INTERNATIONAL PERSPECTIVES

Assessment of Noise Level Distributions in Lagos Metropolis and the Potential for Adverse Health Effects

Zaccheaus Ayo Ibitoye, MSc
Adebayo Moses Aweda, PhD
Peace Chizoba Ofojebe MSc
Department of Radiation Biology and Radiotherapy
College of Medicine
University of Lagos

Abstract **Elevated sound pressure levels can lead to sleep disturbance, annoyance, hearing impairment, speech interference, and severe stress on the auditory and nervous systems if sound levels are continuous and greater than international standard limits. The aim of this study was to evaluate the noise level distributions in Lagos, Nigeria. We selected 32 locations across the Lagos metropolis for this study. A digital sound meter capable of measuring 32 dB–130 dB was used. At each location, minimum and maximum noise levels were determined. Measurements were taken in morning (8–10 a.m.), afternoon (2–4 p.m.), and evening (6–8 p.m.) periods. The obtained values were presented as mean ± standard deviation in decibels (dB). The highest average sound pressure level was found to be 90.3 ± 15.3 dB, while the lowest value was 55.30 ± 4.6 dB. There was no statistical significant difference in the noise level distributions in the three monitoring sessions (p = .74). Noise level distributions in the city exceeded the acceptable standard limits set by the World Health Organization. Health effects related to incessant exposures to high noise levels are likely to be common and may result in negative impacts on the well-being of the inhabitants of the city.**

Introduction

One of the most undesirable side effects of an improperly planned city and poor building construction is environmental pollution and the degradation of quality of life. Noise pollution is an important significant environmental problem in many rapidly growing cities (Björk et al., 2006; Gangwar, Joshi, & Swami, 2006; Kisku et al., 2006). Frequent exposure to high levels of noise has the potential to cause severe stress on the auditory and nervous systems (Stansfeld, Haines, Berry, & Burr, 2009). Extended exposure to excessive sound has been proved to cause physical and psychological damage (World Health Organization [WHO], 2011). Noise adds to mental stress due to its annoyance and disturbance implications, and hence affects the general well-being of those exposed to it (Agarwal & Swami, 2011; Finegold, Harris, & von Gierke, 1994; Singh & Davar, 2004). The primary urban sources of noise are industrial, traffic, and community noise—of which traffic noise is the most important. In traffic noise, vehicles contribute about 70% of noise. Vehicle noise is created by the engine and the exhaust system of vehicles, aerodynamic friction, interaction between the vehicle and road system, and by the interaction among vehicles and indiscriminate use of vehicle horns (Björk et al., 2006; Chauhan, Pawar, Kumar, Kumar, & Kumar, 2010; Pathak, Tripathi, & Mishra, 2008; Rao & Rao, 1991).

In physics, sound is a mechanical energy of a vibrating object transmitted by pressure waves through a medium such as air or water that is capable of being detected by the human (or animal) hearing organs. According to the World Health Organization (WHO), environmental noise is an unwanted or harmful sound created by human activities (Berglund, Lindvall, & Schwela, 1999; WHO, 2011).

Unlike chemical pollution, noise energy does not accumulate in the body or in the environment, but it can have both short- and long-term adverse effects on people. Perceptions of sound and noise are highly subjective: one person's music is another's headache. The two terms are often used interchangeably, although few would call the sound that emanates from a highway anything but noise. Sound (and noise) is actually a process that consists of three components: the sound source, sound path, and sound receiver.

Meanwhile, sound pressure level is a measure of the air vibrations that make up sound. The human ear can detect a wide range of sound pressure levels, expressed in Pascals (Pa) from 20 µPa to 200 Pa, that are measured on a logarithmic scale with units of decibels (dB) to indicate the loudness of a sound. Sound pressure level changes continuously with time or distance, and within certain ranges.

Elevated levels of noise can be a serious threat to public health. Some of the adverse effects of noise pollution are psychological effects, speech interference, sleep disturbance, and poor work performance. Noise is a biological stressor. Among the health risks posed by noise pollution are high blood pressure, coronary heart disease, ulcer, colitis, and migraine headache. It has been demonstrated that there is a relationship between high noise level exposure and health problems (Babisch, 2011; Babisch, Gallacher, Elwood, & Ising, 1988; Concha-Barrientos,

TABLE **1**

Sound Pressure Level Distribution at Different Locations in the Lagos Metropolis

Location #	Name of Location	Average Sound Pressure Level (dB)		
		Morning	Afternoon	Evening
1	Agege (railway crossing)	88.1 ± 6.9	74.6 ± 7.5	74.6 ± 13.4
2	Alaba International Market	84.3 ± 9.6	75.3 ± 2.7	66.3 ± 8.3
3	Alimosho-Ikotun Bus Terminal	78.9 ± 6.5	78.3 ± 7.0	84.5 ± 6.1
4	Computer Village	80.9 ± 1.6	84.0 ± 3.3	55.5 ± 4.6
5	Ebute-Meta Train Terminus	81.9 ± 3.1	82.7 ± 7.5	92.3 ± 10.4
6	Egbeda	79.2 ± 7.4	79.1 ± 12.7	76.8 ± 11.3
7	Iddo Train Terminus	78.9 ± 6.5	78.3 ± 7.0	84.5 ± 6.1
8	Ikeja Bridge	75.8 ± 4.8	76.8 ± 3.7	77.2 ± 6.8
9	Ikeja City Mall	78.9 ± 11.9	76.1 ± 10.5	75.6 ± 8.8
10	Ikeja L.G.A. Secretariat	79.3 ± 7.9	80.7 ± 7.3	71.8 ± 3.7
11	Iyana Ipaja	78.9 ± 6.5	78.3 ± 7.0	84.5 ± 6.1
12	Ketu	81.3 ± 10.0	77.2 ± 6.8	76.1 ± 14.1
13	Lagos Central Mosque Seriki	84.8 ± 4.9	86.5 ± 7.4	83.8 ± 15.2
14	Lagos Island (Broad Street)	73.6 ± 7.6	84.8 ± 4.1	78.7 ± 14.9
15	Lagos Island (Tinubu Street)	79.3 ± 0.6	82.1 ± 10.6	81.4 ± 13.0
16	Lagos State University Gate	69.5 ± 8.1	72.5 ± 9.4	74.9 ± 7.7
17	Mile 12	85.4 ± 6.7	77.2 ± 10.1	68.7 ± 2.5
18	Mile 2	77.7 ± 9.5	76.5 ± 7.3	84.1 ± 6.7
19	Mushin Market	77.7 ± 7.9	83.4 ± 12.2	83.0 ± 11.4
20	Obalande Bus Terminal	81.2 ± 3.0	85.6 ± 10.0	85.8 ± 8.1
21	Ogba-Ojodu	73.8 ± 8.0	75.5 ± 8.6	77.4 ± 7.7
22	Ojo Market	77.7 ± 6.7	73.6 ± 5.2	71.9 ± 9.2
23	Ojota	82.3 ± 8.0	80.5 ± 5.2	88.9 ± 5.2
24	Ojuelegba Bridge	78.7 ± 3.5	87.8 ± 5.3	85.9 ± 12.3
25	Oshodi	78.0 ± 10.6	75.2 ± 9.2	79.1 ± 13.8
26	Oyingbo Market	80.8 ± 6.6	76.9 ± 7.5	88.7 ± 9.4
27	Pen Cinema	80.8 ± 6.6	76.5 ± 7.3	84.2 ± 6.6
28	Sabo-Ikorodu	81.7 ± 5.8	73.9 ± 2.9	90.3 ± 15.3
29	Trade Fair International Market	75.5 ± 6.1	86.3 ± 7.1	67.7 ± 6.2
30	Unilag Gate (Akoka)	74.7 ± 10.0	64.4 ± 1.3	70.1 ± 8.2
31	Victoria Island	76.2 ± 9.7	63.2 ± 4.1	66.2 ± 5.0
32	Yaba-Tejuosho Market	82.5 ± 8.3	76.5 ± 7.3	84.2 ± 6.6

Note. Results are presented as mean ± standard deviation.

Campbell-Lendrum, & Steenland, 2004). Exposure to loud noise increases an arousal response in the body. Adrenaline is released in the blood; heart rate, blood pressure, and respiration increase; gastrointestinal mobility is restricted; blood vessels contract; and muscles are stretched. Even though noise has no relationship with danger, the body automatically responds to noise as a warning signal (Babisch, 2002; den Boer & Schroten, 2007; van Kempen et al., 2012).

Even relatively low levels of noise can adversely affect human health and quality of life (Allaouchiche, Duflo, Debon, Bergeret, & Chassard, 2002; Berglund et al., 1999; Bharanthan et al., 2007). Noise is a psychosocial stressor that activates the sympathetic and endocrine systems. Acute effects occur at high sound levels in occupational settings, and also at lower environmental noise levels when certain activities such as concentration, relaxation, or sleep are disturbed.

The aim of this study is to measure noise level distributions in the metropolis of Lagos, Nigeria, and compare the obtained values with international standard limits, with the purpose of evaluating the possible adverse health effects of noise levels on the generality of the residents.

Materials and Methods

A digital sound meter (DSM 325) was used to measure sound levels in the selected study areas. DSM 325 is a handheld meter for a wide range of applications where accurate sound level measurements are required. The DSM 325 has a measurement range of 32–130 dB over three ranges (32–80 dB, 50–100 dB, and 80–130 dB) with a resolution of 0.1 dB and an accuracy of ± 1.5 dB.

Lagos has a population of approximately 17.5 million people and is the economic nerve center of Nigeria. We selected 32 locations for data collection (Table 1). Factors considered for the selected locations included commercial activities, vehicular traffic, closeness to the motor parks, and markets.

The DSM 325 was placed on a tripod stand at a height of 1.5 m above the ground level with its microphone pointing toward the noise source. Three measurements were taken at 10-min intervals at each location with their longitude and latitude noted. Maximum and minimum sound pressure levels were recorded. The procedures were repeated for three sessions during the weekdays: morning (8–10 a.m.), afternoon (2–4 p.m.), and evening (6–8 p.m.). The obtained values are presented in mean ± standard deviation in dB. SPSS version 20 was used for statistical analysis. A value of $p < .05$ was considered statistically significant.

Results

Sound level distributions for the morning, afternoon, and evening are presented in Table 1; the graphical representations of the distribution in the morning, afternoon, and evening sessions are reported in Figures 1–3. It was observed that the sources of noise distributions were from vehicular traffic, human activities, and commercial activities of the selected areas. No location was free of noise pollution based upon the values we obtained.

The maximum average sound pressure level recorded was 90.3 ± 15.3 dB at Sabo-Ikorodu, while the minimum average value

FIGURE 1

Maximum and Minimum Noise Level Distributions in the Morning Period

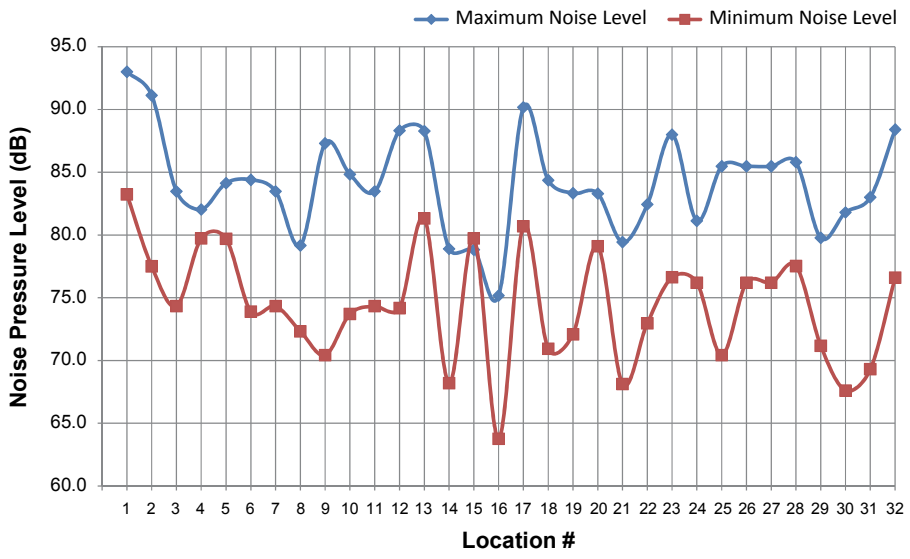
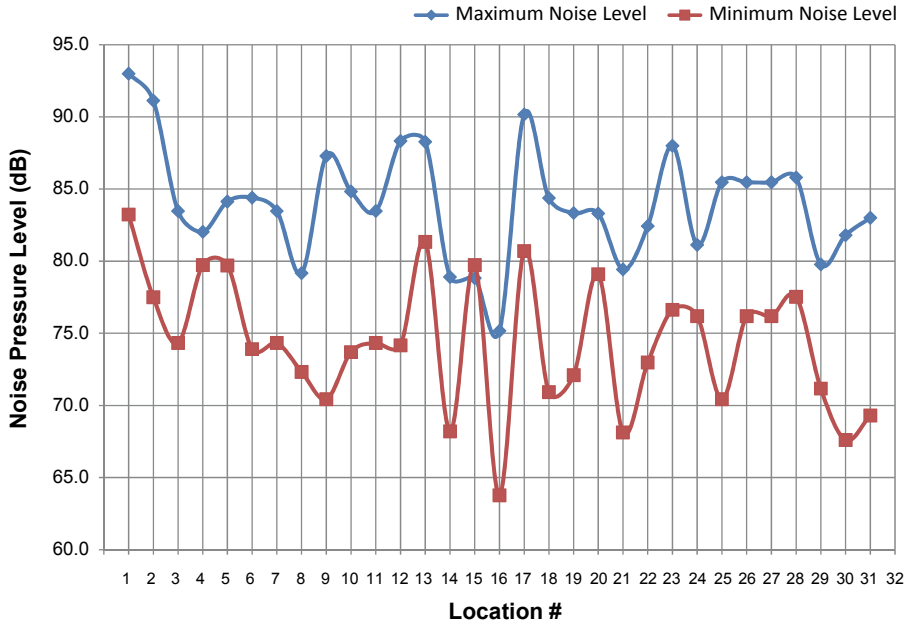


FIGURE 2

Maximum and Minimum Noise Level Distributions in the Afternoon Period



was 55.3 ± 4.6 dB at Computer Village in the evening session. Average sound pressure values for morning, afternoon, and evening were 79.3 ± 3.8, 78.1 ± 5.6, and 78.6 ± 8.3 vdB, respectively. There was no statistically significant difference in the sound level distribution values in the morning, afternoon, and evening sessions (p = .74).

The greatest maximum noise pressure level recorded in the 8–10 a.m. period was 91.1 ± 4.3 dB at Alaba International Market. The greatest minimum noise pressure level of 80.70 ± 5.75 dB was recorded at Mile 2 motor parks.

In the afternoon period of 2–4 p.m., Obalande Bus Terminal had the greatest maximum noise level of 92.63 ± 5.17 dB, with a minimum value recorded as 78.47 ± 3.72 dB. These levels are due to high commercial and vehicular activities in the area. The lowest maximum value was recorded at Unilag gate as 65.30 ± 4.85 dB, with a minimum value of 63.50 ± 5.14 dB. The commercial activity in this area is low because it is an academic environment compared with the other locations. The average maximum and minimum values for the afternoon session were 83.1 ± 6.5 dB and 73.1 ± 5.4 dB, respectively.

In the evening period of 6–8 p.m., the greatest maximum value was recorded at Sabo-Ikorodu area as 101.2 ± 5.6 dB, with a minimum value of 79.5 ± 2.2 dB. The traffic—both human and vehicular—was high in this area. The lowest maximum value of 58.8 ± 7.6 dB with a minimum value of 52.3 ± 3.1 dB was recorded at Computer Village (Ikeja). The average maximum and minimum values for the evening session were 84.9 ± 9.5 dB and 72.3 ± 7.9 dB, respectively.

Discussion

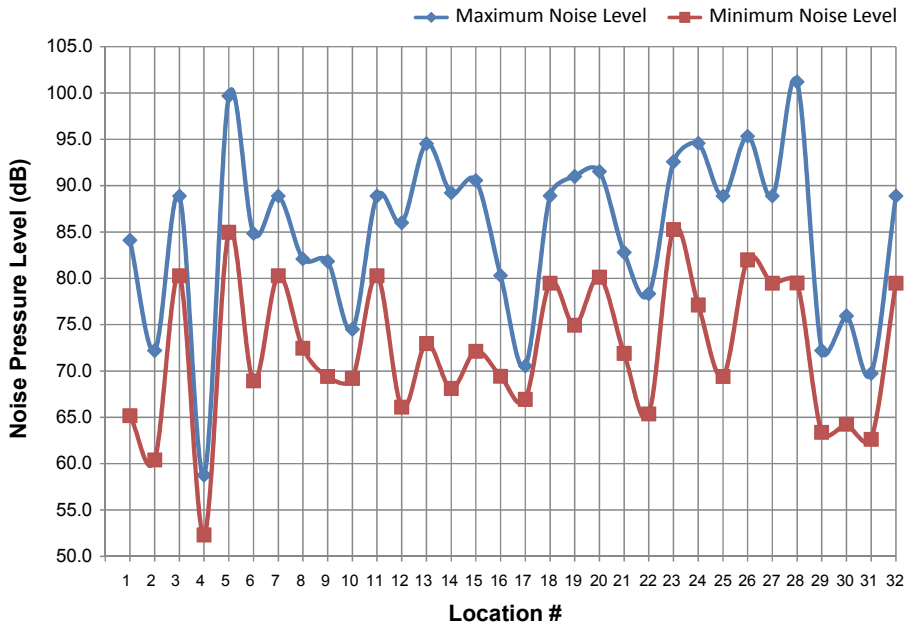
Lagos is a cosmopolitan city with a population of approximately 17.5 million inhabitants and with an annual growth rate of 3.2%. The Lagos metropolis covers 37% of the land area of Lagos State and is home to more than 85% of the state population. It also is the economic hub of Nigeria, with many private and public establishments.

The results obtained showed that the average sound pressure level in the Lagos metropolis was greater than WHO standard guidelines by 43.6%, 42.0%, and 42.7% in the morning, afternoon, and evening sessions, respectively. In comparison with other countries, noise levels measured in various locations in the city were greater than the standard limits. For example, the average noise levels measured in this study were greater than the stipulated limit in commercial areas in Australia (43.1%), India (21.0%), Japan (31.1%), and U.S. (31.1%) (Chauhan et al., 2010).

Human responses to noise exposures differs from person to person and can vary between

FIGURE **2**

Maximum and Minimum Noise Level Distributions in the Evening Period



an adaptation response for low noise levels, to repairable damage that disappears when the noise stops, or irreparable damage after severe exposure. Uninterrupted sleep is known to be a prerequisite for good physiological and mental functioning of healthy persons. Sleep disturbance, on the other hand, is considered to be an environmental noise effect. Environmental noise is not believed to be a direct cause of mental illness, but it is assumed that it accelerates and intensifies the development of latent mental disorders (WHO, 2009). Symptoms such as anxiety, emotional stress, nervous complaints, nausea, headaches, instability, argumentativeness, sexual impotency, changes in mood, increase in social conflicts, as well as general psychiatric disorders have been linked to incessant exposure to noise (Berglund et al., 1999; Chauhan et al., 2010; Pathak et al., 2008; Rao & Rao, 1991; Singh & Davar, 2004). According to Pathak and coauthors (2008), noise is one of the main reasons for headache, high blood pressure, and other stresses among exposed individuals. A study conducted by Finegold and coauthors (1994) indicated a high percentage of respondents displayed an annoyance reaction for the range of noise levels greater than 65 dB.

In this study, a sizable part of the community got annoyed when the noise was greater than a certain level; as the noise level increased, the level of annoyance increased. Road traffic noise studies suggest that cardiovascular risk increases when the outdoor noise levels during the day exceed 60–65 dB and 50–55 dB during the night (Babisch, 2011; Babisch et al., 1988).

The health implication of our monitoring these results indicated that the inhabitants of the Lagos metropolis were exposed to noise levels greater than 55 dB. Therefore, aural and nonaural health effects associated with noise pollution are possibly prevalent. According to previous reports, sleep disturbance, cardiovascular disease, elevated blood pressure level, prevalence of hypertension, myocardial infarction, and increased consumption of cardiovascular medications have been found to be common in areas where residents are continuously exposed to sound levels greater than 60 dB (Babisch, 2002, 2011; Babisch, Beule, Schust, Kersten, & Ising, 2005; Barregard, Bonde, & Ohrström, 2009; Clark & Stansfeld, 2007; Franssen, van Wiechen, Nagelkerke, & Lebret, 2004; Jarup et al., 2008).

Hearing impairment has been associated with excessive and continuous exposure to noise pollution. From the previous studies, men and women are equally at risk of noise-induced hearing impairment, with children and older people being more vulnerable (Berglund et al., 1999; Paunovic, 2013; Sliwinska-Kowalska & Davis, 2012; van Kempen et al., 2012; WHO, 2011). Health-based guidelines on community noise can serve as the basis for deriving noise standards within a framework of noise management.

Key issues of noise management include reduction options, models for forecasting and assessing source control action, setting noise emission standards for existing and planned sources, noise exposure assessment, and testing noise emission standards compliance (Berglund et al., 1999). When there is a possibility that public health will be endangered, even though scientific proof may be lacking, action should be taken to protect public health without awaiting the full scientific proof (Seidman & Standring, 2010). Concerted efforts should be made by the authorities to respond to legitimate complaints and expectations of the citizens to offer a quality sound environment to all metropolitan area inhabitants.

Noise management should have a foundation of constant monitoring of the environment for human exposures to elevated noise pressure levels. Special consideration to the consequences of noise when planning transport systems and land use will help to reduce noise pressure levels. Surveillance of noise-related health effects will help to inform policy to control noise pollution in fast-growing cities such as the Lagos metropolis (European Network on Noise and Health, 2013).

Conclusion

Noise pressure levels measured in the Lagos metropolis exceed the acceptable limits set by WHO. This high noise level can have serious implications for the general health and well-being of the inhabitants of the city. Measures should be taken to reduce the levels of noise pollution in the city. Such measures may include proper maintenance of vehicles and roadways, plantation of trees, and construction of noise barriers.

Corresponding Author: Zaccheaus Ayo Ibitoye, Department of Radiation Biology and Radiotherapy, College of Medicine, University of Lagos, PMB 12003, Idi-Araba, Lagos, Nigeria. E-mail: aibitoye@unilag.edu.ng.

References

Agarwal, S., & Swami, B.L. (2011). Road traffic noise, annoyance and community health survey—A case study for an Indian city. *Noise & Health, 13*(53), 272–276.

Allaouchiche, B., Duflo, F., Debon, R., Bergeret, A., & Chassard, D. (2002). Noise in the postanaesthesia care unit. *British Journal of Anaesthesia*, *88*(3), 369–373.

Babisch, W. (2002). The noise/stress concept, risk assessment and research needs. *Noise & Health, 4*(16), 1–11.

Babisch, W. (2011). Cardiovascular effects of noise. *Noise & Health, 13*(52), 201–204.

Babisch, W., Beule, B., Schust, M., Kersten, N., & Ising, H. (2005). Traffic noise and risk of myocardial infarction. *Epidemiology, 16*(1), 33–40.

Babisch, W., Gallacher, J.E., Elwood, P.C., & Ising, H. (1988). Traffic noise and cardiovascular risk. The Caerphilly Study, first phase. Outdoor noise levels and risk factors. *Archives of Environmental Health*, *43*(6), 407–414.

Barregard, L., Bonde, E., & Ohrström E. (2009). Risk of hypertension from exposure to road traffic noise in a population-based sample. *Occupational and Environmental Medicine, 66*(6), 410–415.

Berglund, B., Lindvall, T., & Schwela, D.H. (1999). *Guidelines for community noise*. Geneva, Switzerland: World Health Organization, Occupational and Environmental Health Team. Retrieved from http://www.who.int/iris/handle/10665/66217

Bharanthan, T., Glodan, D., Ramesh, A., Vardhini, B., Baccash, E., Kiselev, P., & Goldenberg, G. (2007). What do patterns of noise in a teaching hospital and nursing home suggest? *Noise & Health, 9*(35), 31–34.

Björk, J., Ardö, J., Stroh, E., Lövkvist, H., Ostergren, P.O., & Albin, M. (2006). Road traffic noise in southern Sweden and its relation to annoyance, disturbance of daily activities and health. *Scandinavian Journal of Work, Environment & Health*, *32*(5), 392–401.

Chauhan, A., Pawar, M., Kumar, D., Kumar, N., & Kumar, R. (2010). Assessment of noise level status in different areas of Moradabad City. *Report and Opinion, 2*(5), 59–61.

Clark, C. & Stansfeld, S.A. (2007). The effect of transportation noise on health and cognitive development: A review of recent evidence. *International Journal of Comparative Psychology, 20*(2), 145–158.

Concha-Barrientos, M., Campbell-Lendrum, D., & Steenland, K. (2004). *Occupational noise: Assessing the burden of disease from work-related hearing impairment at national and local levels* (Environmental Burden of Disease Series, No. 9). Geneva, Switzerland: World Health Organization. Retrieved from http://www.who.int/quantifying_ehimpacts/publications/9241591927/en/

den Boer, L.C., & Schroten A. (2007). *Traffic noise reduction in Europe*. The Netherlands: CE Delft. Retrieved from http://www.cedelft.eu/publicatie/traffic_noise_reduction_in_europe/821

European Network on Noise and Health. (2013). *Final report* (EU Project no. 226442 FP-7-ENV-2008-1). Luxembourg: Publications Office of the European Union. Retrieved from https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/final-report-ennah-european-network-noise-and-health-project

Finegold, L.S., Harris, C.S., & von Gierke H.E. (1994). Community annoyance and sleep disturbance: Updated criteria for assessment of the impacts of general transportation noise on people. *Noise Control Engineering Journal, 42*(1), 25–30.

Franssen, E., van Wiechen, C.M., Nagelkerke, N., & Lebret, E. (2004). Aircraft noise around a large international airport and its impact on general health and medication use. *Occupational & Environmental Medicine, 61*(5), 405–413.

Gangwar, K.K., Joshi, B.D., & Swami, A. (2006). Noise pollution status at four selected intersections in commercial areas of Bareilly Metropolitan city. *Himalayan Journal of Environment and Zoology, 20*(1), 75–77.

Jarup, L., Babisch, W., Houthuijs, D., Pershagen, G., Katsouyanni, K., Cadum, E., . . . & Vigna-Taglianti, F. (2008). Hypertension and exposure to noise near airports: The HYENA study. *Environmental Health Perspectives, 116*(3), 329–333.

Kisku, G.C., Sharma, K., Kidwai, M.M., Barman, S.C., Khan, A.H., Singh, R., . . . & Bhargava, S.K. (2006). Profile of noise pollution in Lucknow city and its impact on environment. *Journal of Environmental Biology, 27*(Suppl. 2), 409–412.

Pathak, V., Tripathi, B.D., & Mishra, V.K. (2008). Evaluation of traffic noise pollution and attitudes of exposed individuals in working place. *Atmospheric Environment, 42*(16), 3892–3898.

Paunovic, K. (2013). Noise and children's health: Research in Central, Eastern and South-Eastern Europe and Newly Independent States. *Noise & Health, 15*(62), 32–41.

Rao, P.R., & Rao, M.G.S. (1991). Prediction of L_{A10T} traffic noise levels in the city of Visakhapatnam, India. *Applied Acoustics, 34*(2), 101–110.

Seidman, M.D., & Standring, R.T. (2010). Noise and quality of life. *International Journal of Environmental Research and Public Health, 7*(10), 3730–3738.

Singh, N., & Davar, S.C. (2004). Noise pollution—Sources, effects and control. *Journal of Human Ecology, 16*(3), 181–187.

Sliwinska-Kowalska, M., & Davis, A. (2012). Noise-induced hearing loss. *Noise & Health, 14*(61), 274–280.

Stansfeld, S.A., Haines, M.M., Berry, B., & Burr, M. (2009). Reduction of road traffic noise and mental health: An intervention study. *Noise & Health, 11*(44), 169–175.

van Kempen, E., Fischer, P., Janssen, N., Houthuijs, D., van Kamp, I., Stansfeld, S., & Cassee, F. (2012). Neurobehavioral effects of exposure to traffic-related air pollution and transportation noise in primary schoolchildren. *Environmental Research*, *115*, 18–25.

World Health Organization. (2009). *Night noise guidelines for Europe*. Copenhagen, Denmark: World Health Organization Regional Office for Europe. Retrieved from http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2009/night-noise-guidelines-for-europe

World Health Organization. (2011). *Burden of disease from environmental noise: Practical guidance*. Copenhagen, Denmark: World Health Organization Regional Office for Europe. Retrieved from http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2011/burden-of-disease-from-environmental-noise-practical-guidance