Progress of Research on the Effects of Traffic Noise on Human Health

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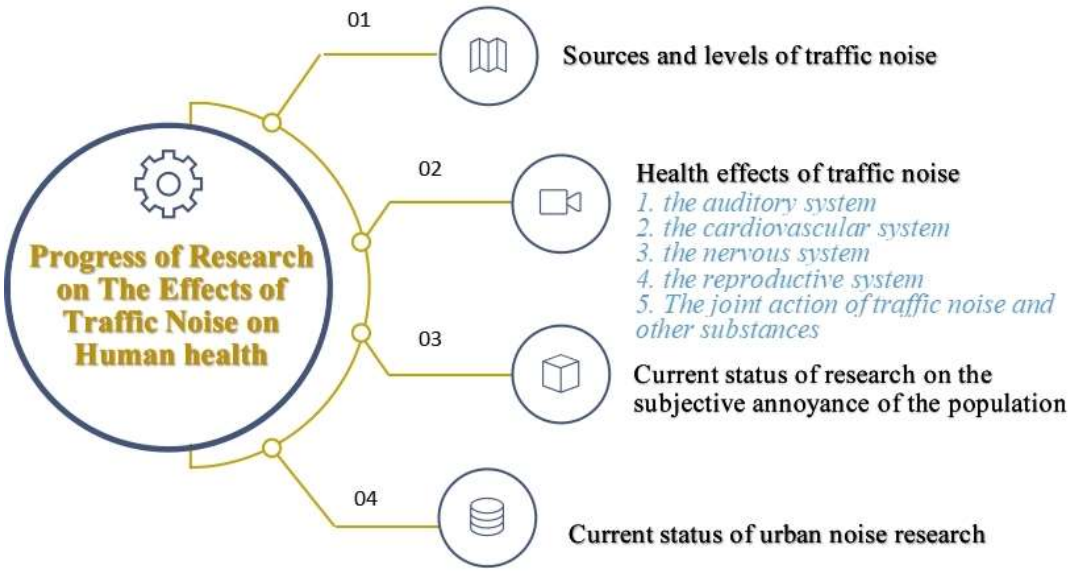
GRAPHICAL ABSTRACT



Abstract:To understand the hazards of noise on human body and to mitigate the effects of noise on human health. This paper introduces the sources and levels of traffic noise, and describes the effects of noise on the combined effects of human auditory system, cardiovascular system, nervous system, reproductive system, and other substances on human physical and mental health as well as physiological and psychological functions and their mechanisms, and highlights the current state of domestic and international research on urban traffic noise to offer suggestions for the future prevention and treatment of noise-induced health concerns.

Keywords: Noise; Traffic; Health effects; Hearing; Noise annoyance.

A convenient, effective, and seamless transportation system was crucial for both sustainable urban development and measuring how modernized a city was. The number of transportation options was substantially growing as a result of the global economy's rapid expansion and the acceleration of urbanization. While transportation has made life easier for the general population, it has also contributed to related environmental issues. Not only has traffic-related air pollution become a severe problem, but the issue of traffic noise pollution has also grown in importance.

Ecological environment department's "national ecological environment letter complaint reporting Management platform" received more than 441,000 public complaints about noise nuisance problems in 2020, accounting for 41.2% of all complaints. Of the various noise sources

in China's urban environment (including traffic noise, industrial noise, construction noise, and social life noise), traffic noise accounted for about 70% of all reports (Sun, 2021). Road noise often causes 10 times more environmental pollution than railroad noise, according to data on noise mapping supplied by the European Environment Agency. Additionally, more than half of the population in many cities is exposed to road noise that exceeds acceptable levels. The worst exposure to road and rail noise among the chosen metropolitan agglomerations is in Paris, the capital of France (Wrotny and Bohatkiewicz., 2021) In Sweden, road traffic accounts for 90% of the life years lost to disability due to noise, and train traffic accounts for 10% (Eriksson et al., 2017). Noise pollution has become one of the environmental pollution that endangers human health and is becoming more and more serious. Long-term exposure to ambient noise can have a number of major negative impacts on human health (Song et al., 2022;Wothge and Niemann, 2020), including ischemic heart disease (Amoatey et al.,2020), depression (Terzakis et al., 2022), sleep disorders (Themann and Masterson, 2019), and noise problems (Gong et al.,2022).

Researchers are paying more attention to the health impacts of exposure to traffic noise as a result of the tendency for traffic noise levels to rise with urbanization. Mann (2022) conducted a quantitative review and comparison of traffic noise prediction models (regression models, lack of use of genetic algorithms, fuzzy systems, neural networks, etc.) developed by researchers for different cities as part of his investigation into the state of traffic noise in developing nations. Through the Life+2013 initiative, the European Commission is co-funding the Dynamap project, which intends to create a dynamic noise mapping technique that can update ambient noise levels by maintaining direct connections to a small number of noise monitoring terminals (Zambon et al., 2018). Ranpise (2022) compiled recent studies on urban traffic noise and discovered that while 7.46% of the publications listed exposure to urban traffic noise pollution, 5.97% of the projects described how to monitor and record noise measurements on urban roadways. In 29.85% of the publications, noise reduction effects and noise level predictions were modeled. The systematic reviews that are now available, however, only give a partial picture of how traffic noise sources affect both physical and mental health. For instance, Janice (2012) Hegewald used a meta-analysis approach to analyze mental health issues in persons exposed to various levels of aviation, rail, and road noise. Munzel (2020) investigated the effects of exposure to traffic noise on stress and sleep disturbance and found that nighttime noise had a more noticeable effect on noise-induced pathophysiology than daytime noise. In order to study the connection between traffic noise and various obesity markers, Gui (2022) carried out a thorough search of epidemiological research looking into the relationship between obesity and noise from traffic in three electronic databases. Therefore, this paper has conducted a systematic literature search on the possible negative impact of traffic noise on the health of the population, considering the damage caused by traffic noise to the physiological and psychological functions of the human body from various angles respectively, and systematically elaborating the impact of environmental noise on human physical and mental health and physiological and psychological functions from four aspects: the sources of traffic noise, the impact of noise on health, noise annoyance research and the current status of urban noise research, in order to provide a theoretical basis for protecting the physical and mental health of people exposed to noise, as shown in Figure 1

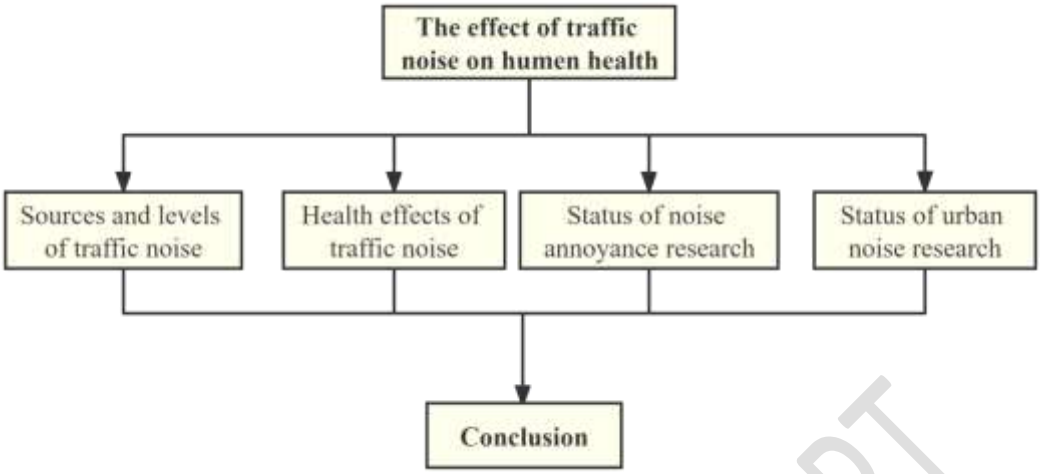


Figure 1. Research Technology Roadmap

1. Sources and levels of traffic noise

Road traffic noise sources are primarily the noise produced by the operation of the vehicle itself and the noise produced by the contact and friction between the tires and the ground when the wheels are rolling (Mann and Singh, 2022). Traffic noise is classified as non-stationary noise. While the wheel contact with the road, friction noise, and the size of the noise are primarily caused by the tires currently in contact with the ground, the difficult-to-discharge contact surface of the air, and the characteristics of the road and the type of motor vehicle are all related to the noise produced by the driving process of the vehicle (Peng et al., 2019); Propulsion system noise is the noise produced by an aircraft's propulsion system, which includes combustion noise, propeller noise, jet noise, fan noise, compressor noise, turbine noise, and other noises, and aerodynamic noise is the other category of airport traffic noise. Aerodynamic noise, commonly referred to as airframe noise, is the noise produced by the airflow pressure disturbance induced by airflow over the fuselage (Ganic et al., 2021); Wheel track noise, pneumatic noise, collector system noise, and structural noise are the main sources of rail traffic noise to the track radiation to the outside environment. The number of persons affected is wider due to the degradation of the urban acoustic environment (Hao et al., 2022).

2. Health effects of traffic noise

Prolonged exposure to noise can have adverse effects on the organism, including "specific" lesions caused by the auditory organs and non-specific lesions caused by the effects of noise. In recent years, research on noise has further revealed additional effects and mechanisms of noise, especially on female physiology and offspring health, which has attracted general attention. The effects of noise on human health also act on, for example, the central nervous system and the cardiovascular system, as shown in Figure 2, the keywords for the study were discovered through topic co-occurrence. Based on its size and color, the keyword tag view displays the research hotspots related to the health impacts of noise and its evolution through time.

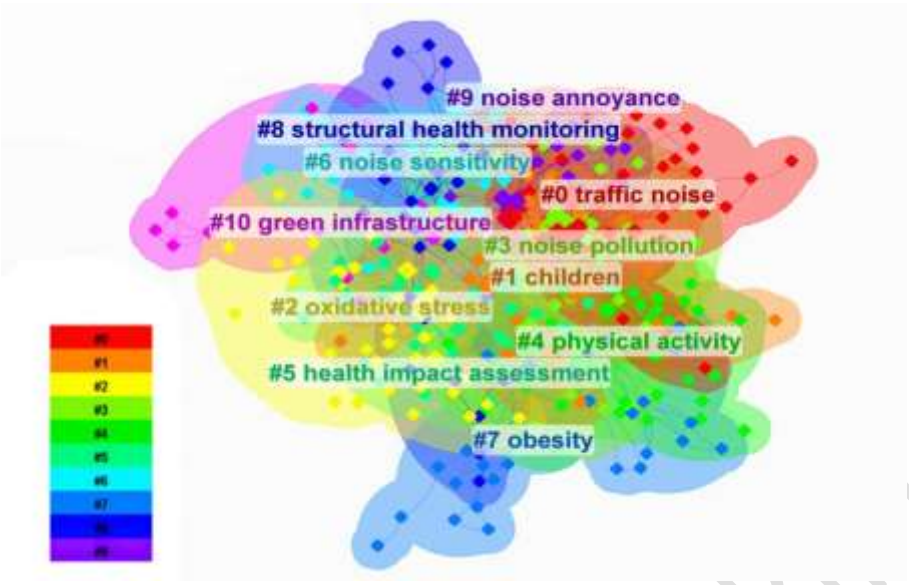


Figure 2.The effect of noise on human health literature from 2012 to 2023 keyword network analysis

2.1 Effects on the auditory system

The level of noise damage to the human auditory system relies on the volume, frequency, and duration of the noise. Strong noise causes transitory injury to the hair cells of the auditory cortex layer organs, which results in a temporary migration of the hearing threshold (auditory fatigue). Long-term exposure to high-noise environments, where the auditory organs are constantly stimulated by noise, can easily result in serious injuries like inner ear hemorrhage, tympanic membrane destruction, and even spirobasal detachment, losing the ability to restore the normal hearing threshold and turning into permanent hearing threshold migration (hearing loss). Some occupations have more significant hazards to the auditory system due to long-term exposure to noise, and noise-induced hearing loss is one of the most important occupational hazards.

Noise-induced hearing impairment is an irreversible sensorineural hearing impairment, which is mainly due to long-term exposure to strong noise. Lin Lin et al. (2005) investigated the hearing loss of workers exposed to noise in a power plant and found that the effect of noise intensity on hearing system damage was grouped by noise intensity dB <85, 85~, 90~, 95~, 100~, and it was seen that with the increase of noise intensity, the detection rate of hearing loss was on the rise, which was 10.00%, 12.26%, 30.61%, 37.73%, and 68.75%; Chen Chaodong et al. (2005) explored the effects of low and medium intensity high frequency noise on the electrocardiogram and hearing of operators, the noise intensity ranged from 53.6 to 98.0 (81.7±5.8) dB, and the hearing loss among operators was 18.9%, which was significantly higher than the 7.6% in the control group ($P<0.01$). The degree of damage increased with increasing working age, becoming particularly evident for those who had worked for more than 15 years; In the study investigating the effect of recreational sexual noise exposure on hearing function in young individuals, Keppler H et al. (2015) subjected subjects to more than 75 dB of weekly equivalent noise; transient tinnitus following recreational sexual noise exposure was identified in 86% of subjects; In 218 male workers recruited from a semiconductor plant, Chou Y F et al. (2009) used a standardized audiometric procedure to measure pure-tone hearing thresholds at 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, and 8 kHz in both ears. The results showed that in subjects working 12 h shifts, the

severity of the binaural hearing loss was significantly reduced.

2.2 Effects on the cardiovascular system

The cardiovascular system has become the focus of an increasing number of studies in recent years. These studies have discovered a strong correlation between exposure to traffic noise and an increased risk of a number of cardiovascular diseases, including hypertension, coronary heart disease, myocardial infarction, ischaemic heart disease, and pulmonary hypertension. In 2018, the World Health Organization released a new environmental noise guideline reporting that the risk of ischemic heart disease increases by 8% for every 10 dB increase in exposure to road traffic noise. Due to the long-term effects of noise on the body, which are accompanied by nervous system damage and plant nerve dysfunction, it is inevitable that it will have an impact on the heart, causing changes in heart rate and myocardial dysfunction, as well as changes in the normal metabolic process of myocardial cells, which can lead to myocardial ischemia and hypoxia. Long-term ischemia and hypoxia can also affect the sinus node's ability to regulate itself, which can cause irregular excitation release In addition to myocardial degenerative disease or cardiac decompensation, it can also result in aberrant myocardial conduction, premature beats, intra-atrial or atrioventricular conduction block, and myocardial degeneration or hypoperfusion (Bluhm and Eriksson, 2011; Van, 2011).

At present, most studies on the influence of noise on cardiovascular diseases are on blood pressure, blood lipids and electrocardiogram. In a meta-analysis of 24 studies conducted in the UK, Germany, and the Netherlands between 1970 and 2010, Van Kempen found a significant positive relationship between exposure to traffic noise and hypertension, with the risk of hypertension rising to 1.03 for every 5 dB increase in noise level (van Kempen and Babisch, 2012). A 1 dB reduction in traffic noise was found to be associated with 284 fewer cardiovascular deaths per day in a study of the relationship between traffic noise and cardiovascular mortality in people over 65 in Spain between 2003 and 2005. This finding suggests that lowering traffic noise has a significant protective effect by lowering the risk of cardiovascular disease (Tobías et al., 2015); Munzel T et al. (2014) found that patients with coronary artery disease had more severe endothelial dysfunction as a result of nighttime exposure to airplane noise. Chronic stress is linked to cardiovascular risk factors such as elevated blood pressure and dyslipidemia, increased blood viscosity and glucose, and blood coagulation factors in both animal models and people. Chronic noise exposure also raises the risk of cardiometabolic disease.

2.3 Effects on the nervous system

Depending on the intensity of stimulation, there may be biochemical or psychological biologic activation for each perceptual capacity. The perception of sound or noise is the same way. As a result of the long-term effects of traffic noise on the human central nervous system, the cerebral cortex may become dysfunctional, leading to an imbalance between inhibition and excitation, which can lead to neurological disorders like headaches, vertigo, insomnia, tinnitus, palpitations, and memory loss. When noise harms the neurological system of a person, it mostly impacts their behavior, mental health, and other conditions including neurasthenia and depression (Maschke et al., 2000).

Although this area has not been studied as extensively and intensively as the effects on the cardiovascular system, there have been some positive findings showing that traffic noise exposure can lead to neurodegenerative syndromes. Using the Neurobchavioral Core Test Battery (NCTB) approach, He L H et al. (2006) did a meta-analysis of the neurological effects of noise and

demonstrated that noise can have a significant impact on workers' nervous systems at 80-85 dB and that there may be a dose-effect association; Qian X Q et al. (2015) selected 2261 noise workers in an oilfield for nervous system examination, and the results showed that the detection rate of neurasthenia syndrome in the noise group was significantly higher than that in the control group ($P< 0.01$), the detection rate of neurasthenia syndrome in the noise group was higher in women (24.9%) than in men (19.3%), and there was a positive correlation between the detection rate of neurasthenia syndrome and noise intensity in the noise group ($r=0.082$). ($p< 0.001$); Lee S et al. (2017) found that there is a dose-response relationship between severe noise/vibration exposure and NSRS (neurological related symptoms), with odds ratios (ORs) of 1.48/1.06 for sleep disturbance, 1.46/1.26 for headache/eye tiredness, and 1.56/1.28 for overall fatigue, respectively; Tonazzini L et al. (2013) used confocal and TIRF microscopy to study the impact of noise on neural protrusion guidance and focal adhesions (FAs) In NGF-differentiated PC12 cells. The results revealed that the loss of neural protrusion guidance was not linearly related to noise but rather a threshold effect that correlates with changes in FA maturation and spatial organization.

2.4 Effects on the reproductive system

The effects of noise on the reproductive system can have a negative impact on the contacts' health as well as the healthy growth of their offspring (Chen et al., 2018), with the main manifestations being dystocia, premature birth, congenital malformations, etc. Long-term exposure to loud noises can also easily result in a range of hormonal secretion and release disorders, which can subsequently have an impact on pregnancy-related issues like infertility, improper placental control, decreased uterine blood flow, and more.

Numerous academics have focused their attention on the impact of noise on reproductive health as an occupational risk factor. Bai Y H et al. (2005) conducted on-site noise monitoring of textile workshops in three areas of Qinghai Province, and the results revealed that the noise levels were 78.8% higher than the acceptable level. In the THREE PLATEAU AREA, 84.9% of the female textile workers had irregular periods, and the irregular indicators were noticeably higher than those in the control group; Farzadinia P et al. (2016) studied the effect of noise pollution on testicular histomorphological parameters and hormonal assessment (ACTH, cortisol and testosterone) revealed that noise stress decreased testosterone levels in the 115 dB treated group while increasing ACTH and cortisol levels. The mean diameter of the germinal tubules and the thickness of the germinal epithelium were smaller in the testes' histological sections when compared to the control group. Reduced thickness of the germinal epithelium; Additionally, the ratio of interstitial to total testicular tissue area increased significantly. It has also been demonstrated that noise stress may harm male fertility. Additionally, exposure to noise during pregnancy might alter the outcome, increasing the likelihood of spontaneous abortion, threatened abortion, and premature birth (Wang et al.,2011; Tao et al., 2014; Dzhambov et al., 2014).

2.5 The joint action of traffic noise and other substances

There are differences in the type and severity of noise hazards to human health due to the presence of a variety of confounding factors during noise exposure, such as smoking, alcohol consumption, high temperatures, other toxic and harmful substances, and air pollution; consequently, whether noise and other substances have a combined effect or independent effects on each other has become a hot topic in current research. According to Ferrite S et al. (2005), numerous ototoxic chemicals identified in the chemical components of mainstream smoke may

have synergistic effects on hearing when paired with noise exposure. This effect of smoking and noise exposure on hearing loss is consistent with biological interaction; Tang Y et al. (2005) investigated the connection between smoking and occupational noise exposure and their combined impact on deafness. Tang Y discovered that smoking and occupational noise exposure had relative risks (RR) for deafness of 2.64 and 1.72, respectively, and that their combined impact was greater than the sum of their individual independent effects(RR=4.85); Liu F. Y.et al. (2008) exposure to heat and noise at work had a synergistic effect that had a higher impact on the cardiovascular system than either factor alone. Plasma endothelin (ET), a factor with a constrictive action, also had a role in the development of hypertension; Huang J et al. (2013) found that the effects of traffic-related air pollutants on HRV indicators were more significant when the noise level was higher, and traffic noise may enhance the effects of traffic-related air pollutants on the human cardiovascular system. The study looked at the effects of traffic noise and traffic-related air pollutants on heart rate variability (HRV) indicators in healthy people.

3. Current status of research on the noise annoyance of the population

The subjective noise annoyance of the population refers to the adverse reactions of different people when they face excessive noise (Tian, 2015; Barcelo et al., 2016), such as "interference with sleep," "health risks," "lack of concentration," and other symptoms. The study of noise and population annoyance is an important field in acoustics. The research methods are mainly divided into three kinds: laboratory research, social investigation, and post-evaluation research. The noise physical index and social psychology have the greatest influence on annoyance level.

Many scholars at home and abroad have studied the annoyance of traffic noise, as shown in Figure 3. The initial researchers mostly studied the adverse effects of traffic noise by means of social questionnaires, the most representative of which was TJ Schultz's in 1978, who proposed the Schultz curve to characterize the relationship between the subjective responses of the population and their noise exposure values by collating and analyzing social survey data (Schultz, 1978). Kaku (1996) evaluated the extent of the effect of train noise and road traffic noise on the senses of the populace and conducted a social survey. Yano et al. (2002) and Sato (2002) generally calculated the amount of each external variable's effect on irritation by analyzing the course of the survey data. The US EPA has conducted research into the annoyance of noise and discovered a link between the introduction of new sound sources and the perceived annoyance of locals.

In China, Fang (2007) employed acoustic analysis to talk about the crowd reaction, the relationship between noise level and crowd displeasure, the amount of noise impact evaluation, the specifics of the evaluation criteria, and how it was used. Through a subjective evaluation experiment, Liang (2016) modeled and examined the annoyance level of vehicle noise from the perspective of timbral tone. Yan (2009) also investigated the degree of population irritation by taking individual variations in demographic parameters into account, and she discovered that this had a considerable impact on the degree of population annoyance.

Figure 3. Analysis of the overall research trend of noise annoyance from 2013 to 2022

4. Current status of urban noise research

As demonstrated in Figure 4, due to the seriousness of the noise pollution, it has received a lot of attention from academics both domestically and overseas. For instance, the European Union has frequently cut the limit of engine noise for newly built cars in participating member states (Hyggs et al., 2002); the United States and Germany have extensively researched the sound barriers necessary for various road types and have established related laws (Defrance and Jean, 2003); It is worth mentioning that, in terms of how to reduce traffic noise pollution foreign scholars mostly suggest to focus measures on sound barriers, road surface measures, Kumar K et al.(2014) used neural networks as a method to determine the height of sound barriers necessary to achieve noise reduction requirements; Golebiewski Ret al. (2003) compared the noise reduction effects of various pavement materials and found that porous materials have the best noise reduction effect and are recommended for widespread use; Sharma A et al. (2014) conducted field monitoring at various times to investigate the magnitude of noise values generated by different vehicle numbers and proposed corresponding noise reduction solutions. Heutschi K et al. (2016) came to the conclusion that the magnitude of noise is inseparable from the vehicle type and speed, and explored workable noise reduction solutions in terms of noise generation theory.

As early as 1997, China issued the Law on Prevention and Control of Environmental Noise Pollution and created a number of noise control regulations in accordance. Domestic scientists' research on noise prevention and control is similar to that of most other nations. According to Lv Honglian's research on techniques for preventing and controlling road noise (Lv, 2016), unexpected honking will result in noise that is 10-15 dB louder than usual driving and even as loud as 125 dB; In order to predict the noise reduction effects of various types of sound barriers on urban elevated roads, Qiu T Q et al.(2016) developed a prediction model using Cadna/A software. The results of this analysis and comparison revealed that, under specific road conditions, fully enclosed sound barriers have a better noise reduction effect and make it simpler to meet the noise standard; Lu X M (2004) studied the noise reduction effect of sound barriers after adding sound absorbers to the sound barriers. To make the sound barriers have an obvious noise reduction effect, it is not only necessary to add sound absorbers at the top of the sound barriers, but also the diameter should be larger than 0.3 m.; Sun W et al. (2014) investigated the absorption effect of various green belts on traffic noise, different types of green belts were installed.

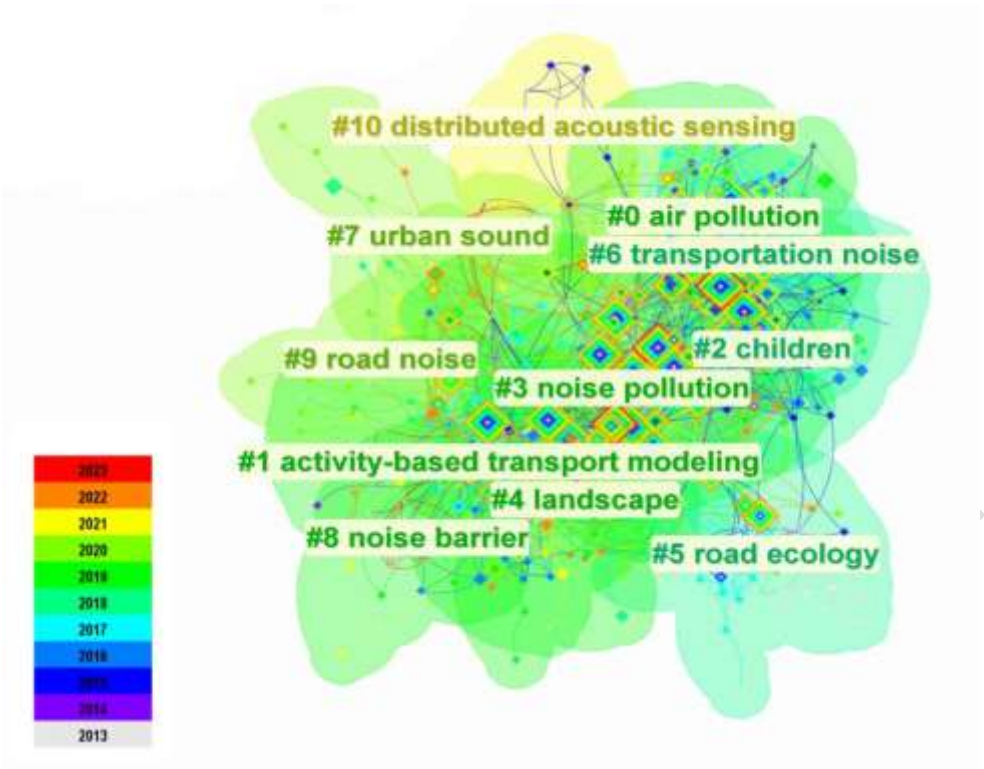


Figure 4. Subject categories of traffic noise research from 2013 to 2023

5. Problems and Prospects

This paper reviews the state of the science regarding the effects of urban traffic noise on human health, analyzes it using the software citespace, describes the harm that traffic noise causes to human physiological and psychological functions from different perspectives, and proposes potential applications and technical challenges based on traffic noise research in the future, providing a scientific basis for additional traffic noise prevention and control and population health protection in the process.

In conclusion, some progress has been made in the study of the health impacts of traffic noise at home and abroad, and there is enough scientific proof that it can harm people's health. However, the following issues still remain with regard to the health effects of traffic noise: (1) The exposure assessment of traffic noise needs to be improved. (2) The threshold of traffic noise's health impact is still unclear. (3) The mechanism of traffic noise's health impact needs to be explored. (4) The combined effect of traffic noise and traffic-related air pollutants needs to be further examined.

To further conduct research on the population exposure characteristics of traffic noise, explore the health impact thresholds of traffic noise, and take into account the combined effects of traffic noise and traffic-related air pollutants, among other things, basic data on the population health effects of traffic noise will be provided by combining advanced traffic noise exposure evaluation techniques with epidemiological and toxicological methods in future studies. 90% of the research that has been published employs quantitative meta-analysis of exposure-response relationships between common noise exposure indicators and common annoyance reactions (Guski et al., 2017). Through the use of meta-analysis, Renner (2021) examines epidemiological studies of the association between chronic exposure to road traffic noise and the prevalence of

arterial hypertension and blood pressure. AM Dzhambov (2016) provides quantifiable estimates of the impacts of ambient noise based on a formal meta-analysis of the links between residential road traffic noise and depression and anxiety. Recio (2016) presented a new integrated stress model that explains two associations between road traffic noise and various harmful effects and diseases found in recent noise studies. This model reflects an update on the effects of environmental noise on sleep disturbances and their consequences in humans, as well as on cardiovascular, respiratory, and metabolic health and the biological mechanisms involved.

Additionally, in order to visualize, automate, and network the processes of noise prediction, status quo evaluation, prevention and control measures, and data management in urban traffic road noise research work, GIS, GPS, remote sensing, and other technologies should be used in a reasonable manner. This will provide a scientific foundation for further traffic noise prevention and control as well as population health protection during the urbanization process. The EU's Dynamap project calls for the creation of an automated noise mapping system that will produce real-time (short-term) noise maps as well as long-term noise assessments(Benocci et al., 2021), drastically cutting down on the resources (time, money, and dedicated staff) required to update noise maps as well as improving and streamlining public information dissemination.

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