway line.

A study in Indonesia by Azzahra et al.[6] on aircraft noise around Halim Perdanakusuma Airport reported a relationship between noise levels and blood pressure. The study showed that respondents living in homes with noise levels ≥55 dB had a higher prevalence of high blood pressure compared to those living in homes with noise levels below that limit. Meanwhile, an international study in the journal EXCLI explains that transportation noise from roads, trains, and air is one of the environmental factors associated with the risk of cardiovascular disease[7]. Although previous research has provided insight into the relationship between noise and blood pressure, the characteristics of exposure in residential areas near railway tracks still require special attention, especially in densely populated areas.

Environmental noise control is regulated through the Decree of the Minister of State for the Environment Number Kep-48/Menlh/11/1996, which sets the noise threshold for residential and settlement areas at 55 dB[8]. Control efforts can be carried out through the implementation of noise quality standards, regulating transportation operations, building sound barriers, and using vegetation as a dampener. Spatial planning that takes into account the distance between noise sources and residential areas is also one approach to reducing exposure[9]. In the air transportation sector, several efforts implemented include limiting night flight hours, regulating flight paths, and regular noise monitoring. In addition, education about the impacts of noise and the implementation of healthy lifestyles can be part of promotional and preventive efforts for the community[10]

Biologically, noise has the potential to trigger a stress response through the central nervous system. Sound received by the sense of hearing can be processed as a disturbing stimulus, then triggering activation of the sympathetic nervous system[11].

This response can involve the release of stress hormones, such as adrenaline and noradrenaline, which can potentially increase heart rate and cause blood vessel constriction. Previous research has also shown that noise exposure can be associated with changes in heart rate variability and increased salivary amylase activity, markers of physiological stress[12]. These mechanisms provide a biological explanation for the possible relationship between noise and blood pressure, but do not necessarily mean that these physiological responses always occur in every exposed individual.

Gaharu Village, East Medan District, is a residential area located near a railway line. The proximity of houses to the line exposes residents to noise when trains pass. Housewives were selected as the research group because domestic activities often take place within their homes, making noise exposure within their homes relevant for study. However, not all housewives have the same activity patterns or duration of time spent at home. Therefore, this study does not assume that all respondents experience daily noise exposure of the same intensity and duration.

Research on aircraft noise around Halim Perdanakusuma Airport has provided an overview of the relationship between noise and blood pressure in communities living near transportation sources. However, residential areas near railway tracks have different characteristics of noise sources and patterns. Information on the relationship between train noise levels and blood pressure in housewives in the densely populated Gaharu Village area still needs to be obtained through on-site research. Therefore, this study was conducted to determine the relationship between noise levels and blood pressure in housewives in residential areas near the railway tracks in Gaharu Village, East Medan District. The results of this study are expected to provide an overview of the noise and blood pressure conditions in the local community and serve as a consideration in health monitoring and environmental noise control efforts.

Materials and Methods

Materials

Primary data. Noise levels were measured using a sound level meter. Blood pressure was measured using a digital sphygmomanometer.

Methods

Methods 1 Blood Pressure Measurement And External Definition

Blood pressure was measured using a digital sphygmomanometer after the respondents had rested for five minutes. High blood pressure was defined in this study based on systolic blood pressure readings of ≥140 mmHg and/or diastolic blood pressure readings of ≥90 mmHg. These readings reflect the readings taken at the time of the study and cannot be used as a clinical diagnosis of hypertension based on a single measurement. Information regarding a history of hypertension diagnosis and use of antihypertensive medications should be provided, if available, in the study data.

Methods 2 Length Of Stay And Noise Exposure

Length of residence was recorded to describe respondent characteristics and residential stability at the study site. However, this variable was not used as a direct measure of cumulative noise exposure because the study did not measure the duration of daily exposure or noise intensity during the respondents' stay at the site.

Methods 3 Noise Measurement And Environmental Characteristics

Noise levels were measured using a sound level meter once at each home when a train passed. These measurements reflect the noise level at the time of the incident, not the average exposure throughout the day or long-term exposure. The study did not conduct repeated measurements during the day and night. Detailed information on the distance from the home to the tracks, noise barriers, building characteristics, train type, and respondents' daily activities was also not collected. Therefore, the measurement results are used as a snapshot of the noise at the time of the observation and are not considered to fully represent each respondent's personal exposure.

Data analysis 4 Conceptual Framework Of The Research

This study assessed the relationship between noise levels measured in the home environment during train passage and respondents' blood pressure levels. Noise was the observed environmental exposure, while blood pressure was the measured outcome. Stress responses, sleep disturbances, and other physiological mechanisms are possible pathways that could explain this relationship, but were not directly measured in this study. This study was an observational study with a cross-sectional design. The study was conducted by observing noise levels in the home environment and measuring respondents' blood pressure without providing any specific treatment or intervention. This design was used to determine the relationship between noise levels and blood pressure levels among housewives in residential areas along the railway line in Gaharu Village, East Medan District.

Variables	Category	Number of People	%
Age	≥ 45 years	65	73,0
	< 45 years	24	27,0
Length of stay	>5 years	66	74,2
	≤5 years	23	25,8
Salt consumption	>5 gram/day	43	48,3
	≤5 gram/day	46	51,7

Results and Discussion

Description of Research Location

Gaharu Village is a sub-district in East Medan District, Medan City, North Sumatra Province. This sub-district is characterized by residential areas, as well as trade and service activities. The Gaharu Village Office is located at Jalan Gaharu Baru No. 2, Lingkungan IX, Gaharu Village, East Medan District, Medan City.

Gaharu Village consists of 12 neighborhoods. Neighborhoods VII, VIII, IX, X, XI, and XII are located near a railway line connecting Medan City with several other areas, including Binjai and Belawan. The proximity of the railway line to residential areas makes environmental noise a significant environmental health concern.

Univariate Analysis

Table 1 Individual Characteristics

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Table 2 Characteristics of Home Noise Levels and Housewives' Blood Pressure

Variables	Category	Number (of Houses)	%
Noise Level	Not eligible	63	70,8
	Meet the requirements	26	29,2
Blood pressure	≥140/90 mmHg	48	53,9
	<140/90 mmHg	41	46,1

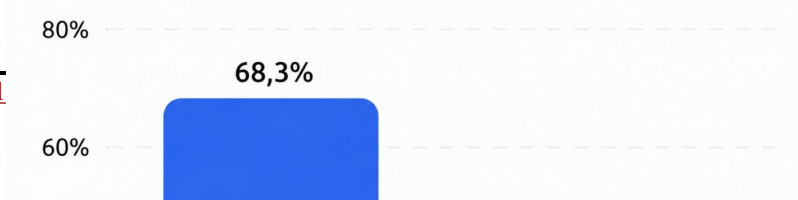


Figure 1. Percentage of respondents with blood pressure ≥140/90 mmHg based on noise level category.

Respondent Characteristics, this study involved 89 housewives living in settlements along the railway line in Gaharu Village, East Medan District, Medan City. Based on age characteristics, the majority of respondents were aged ≥45 years, namely 65 people (73.0%), while respondents aged <45 years numbered 24 people (27.0%). Based on length of residence, 66 respondents (74.2%) had lived in the area for more than five years, while 23 respondents (25.8%) had lived for five years or less. In terms of salt consumption, 43 respondents (48.3%) consumed more than 5 grams of salt per day and 46 respondents (51.7%) consumed 5 grams of salt per day or less.

Age characteristics need to be considered when interpreting research results because age is related to cardiovascular health conditions. As people age, changes in blood vessels and body function can affect a person's blood pressure. Therefore, the large number of respondents aged 45 years and above is an important characteristic to consider when interpreting the findings of this study. However, this study does not indicate whether the relationship between noise and blood pressure differs by age group, as specific analyses by age were not presented.

Most respondents in this study were ≥45 years old. Age is a factor that needs to be considered in the occurrence of hypertension, although the relationship between noise and blood pressure remains the main focus in this study. Research in the pre-elderly group also shows that the occurrence of hypertension is related to several risk factors, such as the habit of consuming salty foods and other individual factors [12].

Blood pressure is also influenced by factors other than noise exposure. Research by Rossy et al.[13] discussed the relationship between body mass index and the incidence of hypertension, while Sultan et al. [14] examined the relationship between gender and occupation and hypertension in the pre-elderly group. This suggests that the results of the relationship between noise and blood pressure need to be interpreted by considering the possibility that other factors may play a role.

Length of residence is also important to consider, given that most respondents have lived in the study area for more than five years. This indicates that they have lived in the area adjacent to the railway for a considerable period of time. However, length of residence cannot be directly interpreted as evidence of continuous noise exposure at the same intensity. Exposure varies from person to person depending on daily activities, time spent at home, train frequency, and the condition of the residential building. These factors were not measured in detail in this study. Therefore, age and length of residence are used to describe the respondents' characteristics, not as evidence that they enhance the effect of noise on blood pressure.

Noise control in residential areas can consider building design and the use of sound barriers. Prihartini et al. [9] discuss the role of gates and retaining walls in controlling external noise. Meanwhile, environmental noise level standards in Indonesia are regulated in the Decree of the Minister of State for the Environment Number Kep-48/Menlh/11/1996. Environmental Noise Exposure in Settlements Along Railway Lines. The measurement results showed that 63 of the 89 houses (70.8%) had noise levels exceeding 55 dB, thus categorizing them as ineligible based on the criteria used in this study. Meanwhile, 26 houses (29.2%) had noise levels of 55 dB or less. The measurement results for the 89 houses showed an average noise level of 62.97 dB, a median of 65 dB, a lowest value of 41 dB, and a highest value of 89 dB. The 95% confidence interval for the average noise level was in the range of 60,70–65,23 dB.

The study's finding that more than half of the homes measured had noise levels above 55 dB provides an important insight into the acoustic conditions of residential areas along the railway line in Gaharu Village. These

results indicate that train noise is an environmental factor that requires attention in public health protection efforts. Train noise has characteristics that can vary depending on time and events, such as when a train passes, so the sound levels experienced by residents vary throughout the day.

Environmentally, the noise level experienced by residents can be influenced by several factors, such as the distance of the house from the railway line, the presence of sound barriers, building materials and design, and the environmental conditions surrounding the house. Houses that are closer to the sound source or have limited barriers have the potential to receive more sound. Conversely, certain building characteristics and barriers can affect the sound entering the house. However, this study did not measure the distance of each house from the railway, building characteristics, or the presence of sound barriers in detail. Therefore, these factors can only be put forward as possibilities that need further investigation, not as proven causes by this study.

Noise measurements were taken once at each house while the train was passing using a sound level meter. Therefore, the average value of 62.97 dB and the range of 41–89 dB reflect the measurement results under these data collection conditions. These values cannot be directly used to describe the average noise level over a 24-hour period or the overall long-term exposure experienced by respondents. Repeated measurements at different times, including when the train is not passing, are needed to obtain a more comprehensive picture of noise patterns in the area.

Despite measurement limitations, the high proportion of homes with noise levels above the established criteria still warrants further environmental monitoring. Such monitoring is essential for understanding noise variations over time and location and provides a basis for environmental management studies for residential areas near railway lines.

Noise Level Analysis

Table 3 Statistical Distribution of Noise Levels in Housewives' Homes in Settlements on the Edge of the Railway Line, Gaharu Subdistrict, East Medan District

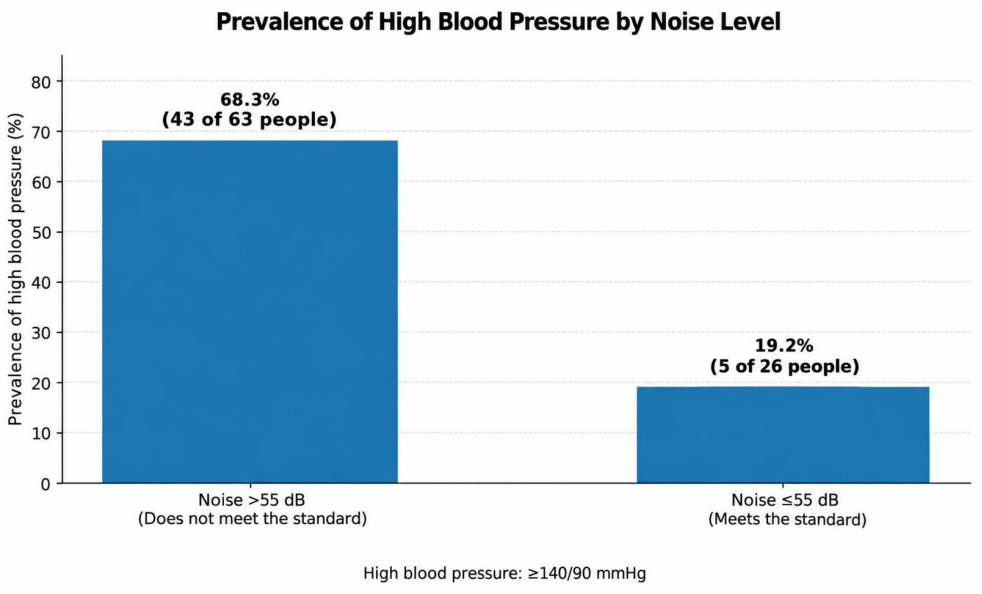
Variabel	Mean	Median	Min-Max	95%CI	N
Tingkat Kebisingan	62,97	65,00	41-89	60,70-65,23	89

Based on Table 4.2, the average noise level in the 89 respondent homes was 62.97 dB, with a median of 65 dB. The lowest noise level was 41 dB and the highest was 89 dB. The 95% confidence interval for the average noise level is in the range of 60.70–65.23 dB. Measurements were taken once while the train passed each house using a sound level meter. Therefore, the measurement results reflect the noise level during that measurement period and do not represent the overall noise variation throughout the day or the long-term exposure of each respondent.

Bivariate Analysis

Table 4.3 Relationship between Noise Levels and Blood Pressure in Housewives in Settlements on the Edge of the Railway Tracks, Gaharu Village, East Medan District

Variables	Kejadian Tekanan Darah				*P Value*	*PR*	CI 95%
Noise Level	≥ 140/90 mmHg		<140/90 mmHg				
	n	%	n	%			
Not eligible	43	68,3	20	31,7	0,001	3,55	1,586-7,843
Meet the requirements	5	19,2	21	80,8			



Relationship between Noise Levels and Blood Pressure in Housewives in Settlements on the Edge of the Railway Line, Gaharu Subdistrict, East Medan District

The results of the study showed that of the 63 respondents who lived in houses with noise levels of more than 55 dB, 43 people (68.3%) had blood pressure ≥140/90 mmHg, while 20 people (31.7%) had blood pressure below 140/90 mmHg. In the group living in houses with noise levels of 55 dB or less, 5 out of 26 respondents (19.2%) had blood pressure ≥140/90 mmHg, while 21 respondents (80.8%) had blood pressure below 140/90 mmHg.

Noise measurements in residential areas are important to determine the level of exposure that could potentially disrupt public comfort and health. Kadir et al.[15] research on traffic noise can also be used as a comparison to demonstrate the importance of paying attention to noise in road environments. However, measurement results from different noise sources cannot be directly compared to train noise.

The chi-square test results showed a p-value of 0.001, less than 0.05. The prevalence ratio (PR) value was 3.55 with a 95% confidence interval of 1.586–7.843. These findings indicate a statistically significant relationship between the noise level category and blood pressure ≥140/90 mmHg in the respondents of this study. The proportion of respondents with blood pressure ≥140/90 mmHg in the group with noise levels greater than 55 dB was approximately 3.55 times the proportion in the group with noise levels of 55 dB or less.

Research by Az-zahro et al. found a relationship between noise intensity and the incidence of high blood pressure in workers at Semarang Tawang Station[16]. Sofia et al. also found a relationship between noise intensity and increased blood pressure in workers. These results support the findings of this study, although the respondent groups and exposure environments were different[17]. The results of this study are in line with the research of Suryadi et al. [18] which discussed the effect of noise intensity on blood pressure in volunteer traffic control workers in Makassar City. Budiawan et al. (2022) found a relationship between exposure to train noise and changes in blood pressure in train drivers and station attendants. These findings can be used as a comparison in research on noise and blood pressure in communities living near railway lines, although the characteristics of the respondents differ[19].This study can be used as a comparison because both studied noise and blood pressure, although the characteristics of the exposure and respondents were different. These differences in conditions need to be taken into account when interpreting the results of the study on housewives living around the railway line.

A 95% confidence interval above 1 supports a relationship between the two variables in this study's data. However, the magnitude of the PR does not necessarily indicate that noise has been proven to cause a 3.55-fold increase in blood pressure. These results indicate a comparison of prevalence between the two groups based on the noise category used. Because this study examined the relationship among respondents at the study site, the results should be interpreted with caution and should not be directly considered as evidence of a causal relationship.

Blood pressure ≥140/90 mmHg in this study is categorized based on the measurement results used. A single measurement in this category does not in itself confirm a clinical diagnosis of hypertension. Confirming the diagnosis requires further assessment by a healthcare professional in accordance with established procedures. Therefore, the study results are more appropriately discussed as a relationship between noise levels and the proportion of respondents with blood pressure ≥140/90 mmHg.

The results showed that the proportion of respondents with blood pressure ≥140/90 mmHg was higher in the group of houses with noise levels >55 dB compared to the group with noise levels ≤55 dB. This finding is important

from an environmental health perspective because 70.8% of the houses studied had noise levels above the threshold used in the study. A study of traffic noise on Jalan Jenggik-Terara also found noise levels exceeding quality standards at some measurement locations [20]. Although the noise sources were different, these findings demonstrate the importance of assessing noise levels in residential areas. However, this study cannot prove that noise directly causes increased blood pressure.

The observed difference in proportions between the two groups suggests the importance of considering noise as an environmental condition potentially associated with cardiovascular health. However, blood pressure may also be related to other factors, such as age, salt intake, pre-existing health conditions, physical activity, medication use, and stress. This study presents some characteristics of the respondents, but the available results are insufficient to determine the individual contributions of these factors to the associations found. Therefore, the statistical relationship between noise and blood pressure remains important to understand, taking into account both the characteristics of the respondents and the limitations of the exposure measurements.

Biological Mechanisms That May Link Noise to Blood Pressure. Physiologically, noise can be an environmental stimulus that triggers a stress response in the body. This response can involve activation of the sympathetic nervous system and the release of hormones associated with the stress response, potentially affecting heart rate, vascular tone, and blood pressure [21]. This mechanism provides a plausible biological explanation for the possible link between noise and cardiovascular health.

However, the body's response to a single noise event must be distinguished from the potential consequences of repeated, long-term exposure. A relatively loud sound, such as a passing train, can elicit a transient response in some people. This acute response is not the same as a persistent change in blood pressure. Long-term effects, if they occur, are related to the likelihood of repeated exposure and the body's responses that occur in the context of everyday life. Therefore, a single measurement of noise from passing trains cannot accurately determine how frequently respondents experience such exposure or whether they experience repeated cardiovascular responses.

In addition to direct responses to noise, sleep disturbances and chronic stress may also be possible pathways linking transportation noise to cardiovascular health. Noise during rest periods can potentially disrupt sleep, while repeated exposure can be a source of environmental discomfort or stress[22]. Long-term sleep disturbances and stress may be associated with physiological processes that impact cardiovascular health[5]. However, these possible mechanisms must be distinguished from the actual results obtained in this study.

This study did not measure sleep quality, stress levels, stress hormone levels, or physiological changes in respondents before and after the train passed. Therefore, these mechanisms are used to explain potential associations based on relevant scientific knowledge, not to suggest that sleep disturbances or stress have been proven to mediate the associations in this study. Further research that measures noise repeatedly and assesses sleep quality, stress, and blood pressure at multiple time points is needed to better understand these associations.

Comparison with Previous Research. The findings of this study are in line with Azzahra's study, which reported a relationship between noise levels and blood pressure in communities around Halim Perdanakusuma Airport, with a p-value of 0.0026 [6]. The similarity between the two studies lies in their attention to environmental noise as a potential exposure related to blood pressure in the community. However, the noise source in Azzahra's study came from aviation activities, while this study focuses on train noise in residential areas.

These differences in sound sources are important because the noise patterns experienced by the public are not always the same. Aircraft noise can be related to the arrival or departure of an aircraft, while train noise is related to the frequency and timing of train passage. The intensity, duration, timing of the sound, and environmental conditions between the sound source and the home can result in different exposure patterns. Therefore, the similarity in the results of the two studies may strengthen the case for studying transportation noise as an environmental health issue, but it does not necessarily imply identical exposure characteristics.

Andjani and Mediana's study on noise in cable industry workers also reported a statistically significant association with blood pressure, with a p-value of 0.007[23]. However, the exposure context in that study differed from this study. Industrial workers generally encounter noise in their work environment, while the housewives in this study lived in a residential area adjacent to a railway line. These differences are related to daily activities, exposure time patterns, and the environmental context in which a person receives noise.

Comparison of the three studies should not be based solely on p-values. A p-value provides statistical evidence for the hypothesis being tested, but it does not necessarily indicate that the association in one study is stronger than in another. A more comprehensive assessment requires information on the size of the association, confidence intervals, noise measurement methods, respondent characteristics, and study designs. Because comparable effect sizes are not fully available in the information from the previous studies discussed here, this study cannot conclude that the associations found are stronger or weaker than those in Azzahra's or Andjani and Mediana's studies.

The contribution of this study lies in observing train noise in the residential environment of housewives, not in the workplace. The results indicate that higher noise levels are associated with a greater proportion of blood pressure

≥140/90 mmHg among respondents in Gaharu Village. These findings further illustrate the importance of considering transportation noise sources in residential environmental health studies. However, differences in design, measurement methods, and populations need to be considered before further comparisons can be made.

Cardiovascular Vulnerability and Interpretation of Respondent Characteristics

Most of the respondents in this study were 45 years of age or older. Age is a relevant characteristic in the discussion of blood pressure because changes in blood vessel function and health factors that accompany aging can affect cardiovascular health. Furthermore, individuals with pre-existing cardiovascular disease or other sources of stress may have different health conditions and responses to environmental stimuli. This suggests that responses to noise may vary from person to person.

However, these characteristics need to be considered in interpreting the results. This study does not present analyses showing whether the relationship between noise and blood pressure differs across age groups, among respondents with pre-existing cardiovascular disease, or among respondents with varying levels of stress. Therefore, the age group ≥45 years cannot be directly considered more susceptible to noise based on the results of this study alone. Similarly, pre-existing health conditions and other stressors can only be cited as potentially relevant factors in the context of cardiovascular health, not as factors that have been demonstrated to influence the results of this study.

The length of residence of more than five years for most respondents also cannot be used as a direct measure of cumulative exposure. Although respondents had lived in the same area for several years, this study did not measure changes in noise levels from year to year, the frequency of train traffic each respondent experienced, or the length of time they were at home. Therefore, length of residence only reflects the duration of residence in the study area and does not indicate the extent of accumulated noise exposure.

In addition to age and length of stay, salt consumption is another characteristic that needs attention because it is related to blood pressure health. In this study, 43 respondents (48.3%) reported consuming more than 5 grams of salt per day, while 46 respondents (51.7%) reported consuming 5 grams per day or less. However, these descriptive data do not prove that salt consumption is related to blood pressure in this study's respondents, as the results of the specific relationship analysis for this variable are not presented in the available results section. Therefore, salt consumption can be cited as a relevant characteristic, but should not be considered a proven factor explaining the relationship between noise and blood pressure based on this analysis.

This explanation of vulnerability emphasizes that the relationship between noise and blood pressure needs to be understood within the context of individual health and environmental conditions. Future research could analyze the effects of noise by age group and gather information on medical history, medication use, activity patterns, and other stress factors. More detailed analysis could help assess whether the relationship between noise and blood pressure differs across population groups with specific characteristics.

Implications for Public Health and Noise Control. The finding that 70.8% of homes measured had noise levels exceeding 55 dB, along with a statistical correlation between noise levels and blood pressure levels ≥140/90 mmHg, suggests the need for attention to residential areas adjacent to railway lines. From an environmental health perspective, regular noise monitoring can be a first step in obtaining a more representative picture of exposure. Monitoring should be conducted at various times and under various conditions, including when trains are passing and when no trains are passing, to assess noise variations.

The results of this study can also be used by stakeholders to assess the condition of settlements near railway lines. Information regarding the distance of houses from the tracks, the condition of buildings, the presence of sound barriers, and noise patterns at specific times can help identify locations requiring further environmental assessment. In residential area planning, noise aspects can be considered alongside other environmental factors. However, this study did not test the effectiveness of measures such as installing sound barriers, changing building designs, or managing transportation. Therefore, these measures represent options for further study, not interventions whose effectiveness has been proven by this study.

Noise control efforts also need to be distinguished from individual health efforts. Environmental-level control can involve noise monitoring, area planning, noise source management, and building condition assessments. Individual-level efforts, meanwhile, can include blood pressure checks, consulting a health professional if readings are high, maintaining a balanced diet, limiting salt intake, and engaging in physical activity appropriate to one's health. These two approaches have different goals. Healthy living behaviors do not replace the need to pay attention to environmental noise sources, while noise control does not replace individual health screenings and treatment.

Blood pressure screening for residents living near railway lines can be considered as part of a health promotion and prevention program. The results of this study indicate that some respondents had blood pressure levels ≥140/90 mmHg, but these measurements are not a substitute for a diagnosis by a healthcare professional. Therefore, respondents with elevated blood pressure readings should receive further examinations in accordance with established healthcare procedures. This study did not evaluate the implementation or effectiveness of the blood pressure screening

program; therefore, these recommendations represent practical implications that need to be followed up and assessed based on community needs.

High blood pressure requires attention because it can increase the risk of complications in organs, including the kidneys and heart. Therefore, the finding of blood pressure ≥140/90 mmHg in respondents in this study is one reason why it is important to monitor the cardiovascular health of people living near railway lines[24].

To obtain stronger evidence, future research should conduct repeated noise measurements at different times, record the distance of homes from railway lines, and assess building characteristics and sound barriers. Further research could also consider measures of sleep quality, stress, medical history, and lifestyle factors. With this data, researchers could more comprehensively assess the relationship between noise and blood pressure and identify other factors that may be associated with the measurement results.

Religious Perspectives and Environmental Ethics. In the social and cultural context of the local community, Surah Luqman verse 19 contains an advice to behave modestly when walking and to lower one's voice. This verse can be briefly presented as an ethical reflection on the importance of maintaining behavior and comfort in community life. In the context of environmental health, this reflection can be linked to concern for a comfortable environment and the well-being of others [25].

However, verse 19 of Surah Luqman is not used as scientific evidence that noise causes increased blood pressure. Explanations regarding the relationship between noise and cardiovascular health remain based on research findings, measurements, and relevant scientific literature. Thus, religious perspectives serve as ethical and social context, while epidemiological and physiological interpretations remain grounded in scientific evidence.

Research Limitations

This study has several limitations that should be considered when interpreting the results. First, noise level measurements were taken once at each house when a train passed. These measurements do not reflect noise variations throughout the day, at different times, or the respondents' long-term noise exposure. Therefore, the measurement results are best understood as a reflection of noise levels at the time of data collection, rather than as a definitive measure of cumulative exposure.

Second, this study did not provide detailed spatial and acoustic characterization, including the distance of each house from the railway, building conditions, and the presence of sound barriers. These characteristics have the potential to influence the noise levels experienced by residents. Because these factors were not measured, this study cannot determine whether differences in housing conditions or distance from the railway explain differences in noise levels among respondents.

Third, some information about respondents was obtained through direct interviews, so the accuracy of the data depends on the respondents' ability to recall and convey the information. This is especially important for self-reported information, such as salt consumption. Furthermore, this study did not directly measure sleep quality, chronic stress, or stress hormones. Therefore, these factors cannot be definitively identified as mechanisms explaining the relationship between noise and blood pressure in this study.

Fourth, characteristics such as age, length of residence, salt intake, and other health conditions should be considered when interpreting the relationship between noise and blood pressure. However, the results presented do not demonstrate an analysis that can confirm the contribution of each of these factors or the differences in the relationship by specific characteristic groups. Length of residence also cannot be used as a substitute for measuring cumulative noise exposure.

Considering these limitations, the results of this study indicate a statistical association between noise levels and blood pressure levels ≥140/90 mmHg among housewives at the study site, but cannot yet confirm a causal relationship. Future research should utilize repeated noise measurements, account for spatial and building characteristics, and gather additional information on health conditions and other factors that may be associated with blood pressure.

Conclusion

This study shows a significant relationship between noise levels in residential areas along the railway line and blood pressure in housewives in Gaharu Village, East Medan District, Medan City ($p = 0.001$; PR = 3.55; 95% CI = 1.586–7.843). A total of 70.8% of the houses measured had noise levels exceeding 55 dB, so this condition requires attention as an environmental health problem in residential areas around the railway line. These findings indicate the importance of environmental noise monitoring and blood pressure checks for the local community. Further research with repeated noise measurements, assessment of house conditions and distance from the railway line, and assessment of other factors related to blood pressure are needed to obtain a more comprehensive picture. Further assessment at the community level is also needed as a basis for determining noise management measures and public health protection efforts.

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Declarations

Author contribution	:	F.F.A.S, Y.K.A., H.E.S, Z,A and W. contributed to the conception and design of the study, as well as to the collection, analysis and interpretation of data. F.F.A.S drafted the manuscript Y.K.A, H.E.S, Z.A, W revised it critically for important intellectual content. Y.K.A reviewed and approved the final version of the manuscript for publication. All authors agree to be accountable for all aspects of the work and to ensure that any questions relating to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
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Conflict of interest	:	The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
Ethics Declaration	:	This study was conducted after obtaining research permits from local authorities. All participants were explained the purpose and procedures of the study and provided informed consent prior to data collection. Participants' confidentiality and anonymity were maintained throughout the research process. No personally identifiable information will be disclosed in publications.
Additional information	:	The authors affirm that all statements and interpretations presented in this review are based on fieldwork data and published literature and represent an independent scientific synthesis of the authors..

Informed Consent Statement

All respondents were provided with an explanation of the purpose, procedures, benefits, and their rights in the study. Respondents' consent to participate in the study was obtained before data collection.

Data Availability Statement

The data generated and/or analyzed during this study are not publicly available due to privacy and confidentiality considerations but may be available from the corresponding author upon reasonable request.

AI Disclosure

The authors acknowledge the use of DeepSeek Proofreader solely for English language editing and improvement of manuscript readability. All AI-generated suggestions were critically reviewed, revised, and verified by the authors to ensure the accuracy, integrity, and scientific validity of the manuscript. The authors take full responsibility for all content presented in this work.

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