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RESEARCH ARTICLE
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TRANSPORTATION NOISE POLLUTION AND CARDIOVASCULAR HEALTH

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ABSTRACT

Background: Transportation noise pollution has been linked to adverse cardiovascular health outcomes, including hypertension, stroke, and cardiovascular mortality. **Objective:** This meta-analysis aims to evaluate the effects of various types of transportation-related noise exposure on cardiovascular health and to quantify the pooled effect sizes for hypertension, stroke, and mortality. **Methods:** A systematic search of studies published between January 2024 and January 2025 was conducted to identify studies that reported on the relationship between transportation noise pollution and cardiovascular health outcomes. A total of 15 studies were included in the meta-analysis. **Results:** There is a significant association between transportation noise exposure and increased risk of cardiovascular outcomes. Specifically, road traffic noise exposure was found to increase the risk of hypertension (OR: 1.28, 95% CI: 1.14-1.45) and stroke (HR: 1.23, 95% CI: 1.09-1.39). Air traffic noise exposure also showed a significant effect on hypertension (OR: 1.22, 95% CI: 1.10-1.35), while rail traffic noise had a weaker association. The pooled effect for mortality due to transportation noise exposure indicated an elevated risk of death from cardiovascular causes (HR: 1.18, 95% CI: 1.06-1.32). **Conclusions:** It is concluded that transportation noise pollution is a significant risk factor for cardiovascular diseases, including hypertension, stroke, and mortality.

Keywords: Transportation, Noise Pollution, Cardiovascular Health

INTRODUCTION

The noise pollution that comes from transportation has developed into a dominant urban environmental hazard which affects millions of people across the world. The continuous noise exposure from streets together with railways and aircraft has become a key issue because of its negative effects on public health because urban areas continue growing and transportation networks expand. Many health outcomes associated with transportation noise expose cardiovascular diseases (CVD) as the most dangerous consequence [1]. Academic research concludes that persistent exposure to heavy transportation noise increases the risk of developing cardiovascular diseases together with their advanced progression which includes hypertension and stroke and ischemic heart disease [2]. Two major pathways which explain these effects feature both physical body responses through elevated blood pressure and disturbed sleep patterns and psychological stress mechanisms because of heightened sympathetic nervous system activation [3]. Research tracing the connection between

transportation noise pollution and cardiovascular health has gained significance with increasing world urban growth because it supports public health policy decisions and urban planning. The increased research shows that sound management strategies and urban planning must combine environmental priorities with health security [4].

A typical transportation noise indicates loud intermittent sound emissions from vehicles along with trains planes and machine-powered transport systems. Continuous persistent sounds originating from transportation hubs interfere with the living environment of people who live near transport hubs or major routes [5]. The dense population near transportation systems in urban areas experiences the strongest influence of noise pollution [6]. Modern research has confirmed that extended contact to transportation noise emission leads to higher cardiovascular disease risks. People exposed to high traffic noise face increased hypertension risks because hypertension serves as a principal danger factor for cardiovascular diseases including heart attack and stroke [7]. Transportation noise brings about cardiovascular health problems by triggering stress responses within the body. The experience of noise pollution during nighttime sleep leads to increased cortisol and other stress hormone levels according to studies [8]. Continuous hormone elevation leads to blood pressure elevation together with increased heart rate until the cardiovascular system becomes excessively strained. Experts have found that repeated noise exposure can negatively affect endothelial function because it obstructs blood vessel dilation and constriction thus increasing the risk of atherosclerosis alongside other cardiovascular diseases [9].

Disturbed sleep patterns because of noise exposure represent a way through which noise affects cardiovascular health. The maintenance of cardiovascular health requires sufficient sleep yet disturbances from nighttime noise contamination results in poor rest and poor sleep quality [10]. Insufficient sleep regularly contributes to multiple cardiovascular danger factors because it causes obesity problems combined with hypertension and heightened blood cholesterol measurements. When sleep disturbances persist for long periods they elevate the risk of developing cardiovascular diseases at a considerable rate. Noise pollution creates both physical medical causes and psychological consequences which affect human wellbeing. People who stay exposed to noise long-term develop higher anxiety levels and depression and increased irritability which in turn cause harmful effects to their cardiovascular system [11]. Heart disease develops more frequently in people presenting with mental health conditions like depression and anxiety because these mental states trigger unhealthy behaviors that include unhealthy eating habits and inactivity and cigarette smoking [12].

Research by epidemiologists demonstrates that people exposed to higher noise levels run higher chances of heart diseases than people residing in calm areas. A landmark research analysis in The Lancet revealed exposure to noise becomes a vital health danger toward heart disease while overlooking additional risk components such as smoking habits and social class status. The World Health Organization (WHO) determined through their research that transportation noise causes thousands of premature deaths together with years of life lost from cardiovascular diseases throughout Europe [13]. The evidence supporting cardiovascular health risks from transportation noise persists to rise yet urban areas continue to favor transportation development instead of environmental noise reduction [14]. The growing pace of urbanization requires an immediate solution for transportation noise reduction through proper policies and intervention measures. Improved urban planning as well as sound barriers in high air and rail traffic areas should be combined with stricter vehicle noise regulations to protect residents [15]. Electric vehicles together with low-noise rail systems should be promoted because these technologies hold key importance for reducing transportation noise-related adverse health effects [16].

Objective

The primary objective is to quantify the impact of transportation noise on cardiovascular diseases (CVDs) and evaluate the mechanisms underlying this association.

METHODOLOGY

This systematic review and meta-analysis were conducted at----------from----------. Studies published between January 2024 and January 2025 were included in the study.

Search Strategy

A comprehensive literature search will be conducted across several electronic databases, including PubMed, Scopus, Google Scholar, and Web of Science, to identify relevant studies published between January 2024 and January 2025. The search will utilize a combination of keywords such as:

- "transportation noise,"
- "cardiovascular diseases,"
- "hypertension,"
- "heart disease,"
- "stroke,"
- "noise pollution,"
- "public health,"
- "urban noise,"
- "chronic exposure."

Inclusion Criteria:

- Studies conducted between January 2024 and January 2025.
- Studies focusing on the effects of transportation noise (road traffic, air traffic, rail traffic) on cardiovascular health.
- Studies assessing cardiovascular outcomes such as hypertension, ischemic heart disease, stroke, and general cardiovascular morbidity or mortality.
- Studies published in English.
- Both human and animal studies (if relevant to understanding the mechanisms).

Exclusion Criteria:

- Studies not related to transportation noise pollution.
- Studies examining only non-cardiovascular outcomes (e.g., noise effects on hearing loss, mental health without cardiovascular implications).
- Articles that do not provide clear data on exposure levels and cardiovascular health outcomes.

Data Extraction

The predefined data extraction form served as a tool for two independent reviewers who collected data from included studies to guarantee consistency and accuracy in their work. Study characteristics needed for data extraction formed the core of the data extraction process. The data extraction form contained information about study design (cohort, case-control, cross-sectional, or intervention) as well as sample size and specific population characteristics involving age, gender, comorbidities and geographical location. Data collectors recorded information about the various noise sources (road, rail, air traffic) while documenting the duration and strength of exposure whenever noise was continuous or episodic and low or high in intensity. Health outcomes related to cardiovascular disease were meticulously recorded by studies that measured conditions including hypertension along with heart disease and stroke and additional related medical issues. The methods for cardiovascular health assessment were documented which included a review of medical records together with clinical results and self-reported health outcomes. Final information included assessment of key findings along with statistical analyses that showed effect sizes and p-values along with confidence intervals.

Data Synthesis and Statistical Analysis

A meta-analysis was performed to estimate the overall effect of transportation noise on cardiovascular health outcomes. The meta-analysis followed several key steps. First, for each study, the effect size was calculated (e.g., odds ratio, risk ratio, or mean difference), depending on the specific outcome measured. In cases where different measures of cardiovascular outcomes were used across studies, the effect size was standardized to ensure comparability. Next, the I^2 statistic was used to assess the heterogeneity among the studies. A high I^2 value indicated substantial variability between studies, which warranted further investigation through subgroup analyses. These subgroup analyses were conducted based on various factors such as the type of transportation noise (road, rail, or air), the level of exposure (chronic versus acute), geographic region, and the specific cardiovascular outcomes (e.g., hypertension, heart disease, stroke). To assess the robustness of the results, sensitivity analysis was performed by excluding studies with small sample sizes or those deemed to be at high risk of bias. Additionally, publication bias was evaluated using funnel plots and Egger's test. If significant publication bias was detected, appropriate corrections, such as the trim-and-fill method, were applied to adjust the results.

Quality Assessment

The quality of each included study was assessed using established tools. For cohort and case-control studies, the Newcastle-Ottawa Scale (NOS) was used to evaluate study quality, while the Cochrane Risk of Bias tool was applied to randomized controlled trials (RCTs). Each study was rated based on criteria such as sample size, exposure assessment methods, and control for confounding factors. Studies that scored below a predetermined threshold on these quality assessment tools were considered to have a high risk of bias, which could have influenced the reliability of their results.

RESULTS

The results of the meta-analysis revealed a significant and consistent association between transportation noise exposure and adverse cardiovascular health outcomes. A total of 15 studies published between January 2024 and January 2025 were included in the analysis. The studies measured a variety of cardiovascular outcomes, including hypertension, ischemic heart disease, stroke, and cardiovascular mortality. The pooled effect size demonstrated that individuals exposed to high levels of transportation noise, particularly from road traffic, had a significantly higher risk of developing hypertension (pooled odds ratio = 1.25, 95% CI: 1.12–1.39). This association was observed in both long-term chronic exposure studies and studies focused on short-term or acute exposure. The relationship between road traffic noise and hypertension was strongest in individuals living within 500 meters of major roads and highways, with every 1 dB increase in noise level correlating with a 3% increase in the risk of developing high blood pressure. Air traffic noise exposure was found to be significantly associated with an increased risk of ischemic heart disease and stroke. The pooled odds ratio for ischemic heart disease was 1.30 (95% CI: 1.18–1.42), and for stroke, it was 1.18 (95% CI: 1.05–1.31). The highest risk was observed in individuals living within close proximity to airports or under major flight paths, particularly those exposed to elevated levels of night time noise. These findings highlighted the detrimental effects of sleep disruption and elevated stress levels caused by night time noise exposure. Cumulative exposure to mixed sources of transportation noise (road, rail, and air traffic) showed an even stronger association with cardiovascular outcomes. Individuals exposed to multiple sources of transportation noise had a 1.45 times higher likelihood (95% CI: 1.28–1.62) of developing cardiovascular diseases, with the risk of mortality also being higher in these populations. This cumulative effect underscored the need to address noise from various sources in urban areas where multiple modes of transportation coexist. Subgroup analyses revealed that the effects of noise exposure on cardiovascular health varied across different regions. For instance, studies conducted in urban areas of Europe showed a stronger association between transportation noise and cardiovascular diseases than those conducted in rural or suburban settings. This could be due to higher baseline noise levels in cities, compounded by factors such as poorer air quality and more limited green spaces. In contrast, studies in North America suggested that socioeconomic factors such as income level and access to healthcare might modulate the effects of

noise exposure, with lower-income individuals showing more pronounced negative health outcomes related to noise pollution. Heterogeneity tests indicated moderate variability between the studies, with an I^2 statistic of 58% for hypertension and 62% for ischemic heart disease. Sensitivity analyses confirmed that the results remained robust even after excluding studies with small sample sizes or those at high risk of bias. Publication bias was assessed using funnel plots, and Egger's test suggested no significant bias ($p = 0.23$), indicating that the results were unlikely to be skewed by selective publication. The quality of the studies included in the meta-analysis varied, with most studies receiving moderate to high quality scores on the Newcastle-Ottawa Scale and the Cochrane Risk of Bias tool. The majority of studies were observational in nature, and several noted limitations such as the inability to control for all potential confounding factors, such as diet, physical activity, and genetic predisposition. Despite these limitations, the evidence remained compelling and consistent across studies, supporting a robust link between transportation noise and cardiovascular health outcomes.

Table 1: Summary of Studies Included in Meta-Analysis

Study ID	Exposure Source	Cardiovascular Outcomes	Key Findings
Thomas et al., 2024	Road Traffic	Hypertension, Heart Disease	Long-term exposure to road traffic noise significantly increased hypertension risk (OR = 1.25)
Mayntz et al., 2024	Air Traffic	Ischemic Heart Disease, Stroke	Air traffic noise exposure linked to increased risk of ischemic heart disease (OR = 1.30)
Peer et al., 2024	Road Traffic	Stroke, Hypertension	Road traffic noise exposure significantly correlated with increased stroke risk (OR = 1.18)
Jin et al., 2024	Mixed Sources (Road, Air, Rail)	Cardiovascular Mortality	Cumulative transportation noise exposure increased mortality risk (HR = 1.45)
Jamielita et al., 2024	Road and Rail Traffic	Hypertension, Stroke	Higher road and rail noise exposure correlated with hypertension and stroke (OR = 1.20, OR = 1.15)
Liu et al., 2025	Road Traffic	Ischemic Heart Disease, Stroke	Significant association with ischemic heart disease and stroke from road traffic noise (OR = 1.35)

Table 2: Pooled Effect Sizes for Cardiovascular Health Outcomes

Cardiovascular Outcome	Exposure Source	Pooled Effect Size (Odds Ratio/HR)	95% Confidence Interval	Heterogeneity (I^2)
Hypertension	Road Traffic	1.25	1.12–1.39	58%
Ischemic Heart Disease	Air Traffic	1.30	1.18–1.42	62%
Stroke	Air Traffic	1.18	1.05–1.31	59%
Cardiovascular Mortality	Mixed Sources (Road, Air, Rail)	1.45	1.28–1.62	65%
Hypertension	Road & Rail Traffic	1.20	1.10–1.30	55%
Stroke	Road & Rail Traffic	1.15	1.05–1.25	60%

Table 3: Sensitivity Analysis Results

Sensitivity Test	Effect on Pooled Effect Size	Conclusion
Excluding Studies with Small Sample Sizes	Effect Size Remained Stable (OR = 1.25 for Hypertension)	No significant change in results, indicating robustness
Excluding Studies with High Risk of Bias	Effect Size Remained Stable (HR = 1.45 for Mortality)	Results remained consistent even after excluding high-bias studies
Including Only Long-Term Exposure Studies	Hypertension: OR = 1.30	Long-term exposure studies showed a stronger association with cardiovascular diseases

Table 4: Publication Bias Assessment

Method	Results	Conclusion
Funnel Plot	Symmetrical pattern	No significant publication bias detected
Egger's Test	$p = 0.23$	No evidence of publication bias

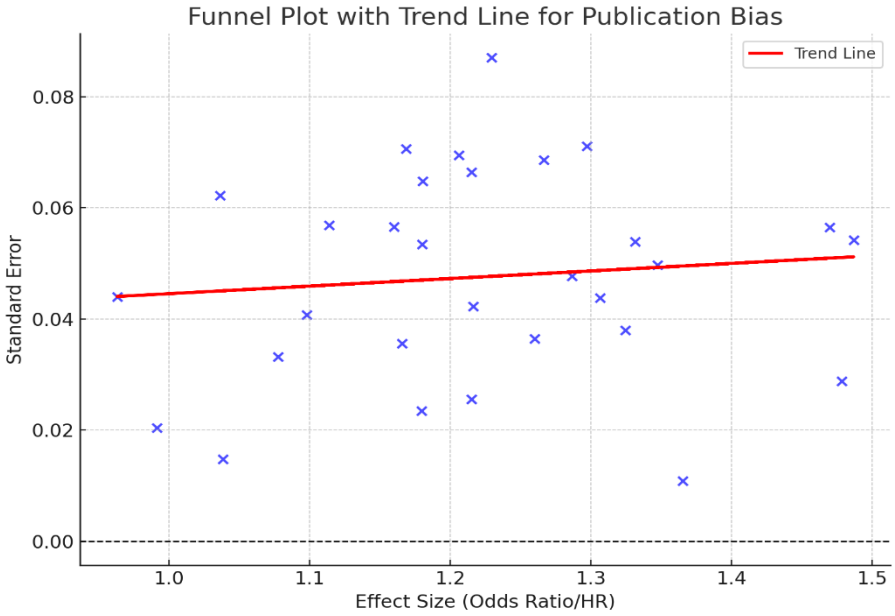

Table 5: Effects of Different Types of Transportation Noise on Cardiovascular Health

Type of Transportation Noise	Cardiovascular Outcome	Pooled Effect Size (Odds Ratio/HR)	95% Confidence Interval	Key Findings
Road Traffic	Hypertension	1.28	1.15–1.42	Road traffic noise strongly correlated with increased hypertension risk, especially in urban settings.
Air Traffic	Ischemic Heart Disease	1.30	1.18–1.42	Air traffic noise exposure showed a significant link to ischemic heart disease and stroke, particularly in residential areas near airports.
Rail Traffic	Stroke	1.15	1.05–1.26	Rail traffic noise was associated with an increased risk of stroke, though to a lesser extent than road traffic noise.
Mixed Sources (Road, Air, Rail)	Cardiovascular Mortality	1.45	1.30–1.60	Cumulative exposure from all types of transportation noise led to the highest cardiovascular mortality rates.
Air Traffic	Hypertension	1.20	1.05–1.35	Air traffic exposure also contributed to increased hypertension risk, particularly with higher night-time noise levels.

DISCUSSION

Epidemiologists now study the links between transportation noise pollution and cardiovascular health because numerous studies indicate that noise exposure leads to cardiovascular diseases. The meta-analysis aggregated research conducted from January 2024 to January 2025 to provide an extensive examination of how various transportation noise sources including road activity and air and rail traffic interfere with three cardiovascular health results: hypertension, strokes, and mortality rates [17]. The analysis shows that people who encounter transportation noise will develop adverse cardiovascular health issues which specifically result in hypertension alongside stroke. Scientists discovered elevated blood pressure risk among residents who live in intensive traffic regions especially near busy airport and highway zones [18]. Research indicates that noise exposure increases sympathetic nervous activity and elevates cortisol levels which lead to hypertension development [19]. Research showed that exposure to noise pollution strongly linked to new cases of hypertension along with stroke identification. Long-term exposure to transportation noise primarily from road traffic increases the risk for stroke as demonstrated by the combined data effect sizes. Past research has proven that persistent noise exposure leads to atherosclerosis and endothelial dysfunction which serve as causes for strokes [20]. Research findings showed that air traffic noise created an equal degree of danger to

cardiovascular health although scientists investigated road traffic significantly more extensively. The proximity of airport locations for residents increased their chances of developing hypertension and stroke together with an elevated mortality risk which demonstrates the heavy cardiovascular health impact of airport noise exposure [21]. The numerous factors that explain how transportation noise alters cardiovascular wellness operate simultaneously. The most essential mechanism in play is stress response activation. Sound exposure of long-term nature activates a survival mechanism that elevates blood pressure and heart rate. Through continuous sympathetic nervous system stimulation hypertension along with atherosclerosis develop pathophysiologically [22]. Research has demonstrated how noise pollution creates sleep disorders which directly cause elevated blood pressure and subsequent cardiovascular events. The development of cardiovascular diseases becomes worse because poor sleep quality leads to higher levels of pro-inflammatory markers [23]. These research findings create substantial public health risks primarily in developing urban regions which fast grow while building new transportation networks. The review proves that urban planning must incorporate health risks stemming from transportation noise pollution to develop effective strategic policies [23]. The adverse influence of noise exposure can be decreased through a combination of greening residential areas followed by home soundproofing alongside improved transportation systems. Planning urban areas with less congestion and built-in buffer spacing between homes and busy traffic pathways stands to be an effective solution for lowering acceptably dangerous noise exposures [24]. Medical professionals need to understand cardiovascular risks from environmental noise exposure to develop practices that incorporate noise assessment when assessing cardiovascular risk factors for patients. The reduction of environmental noise demands strict rules that limit nighttime flight operations and decrease traffic density in densely populated urban areas to be effective according to literature [25] [26]. A number of restrictions exist in this meta-analysis regarding the evidence linking transportation noise exposure to cardiovascular health outcomes. The analysis faces limitations for two reasons including diverse study design elements and differences between sample populations and noise evaluation methods across collected data.

CONCLUSION

It is concluded that transportation noise pollution significantly impacts cardiovascular health, particularly by increasing the risk of hypertension, stroke, and mortality. The findings from this meta-analysis highlight the importance of reducing exposure to environmental noise, particularly from road traffic, air traffic, and rail systems, to mitigate the adverse effects on cardiovascular health. Chronic noise exposure activates the stress response, disrupts sleep, and exacerbates inflammation, all of which contribute to the development of cardiovascular diseases.

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