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How To Minimize Transportation Noise Pollutions And Transportation Noise-Related Diseases Using Artificial Intelligence

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Abstract: Transportation noise pollution has become a global environmental issue with serious health and ecological consequences. This article examines the role of artificial intelligence (AI) in addressing the complex challenges of noise pollution and minimizing its associated health risks using AI-based techniques, like to use the power of machine learning (ML) or Artificial Neural Networks (ANN) in conjunction with metaheuristic algorithms to minimize transportation noise pollution and transportation noise-related diseases.
The article highlights the limitations of traditional noise monitoring and mitigation methods, emphasizing the potential of AI-driven solutions. AI-based techniques such as noise prediction models, real-time mapping, traffic flow optimization, and smart routing, additionally, it summarizes the transportation noise outlined in several guidelines and standards, including the Environmental Noise Directiv,Noise in Europe – EEA 2014,Environmental noise in Europe – EEA 2020,WHO Environmental noise guidelines for the European Region-, Critical noise values in EU (IG Noise),and etc are explored for reducing noise generation across transportation systems. The article also discusses the challenges of data quality, algorithmic biases, and ethical considerations in AI applications. Finally, it explores the future of AI in transportation noise reduction, including opportunities for interdisciplinary research and the integration of emerging technologies such as blockchain and augmented reality. This review underscores the transformative potential of AI in combating transportation noise pollution and protecting public health.

Keywords: *Artificial Intelligence; Artificial Neural Networks; Machine Learning; Noise Pollution; Environment; Transportation Noise, and* AI-based techniques.

1. Introduction

1.1 Background on transportation noise pollution and its global impact

Transportation noise shows measurable impacts on human health, cognition, behaviour, and quality of life. [1] document moderate evidence that road and aircraft noise disrupt sleep via increased cortical awakenings and self-reported sleep disturbance. Several papers link noise exposure to cardiovascular effects. [2] and [3] report elevated risks of hypertension, vascular dysfunction, and cardiovascular morbidity, while [4] quantify the burden as 6000 years of life lost in a Swiss population.

Noise exposure also appears in studies to affect mental well-being and cognitive performance. [5] describe associations with psychological symptoms, impaired reading comprehension, and memory deficits in children, and [6] report an 11% increase in odds for hyperactivity/inattention per 10 dB increase in road traffic noise. Additional qualitative evidence highlights altered lifestyle and recreational activities, changes in public space use, and diminished quality of life. These findings, drawn from studies spanning diverse populations and regions, indicate that transportation noise pollution exerts a range of adverse global effects on physical, mental, and social health.

1.2 Overview of noise-related health issues (e.g., cardiovascular diseases, sleep disturbances, cognitive impairment)

Environmental noise, particularly from transportation sources, poses significant health risks beyond auditory effects. Chronic exposure can lead to cardiovascular diseases, including hypertension, myocardial infarction, and stroke [7; 3]. Noise disrupts sleep patterns, increases stress hormone levels, and induces oxidative stress, contributing to endothelial dysfunction [3; 8]. Cognitive impairment, decreased school performance, and mental health issues are also associated with noise exposure [9]. The World Health Organization estimates that over 1.6 million healthy life-years are lost annually due to traffic noise in Western Europe [7]. Emerging concerns include "e-noise" from electronic devices, which may have similar health impacts [10]. As noise exposure continues to increase globally, it remains a significant public health challenge for the 21st century [11]. Effective noise mitigation strategies are crucial for protecting public health [3].

1.3 Importance of addressing noise pollution with modern solutions

Noise pollution, a growing environmental concern, poses significant threats to human health and well-being [12]. Sources include urbanization, industrialization, and transportation [13; 14]. Prolonged exposure can lead to various health issues, including stress, sleep disturbances, hearing impairment, and reduced cognitive performance [14;15;16]. The effects extend beyond human health, impacting wildlife and property values [16]. Addressing noise pollution requires a multifaceted approach, including regulatory measures, urban planning, and technological innovations [17; 18]. Mitigation strategies involve controlling noise at the source, during transmission, and at the receiver end [13]. Public awareness and education are crucial in combating noise pollution [14]. Implementing these strategies can help create quieter, healthier environments and improve overall quality of life [18; 16].

The contribution of the paper is to provide by outlining of the major sources of transportation noise, including road traffic, railways, aviation, and maritime transport, and their impacts on human health, such as cardiovascular diseases, sleep disturbances, hearing loss, and cognitive impairments. The integration of AI into urban planning, health impact assessments, and public awareness initiatives offers significant advantages in mitigating noise-related diseases. The ecological balance of the environment is emerging because of human disruptions. Technological developments are experienced at a dizzying pace, and for that reason, many problems that were considered impossible to solve in the past are easily solved. The article concludes with a discussion of the shortcomings of existing research and possible future research directions. Overall, this review article offers a comprehensive guide for researchers and professionals working on the AI based- techniques and noise in transportation.

2. Transportation Noise Pollution: Sources and Impacts

2.1 Major sources of transportation noise (road traffic, railways, aviation, maritime)

Transportation noise from road, rail, aircraft, and maritime sources significantly impacts public health and quality of life. Studies have shown that exposure to these noise sources is associated with increased cardiovascular mortality, particularly myocardial infarction [19; 20]. The effects of transportation noise on sleep disturbance and annoyance have also been extensively studied, with railway noise found to have the highest probability of causing awakenings, followed by road and aircraft noise [21]. Noise interventions have been shown to positively affect health outcomes, regardless of the source type or intervention method [22]. Recent research has focused on developing more accurate noise mapping techniques for complex environments like ports. While transportation noise remains a significant environmental concern, ongoing efforts to measure, model, and mitigate its impacts continue to inform policy and improve public health outcomes [23; 24].

2.2 Health and environmental impacts of transportation noise pollution- 1

Transportation noise pollution, particularly from road traffic, is a significant environmental health risk. Chronic exposure can lead to various auditory and non-auditory effects. Noise-induced hearing loss and tinnitus are primary auditory impacts [25]. Non-auditory effects include sleep disturbance, annoyance, cognitive impairment, and cardiovascular disorders [26]. Recent high-quality cohort studies have consistently linked road traffic noise to increased risks of ischemic heart disease, heart failure, diabetes, and all-cause mortality [27]. The underlying mechanisms involve physiological stress responses, oxidative stress, and inflammation [27]. In the United States, an estimated 104 million people were at risk of noise-induced hearing loss in 2013 [28]. Effective interventions to reduce noise pollution include direct regulation, altering the informational environment, and modifying the built environment [28].

Transportation noise pollution, particularly from road traffic, has been associated with increased risks of cardiovascular and metabolic disorders. Studies have found links between noise exposure and ischemic heart disease, hypertension, stroke, diabetes, and obesity [29; 30; 3]. A meta-analysis of longitudinal studies revealed a relative risk of 1.08 (95% CI: 1.01-1.15) for ischemic heart disease per 10 dB increase in road traffic noise [31]. The biological mechanisms underlying these associations involve sleep disturbance, stress hormone elevation, oxidative stress, and vascular dysfunction [3; 32]. While the evidence for some outcomes is still limited, the overall body of research suggests that transportation noise is an independent risk factor for cardiometabolic diseases, even when accounting for air pollution exposure [33; 34].

Transportation noise pollution has been linked to various mental health and cognitive effects in both adults and children. Studies have found associations between noise exposure and increased risk of depression, anxiety, and cognitive impairment [35; 2]. Long-term exposure to traffic noise has been shown to impair quality of life, affect cognitive development in children, and potentially contribute to neurodegenerative diseases [5; 26]. Aircraft noise, in particular, has been associated with a 12% increased risk of depression per 10 dB increase in noise levels [35]. In children, road traffic noise has been linked to hyperactivity/inattention and behavioral difficulties [6]. The mechanisms underlying these effects may include sleep disturbance, annoyance, and physiological stress responses [36; 37]. However, more research is needed to fully understand the independent effects of noise pollution on mental health and cognitive function [38].

Transportation noise pollution has significant impacts on both human health and biodiversity. In humans, it can cause annoyance, sleep disturbance, cardiovascular issues, and mental health problems [26; 39]. For wildlife, noise pollution affects behaviour, communication, and foraging efficiency across various species [40; 41]. Studies have shown that terrestrial wildlife responses begin at noise levels around 40 dBA [40]. Noise impacts have been extensively researched in mammals, birds, and fish, but less is known about its effects on amphibians, reptiles, and invertebrates [42]. Mitigation strategies include noise barriers, acoustic building materials, and improved road surfaces [43]. To address knowledge gaps and develop effective conservation measures, future research should focus on understudied species, explore interacting stressors, and assess the outcomes of noise mitigation efforts [40; 44].

2.3 Challenges in traditional noise monitoring and mitigation approaches

Traditional noise monitoring and mitigation approaches face several challenges in urban environments. While conventional methods rely on contact sensors for machine condition monitoring, acoustic-based techniques offer a non-contact alternative but are sensitive to background noise [45]. Environmental noise pollution affects millions in urban areas, with current reporting programs often ineffective due to misaligned perceptions between residents and authorities [46]. Wireless acoustic sensor networks (WASNs) have emerged as a solution for smart city noise monitoring, evolving from high-accuracy commercial devices to low-cost sensors [47]. Traditional traffic noise control methods are limited in addressing diffuse acoustic soundscapes, necessitating alternative approaches like acoustic absorption [48]. Advanced systems integrating sensors, citizen science, and big data analytics offer promising solutions for comprehensive urban noise monitoring and mitigation [49; 50]. However, the proper implementation of regulations and cost-effective strategies remains a crucial challenge [51]. For more information, see the appendix.

3. Overview of Artificial Intelligence (AI) in Noise Pollution Management

3.1 Definition and key AI technologies (e.g., machine learning, deep learning, neural networks)

Artificial Intelligence (AI) is a broad field aimed at creating intelligent machines capable of performing tasks typically requiring human intelligence [52]. Machine Learning (ML), a subset of AI, enables software to improve predictive accuracy using historical data [53]. Deep Learning (DL), a subset of ML, involves training models using neural networks and large labelled datasets [54]. These technologies have applications in various sectors, including healthcare, finance, and transportation. Key AI technologies include neural networks, natural language processing, and computer vision [55]. ML algorithms can be designed to optimize automatically through experience with limited human intervention. Neural networks are used to implement machine learning and design intelligent machines, with applications in speech recognition, computer vision, and natural language processing [56].

3.2 Applications of AI in environmental and health management

Artificial Intelligence (AI) is revolutionizing environmental health and management across various domains. AI applications include pollution monitoring, disaster response, and sustainable practices [57]. Machine learning algorithms analyze complex data to predict chemical toxicity and estimate human exposures to contaminants. AI contributes to achieving sustainable development goals, optimizing renewable energy management, and enhancing environmental health analysis [58]. Deep learning techniques are used for wildlife tracking, habitat assessment, and biodiversity analysis. AI also aids in disaster risk evaluation and emergency health management [59]. Image-based convolutional neural networks offer cost-effective means of estimating local environmental exposures [60]. However, challenges such as data quality, algorithmic bias, and ethical considerations need addressing [61]. Interdisciplinary collaboration is crucial for leveraging AI's full potential in environmental studies and sustainable practices [62].

3.3 Advantages of using AI over traditional noise pollution mitigation techniques

AI-based noise reduction techniques offer significant advantages over traditional methods in addressing noise pollution. AI approaches demonstrate superior performance in known environments, providing better noise reduction and enhanced audio quality [63; 64]. These techniques can effectively handle complex, dynamic noise environments, surpassing traditional methods like spectral subtraction and Wiener filtering [64]. AI-driven devices can detect, locate, and mitigate noise sources in real-time, as demonstrated in underwater noise cancellation for marine environments [65]. AI technologies enable efficient noise monitoring, analysis, and classification in urban soundscapes [66; 67]. Furthermore, AI applications extend to various environmental pollution controls, including wastewater treatment, air quality monitoring, and solid waste management [68]. While AI methods show promise, combining them with traditional techniques can provide better stability in certain scenarios [63]. Overall, AI approaches offer more precise, efficient, and adaptable solutions for noise pollution mitigation.

4. AI-Based Methods for Minimizing Transportation Noise Pollution

4.1 Noise prediction and modelling using AI

Recent research has focused on developing artificial intelligence (AI) models for predicting transportation noise, particularly from road and rail traffic. Various AI techniques have been employed, including artificial neural networks, support vector regression, and neuro-fuzzy systems [69]. These models have shown improved performance compared to conventional methods, with some studies reporting accuracy improvements of up to 29% [69]. Input parameters typically include traffic volume, vehicle types, and speed [70]. Researchers have also explored ensemble models and feature selection techniques to enhance prediction accuracy [69]. While AI models have demonstrated promising results, some studies suggest that their performance should be compared with established empirical models in countries where such models exist [70]. Additionally, researchers have emphasized the need for high-quality data and centralized databases to improve model accuracy.

Recent research has focused on developing real-time noise mapping systems using advanced technologies and artificial intelligence. These systems employ low-cost sensors and IoT devices to collect noise data, which is then processed using AI algorithms to generate dynamic noise maps [71; 72]. Crowdsensing and participatory approaches have been explored to increase data resolution and coverage [73; 74]. Some systems incorporate spatial interpolation techniques to estimate noise levels in areas without direct measurements [75]. Advanced methods combine traffic simulations with noise modelling to provide near-real-time mapping and exposure assessment [76]. These innovative approaches aim to overcome the limitations of traditional noise mapping methods, offering more accurate, cost-effective, and timely solutions for urban noise pollution monitoring and management. The resulting noise maps can be used for various applications, including public awareness, urban planning, and health impact assessments.

4.2 Noise monitoring and data collection

Recent research highlights the development of IoT-enabled noise monitoring systems for urban environments. These systems utilize low-cost sensors and microcontrollers to measure sound levels in real-time, transmitting data to online servers for analysis [77; 78]. The integration of IoT technology allows for continuous monitoring, scalability, and prompt alerts when noise levels exceed thresholds [78; 79]. Some systems also incorporate air quality monitoring alongside noise pollution detection [80]. Researchers have proposed frameworks for vehicular noise monitoring in smart cities, using sensors, cameras, and GPS to track individual vehicles [81]. These IoT-based systems offer advantages such as affordability, modularity, and easy installation compared to traditional methods [79]. The implementation of such systems can help address health concerns related to noise pollution and improve urban living environments [82; 81].

Recent research has explored the use of AI for identifying noise hotspots and patterns in urban environments. AI-based techniques have been applied to acoustic source identification, improving the efficiency and accuracy of noise detection [83]. These methods have been used to create noise maps and identify hotspots for marine mammals [84] and to analyze rail transport noise. Machine learning algorithms have been employed for aircraft noise identification [85; 86] and urban nightlife noise analysis using mobile phone data [87]. Advanced software like NorCloud utilizes AI for efficient noise monitoring and analysis in complex urban soundscapes [66]. Additionally, AI approaches have been applied to noise prediction, using techniques such as tesseral addressing to improve computational efficiency [88]. These advancements demonstrate the potential of AI in addressing noise pollution and informing urban planning decisions.

4.3 Optimizing transportation systems with AI

Artificial Intelligence (AI) is increasingly being applied to optimize traffic flow and reduce noise pollution in urban areas. AI-based models have shown promise in predicting and managing vehicular traffic noise [70; 69]. These models utilize input parameters such as traffic volume, vehicle speed, and vehicle types to enhance prediction accuracy [69]. AI techniques can optimize vehicle routing, reduce congestion, and minimize environmental impacts [89]. Machine learning algorithms can predict traffic patterns and adjust signal timing to improve traffic flow and reduce air pollution [90]. In connected vehicle environments, traffic signal optimization can be employed to minimize noise emissions while improving overall traffic performance [164]. The implementation of AI-powered Intelligent Transportation Systems (ITS) can contribute to more sustainable urban mobility, particularly in developing countries [91; 92].

Recent research highlights the potential of AI and smart technologies to optimize urban logistics and reduce environmental impact. AI-driven systems integrating autonomous vehicles and IoT can enhance route planning, traffic flow, and demand management in smart cities [93]. Machine learning methods can estimate traffic noise levels to generate quiet routes for pedestrians [94]. Smart logistics platforms utilizing vehicle sharing and routing optimization can improve last-mile delivery efficiency [95]. Studies have explored green vehicle routing problems, considering factors such as noise exposure and emissions [96]. Innovative strategies for last-mile logistics, including new vehicles, proximity stations, collaborative urban logistics, and optimized routing, can help reduce externalities in urban areas [97]. The integration of AI, machine learning, and deep learning in smart logistics offers promising directions for future research and development [98].

Recent research has focused on reducing noise in aviation and railways using artificial intelligence (AI) and machine learning techniques. In aviation, studies have explored passive noise reduction methods for airfoils and wings [99], as well as AI models for aircraft noise identification and extraction [163]. Machine learning approaches have been applied to predict ground-level aviation noise [100] and quantify tram noise at sharp curves [120]. For railways, AI methods have been investigated for traffic noise detection, and the European RAILS project is exploring AI applications in the rail sector [101]. These studies aim to address the growing environmental concerns associated with transportation noise [102] and develop innovative solutions for noise prediction and reduction [103]. For more information, see the appendix.

5. AI Solutions for Reducing Noise-Related Diseases

5.1 AI in health impact assessments

Recent studies have highlighted the widespread impact of transportation noise on population health and well-being. Research indicates that a significant portion of the U.S. population is exposed to harmful levels of transportation noise, with an estimated 94.9 million people exposed to ≥45 dB LAeq [104]. This exposure disproportionately affects non-White populations, raising environmental justice concerns [104]. Advanced modelling techniques, including agent-based simulations and machine learning approaches [68], have been developed to predict noise exposure at fine spatial scales. These models incorporate various factors such as traffic volume, road features, and land use. The health implications of noise exposure extend beyond annoyance and sleep disturbance to include potential impacts on cardiovascular health and childhood learning [121]. Studies emphasize the need for targeted noise mitigation strategies and policies to address this pervasive environmental health issue [94].

Recent research highlights the potential of AI and IoT technologies in monitoring health outcomes related to noise and air pollution. Several studies propose systems for real-time noise monitoring using

IoT devices and wireless sensors [79; 105]. These systems can detect unhealthy noise levels and notify managers to take action. Similarly, air pollution monitoring systems using IoT and big data have been developed to assess public health risks [106; 107]. Integrated approaches combining various data sources, including crowdsourcing and social media, have been suggested for more comprehensive environmental intelligence [50; 108]. Advanced AI techniques, such as deep learning and convolutional neural networks, show promise in analyzing environmental exposures using images and other data sources [60]. These technologies offer opportunities for enhanced health monitoring, particularly in urban areas and developing countries with limited infrastructure [109].

5.2 AI-assisted noise mitigation in urban planning

Artificial intelligence (AI) has revolutionized the design and optimization of noise barriers and quiet zones. Expert systems like CHINA can design highway noise barriers comparable to human experts [110]. Artificial Neural Networks (ANNs) have been employed to determine optimal barrier heights [111] and material properties [112], as well as to model insertion loss for Indian traffic scenarios [125]. AI-driven techniques enable architects to analyze architectural parameters for ideal sound properties in room acoustics design [113]. Generative design and visual programming have been used to automate barrier dimensioning and performance evaluation [122]. AI systems can also optimize noise barrier plans considering health impacts, productivity, and costs [123]. Furthermore, AI-powered automated noise monitoring systems can recognize and classify various noise sources, enhancing urban soundscape management [124].

Recent research highlights the potential of integrating artificial intelligence (AI) with urban green spaces for noise reduction and environmental improvement. Green areas can significantly reduce sound levels through porous ground effects and leaf surface attenuation [126]. AI-driven simulations can optimize park designs, enhancing thermal comfort and air quality [127]. GeoAI technologies help reveal the contribution of different green space features to mitigating urban heat islands. Long Short-Term Memory (LSTM) models can optimize urban green space planning and design, particularly for reducing PM2.5 concentrations. Urban green spaces can absorb 5-10 dB(A) of traffic noise, with leaves playing a crucial role in sound absorption [114]. AI techniques are revolutionizing acoustics design and noise management, enabling precise analysis of architectural parameters and materials for optimal soundscapes [113]. These advancements demonstrate the significant potential of AI in enhancing urban green spaces for noise reduction and environmental improvement.

5.3 AI-enabled public awareness and engagement tools

Noise awareness campaigns utilizing data visualization and AI have gained traction in recent years. Crowdsourcing apps like SoundPrint have been used to collect noise data and raise public awareness [115]. Visualization tools have been developed to analyze and present environmental noise data, aiding decision-makers in understanding noise landscapes and improving policies [116]. These tools often incorporate 3D city models and interactive soundscapes to enhance public engagement [118]. Communicating noise information effectively to the public is crucial, with various indicators and representation methods being explored [117]. Participatory approaches and citizen involvement have been emphasized in noise mitigation planning and action plan implementation [119]. Crowdsourcing methods, such as mobile apps for noise data collection, have been proposed to gather large-scale noise data and generate noise models [128; 129], contributing to increased public awareness and more comprehensive noise mapping.

Recent research has focused on developing AI-powered apps to educate communities about noise hazards and promote safe listening practices. Several smartphone applications have been created to measure environmental noise levels, collect data, and raise awareness about noise pollution [130; 131;

132]. These apps serve as educational tools, helping users understand acoustic concepts and the health impacts of noise exposure [133; 134]. Studies have shown that repeated use of such apps can lead to increased awareness and improved recognition of different noise levels [136]. Some applications incorporate personalized features, providing real-time alerts and recommendations based on individual sound exposure [135]. By engaging citizens in participatory noise sensing, these technologies not only collect valuable data but also promote community involvement in addressing noise-related issues [130; 136].

6. Challenges and Future Directions

6.1 Technical limitations in AI applications for noise pollution

Recent research highlights the potential of artificial intelligence (AI) in addressing environmental challenges, particularly in air quality control and noise pollution monitoring. AI techniques like machine learning, deep neural networks, and fuzzy logic have shown promise in predicting pollutant concentrations and optimizing control systems [137]. However, these applications face several limitations. Data quality issues, including noise and bias in measurements, can affect model performance. Environmental injustice may arise from unequal access to AI technologies across regions [138]. Technical challenges include the need for large datasets, high computational power, and the complexity of real-world sound environments. Additionally, the accuracy of AI-based models should be compared with established empirical models in countries where they exist [70]. Despite these limitations, AI approaches show potential for improving air quality prediction and noise pollution monitoring in smart cities [139].

6.2 Ethical and privacy considerations in using AI and IoT sensors

The integration of AI and IoT sensors raises significant ethical and privacy concerns. These technologies collect vast amounts of sensitive data, potentially compromising individual privacy [140; 141]. AI-based sensors, while offering enhanced capabilities for IoT applications, must be designed with robust security measures to protect against data breaches and unauthorized access [142; 143]. The concept of "Privacy Spaces" has been proposed to manage data collection and sharing within defined boundaries [144]. Ethical considerations, including user consent and responsible use of IoT technologies, are crucial for maintaining trust and ensuring societal benefits [145]. Legal frameworks, such as GDPR, play a vital role in regulating data protection [140]. As IoT applications expand into areas like environmental monitoring and healthcare, balancing innovation with privacy and security remains a critical challenge [146; 147].

6.3 Opportunities for interdisciplinary research and innovations

Interdisciplinary research offers unique opportunities for innovation and addressing complex societal challenges [148; 149; 150]. It enables the integration of diverse perspectives, methodologies, and technologies to create new knowledge and solutions [149; 151]. However, interdisciplinary collaborations face challenges such as communication barriers, credit allocation, and institutional obstacles [152; 151]. To overcome these challenges, researchers can implement strategies like developing common languages, focusing on conceptual models, and providing timely feedback [153]. Successful interdisciplinary research requires supportive organizational structures, funding, and training programs [150; 154]. Additionally, interdisciplinary projects can create diverse impacts beyond commercialization, benefiting academia, industry, and the nonprofit sector [155]. Despite the challenges, interdisciplinary research remains crucial for driving innovation and addressing complex problems in the 21st century [154; 150].

6.4 Potential for integrating AI with other emerging technologies (e.g., blockchain, augmented reality)

The integration of AI and blockchain technologies offers significant potential for innovation across various domains. AI can enhance blockchain design, operation, and security ([156; 157], while blockchain provides a decentralized, secure platform for AI applications [158; 159]. This synergy enables improved data security, transparent decision-making, and efficient resource management [160]. Applications include decentralized AI, autonomous agents, and personalized experiences in emerging technologies like the Metaverse [161; 162]. However, challenges such as privacy concerns, regulatory issues, and technical complexities need to be addressed. As research in this field progresses, the integration of AI and blockchain is expected to revolutionize industries including finance, healthcare, and supply chain management, driving the future of data security and business intelligence [160].

6.5 Summary of Findings

The study explores the significant global impact of transportation noise pollution and its associated health risks. It highlights key aspects such as:

- Major contributors include road traffic, railways, aviation, and maritime transport.
- Health impacts range from cardiovascular diseases, hearing loss, and sleep disturbances to cognitive impairments and mental health challenges.
- Environmental impacts extend to wildlife, affecting their behaviour, communication, and ecosystems.
- Current noise monitoring and mitigation methods face limitations, such as the inability to address complex urban noise environments effectively.
- AI techniques, such as machine learning and IoT-enabled devices, have demonstrated significant potential in real-time noise monitoring, dynamic noise mapping, and traffic flow optimization.
- AI can enhance noise barrier designs, optimize urban planning, and develop predictive models to mitigate noise impacts more efficiently than traditional methods.
- AI helps predict populations at risk from noise exposure and monitor health outcomes.
- Integrating green spaces and noise barriers optimized with AI contributes to noise reduction.
- AI-powered tools educate communities about noise hazards and promote public engagement.
- Barriers include data quality issues, algorithmic biases, and ethical concerns.
- There is potential for interdisciplinary research and integrating AI with technologies like blockchain and augmented reality for more innovative solutions.

6.6 Recommendations

- Develop AI-based predictive models for noise pollution monitoring and mitigation.
- Expand the use of IoT-enabled sensors for real-time data collection and analysis.
- Implement AI tools to predict populations at risk and monitor the health impacts of noise pollution.
- Promote public awareness using AI-powered apps and educational tools.
- Incorporate AI to optimize the design of noise barriers, quiet zones, and green spaces.
- Utilize AI-driven simulations for urban planning to minimize noise impacts on residential areas.
- Foster collaborations between environmental scientists, urban planners, and AI developers to address noise pollution comprehensively.
- Establish robust frameworks for data privacy and ethical use of AI in noise monitoring systems.
- Improve the transparency and scalability of AI models to gain public trust.

- Governments and organizations should invest in AI-driven noise management technologies and promote policies that incentivize sustainable practices.

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Appendix

Key facts and figures from Environmental noise in Europe — 2025

EEA Report 05/2025

1. EU noise indicators for strategic noise maps

L_{den}: refers to an A-weighted average sound pressure level (SPL) over all days, evenings and nights in a year, with an evening weighting of 5dB and a night weighting of 10dB.

L_{night}: refers to an A-weighted annual average night period of exposure.

Source: EU, 2002.

1.2 Table 1.1 Estimated completeness of the information reported under the END 2022 in terms of population exposure to noise, EEA-32 (excluding Türkiye)

Source	Completeness of submitted data in %						
	Inside urban areas			**Outside urban areas**			**Total**
	Road	**Rail**	**Air**	**Road**	**Rail**	**Air**	**All**
Lden ≥55dB	**82.2**	**79.2**	**91.1**	**87.3**	**94.3**	**95.5**	**84.2**
Lnight ≥50dB	**82.2**	**80.0**	**97.3**	**89.4**	**94.6**	**94.3**	**84.7**

Source: EEA, based on data reported under the END (EEA, 2025).

1.3- Table- END reporting thresholds and WHO recommended noise levels

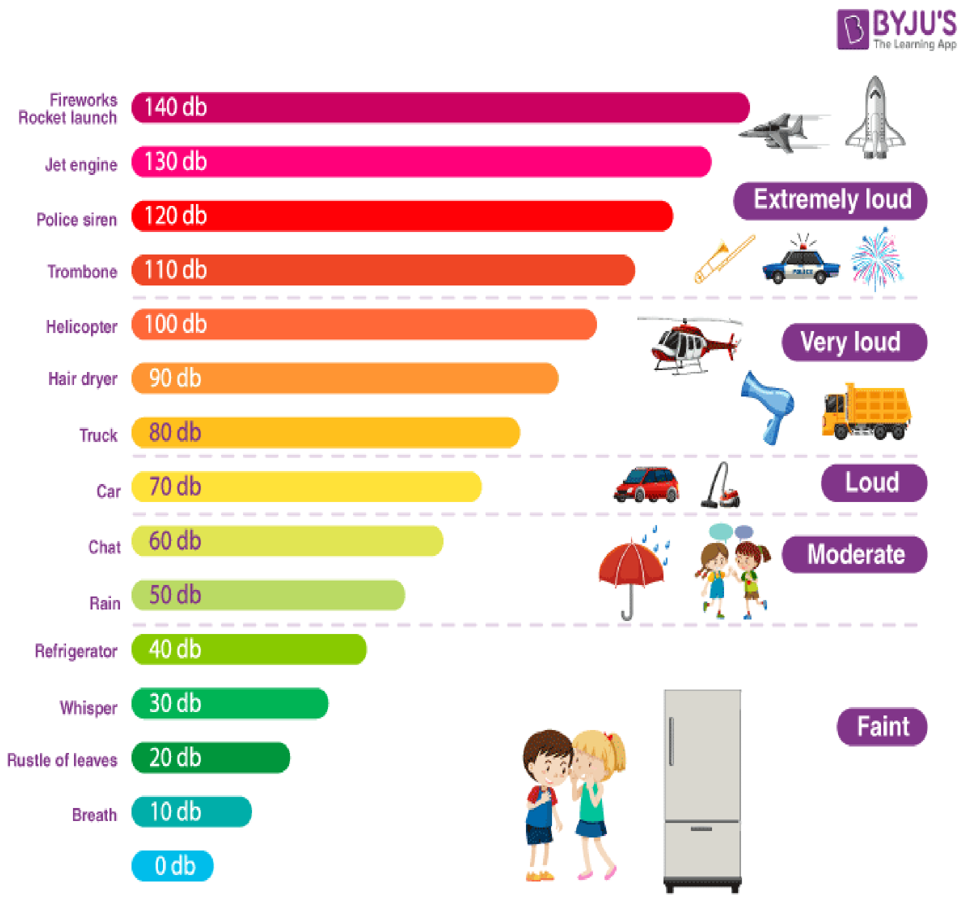
Noise source	Noise indicator	END reporting thresholds	WHO environmental noise guidelines
Road	Lden 24-hour annual average with weightings for the evening and night periods.	55dB	53dB
	Lnight Annual average for the night period.	50dB	45dB
Rail	Lden 24-hour annual average with weightings for the evening and night periods.	55dB	54dB
	Lnight Annual average for the night period.	50dB	44dB
Air	Lden 24-hour annual average with weightings for the evening and night periods.	55dB	45dB
	Lnight Annual average for the night period.	50dB	40dB

Notes: L_{den}, day-evening-night noise level. L_{night}, night noise level.

Sources: EU, 2002 and WHO, 2018.

2. National Transportation Noise Map

2.1 Decibel (dB) levels are used to measure noise, with levels above 65 dB considered noise pollution and levels above 75 dB potentially harmful.



https://cdn1.byjus.com/wp-content/uploads/2023/03/Noise-Pollution-2.png

3. Biological mechanisms – how does environmental noise affect human health

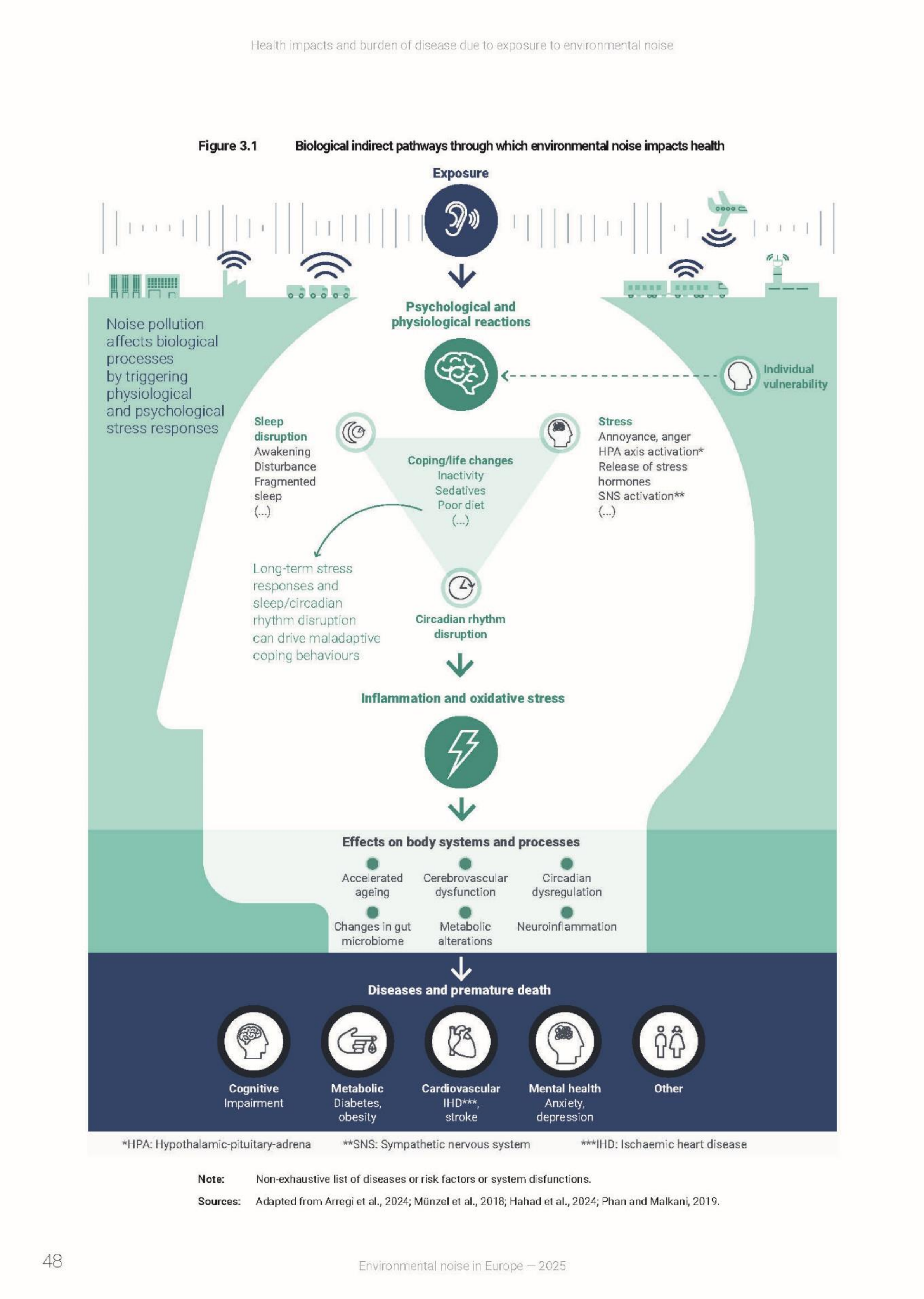


Figure 3.1 Biological indirect pathways through which environmental noise impacts health