Road Traffic Noise and $PM_{2.5}$ Impacts on Workers' Health in Different Microenvironments of an Urban Traffic Corridor

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By

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CERTIFICATE

This is to certify that Argha Kamal Guha has been working under my supervision since July, 2016 as a Ph.D. student of the Department of Civil Engineering in Indian Institute of Technology Guwahati. His thesis entitled **"Road Traffic Noise and $PM_{2.5}$ Impacts on Workers' Health in Different Microenvironments of an Urban Traffic Corridor"** is an authentic record of the results obtained from the research work carried out under my supervision in the Department of Civil Engineering, Indian Institute of Technology Guwahati, Assam, India. I certify that he has fulfilled all the requirements according to the rules of this institute regarding the investigations embodied in his thesis and this work has not been submitted elsewhere for a degree.

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DECLARATION

I declare that the research work embodied in this doctoral thesis is the result of the investigations carried out by me in the Department of Civil Engineering, Indian Institute of Technology Guwahati, India. The sources referred in the creation of this research work have been appropriately acknowledged. I have not knowingly copied or used the words or ideas of others without acknowledgement.

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Dedicated

to

the lotus feet

of

Holy Trio

(Bhagwaan Shri Ramakrishna Paramahansha Deva, Holy Mother Shri Sarada Devi and Revered Swami Vivekananda),

My Spiritual Shri Gurudeva (Revered Swami Suhitananda Ji Maharaj),

My Parents (Late Sri Avik Kamal Guha and Smt. Bijaya Guha)

&

My Mentor (Prof. Sharad Gokhale)

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ABSTRACT

Urban traffic corridors are severely polluted by traffic air, and noise pollution due to unprecedented growth of traffic. This study investigated the workplace annoyance and cardiovascular health of people working in two microenvironments such as street (vendors) and workplace (office workers) whose blood pressure (BP) and heart rate (HR) might be affected due to regular exposure to $PM_{2.5}$ and traffic noise. The $PM_{2.5}$ and noise levels measurements, face-to-face questionnaire survey and health check-ups were carried out on working days from 10 a.m. to 8 p.m. in Jan-Dec 2019. The data was analysed by various statistical approaches in which the link between the traffic-borne $PM_{2.5}$ and noise level at 1/3rd octave frequencies has been established with the participants' BP and HR considering the demographic, socio-contextual, habitual and annoyance perception factors. The median measure of $PM_{2.5}$ (106.67 µg/m^3 at street level and 33.33 µg/m^3 at office indoor) and noise level (71.35 dB (A) at the street and 65.78 dB (A) at office indoor) violated the WHO and NAAQS allowable limit. In winter, noise levels and $PM_{2.5}$ were relatively higher than in other seasons. The street-side $PM_{2.5}$ has been observed to be slightly correlated (ρ=0.299-0.344) with street-side peak noise and background noise, which might be due to the significant contribution from the same source on noise and the particulate pollution in that study area. This slight correlation suggests there might be the possible influence of other sources and some urban factors.The workplace annoyance was correlated with questionnaire variables (ρ: 0.364-1.000) and $PM_{2.5}$ (ρ:-0.326-0.235). The low-mid frequencies noise, $PM_{2.5}$, residential characteristics, family income, smoking, night traffic activities near residential area, and family income were the significant predictors of workplace annoyance. The results showed that above 40 dB (A) of 50Hz, 35 dB (A) of 100 Hz, 50 dB (A) of 315 Hz noise spectrum and > 50µg/m^3 of $PM_{2.5}$ significantly increase high annoyance perception of the respondents. While, noise level > 55 dB (A) 630 Hz leads to decrease annoyance of office workers' and > 100µg/m^3 of $PM_{2.5}$ leads to decrease the annoyance of street vendors.

The results further showed that the workers working in traffic corridors had abnormally high BP and HR. The systolic BP, diastolic BP and HR values were higher than normal in male workers than female workers. The influence of low noise spectrum (50-630 Hz) was mostly observed. Therefore, the combined effect of $PM_{2.5}$ > 50 µg/m^3 and noise spectrum (63 and 100 Hz) > 30 dB (A) significantly affected the office workers' health in the traffic corridors. The hearing aids, breathing troubles in the traffic corridor and annoyance perception also influenced the BP and HR of the respondents. SoundPLAN traffic noise modelling study highlighted that car movement significantly contributes the low frequencies noise spectrum while, bus and truck contributes the higher frequency noise in that study area. The results are indicative and might be helpful in urban environmental planning to improve the well-being of urban traffic corridor users.

Keywords Urban traffic noise; 1/3rd octave frequency; $PM_{2.5}$, Cardiovascular health; Traffic corridors; Workplace exposure; Environmental health

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LIST OF SYMBOLS

Symbol	Description
dB(A)	Decibel (A)-weighted
dB(C)	Decibel (C)-weighted
L_{peak}	Peak noise level measured at C-weighting network
L_{max}	Maximum average noise level measured at A-weighting network
L_{min}	Minimum average noise level measured at A-weighting network
L_{eq}	Equivalent noise level measured at A-weighting network
L_{10}	Noise level equal or exceeded the 10% of monitoring duration and it is widely known as peak noise component
L_{50}	Noise level equal or exceeded the 50% of monitoring duration and it is widely known as median noise
L_{90}	Noise level equal or exceeded the 90% of monitoring duration and it is widely known as background noise component
L_{95}	Noise level equal or exceeded the 95% of monitoring duration and it is widely known as background noise component
$NC_{(L90)}$	Noise climate indicates the fluctuation of noise level w.r.t. L_{90}
$NC_{(L95)}$	Noise climate indicates the fluctuation of noise level w.r.t. L_{95}
PM_{10}	Particulate matter which is having aerodynamic diameter equal or less than 10 µm
$PM_{2.5}$	Particulate matter which is having aerodynamic diameter equal or less than 2.5 µm
PM_1	Particulate matter which is having aerodynamic diameter equal or less than 1 µm
WA	Workplace annoyance
RA	Roadside annoyance
NA	No annoyance
SA	Slight annoyance
MA	Medium annoyance
HA	High annoyance
FB	Fractional Bias
O.R.	Odds Ratio
C.I.	95% Confidence Interval

LIST OF ABBREVIATION

Abbreviation	Description
BP	Blood Pressure
CoRTN	Calculation of Road Traffic Noise Model
CPCB	Central Pollution Control Board
DALY	Disability-Adjusted Life Years
DBP	Diastolic Blood Pressure
DOT	U.K. Department of Transport
FHWA	U.S. Federal Highway Administration
FNM	Façade Noise Map
GNM	Grid Noise Map
HR	Heart Rate
HRV	Heart Rate Variation
IHD	Ischemic Heart Disease
MUV	Multi-utility Vehicle
NAAQS	National Ambient Air Quality Standard
NIPTS	Noise Induced Permanent Threshold Shift
OSHA	Occupational and Safety Health Administration
PNC	Particle Number Concentration
PTFE	Polytetrafluoroethyne
RLS-90	German Standard Richtlinien für den Lärmschutz an Straben Trafiic Noise Model
SBP	Systollic Blood Pressure
SLM	Sound Level Meter
SWISS TPH	SWISS Tropical and Public Health Institute
TNI	Traffic Noise Index
TNM	Traffic Noise Model
UFP	Ultrafine Particulate Matter which is having aerodynamic diameter of equal or less than 0.1 μm
UN	United Nation
USEPA	United State Environmental Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organisation
WRI	World Resource Institute
YLL	Years of Life Loss

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Rapid urbanisation is leading to environmental pollution, is of utmost concern for its impact on human health. Air and noise pollution are the significant environmental stressors of urban areas. Road traffic contributes to substantial proportion of environmental air and noise pollution in urban areas (Jiménez-Uribe et al., 2020) and add pollution loads in the close vicinity of human activities. Besides increasing traffic emissions, rapid urbanisation and populations make medium-to-high density housing development in cities almost inevitable particularly, in and near transportation hubs and shopping malls. The problem of air pollution becomes severe when the road is flanked by the high-rise and densely populated buildings that create deep roadway canyons impeding the dispersion of pollutants. Thus canyon effects can further elevate the on-street pollutant levels (Colvile et al., 2001 ; Huang et al., 2021). Even during less traffic on urban roadways, it pollution is much higher than on broad and open streets (Rakowska et al., 2014). Similarly, noise due to multiple reflections by the roadside buildings and other surfaces, on street noise levels are very high. Therefore, urbanising cities are facing degradation of air and noise quality.

1.2 TRAFFIC AIR AND NOISE POLLUTION AND ITS' HUMAN HEALTH CONSEQUENCES

Urbanisation in Indian cities have increased vehicular population up to 700% from 1990 – 2010, which is expected to increase higher by 4 - 5 times by 2030 (Guttikunda and Mohan, 2014). The older vehicles are emission intensive and contribute 30 - 50% of the total air and noise emissions from the transport sector (Guttikunda and Mohan, 2014). In most Asian cities (such as Mumbai, Kolkata, Delhi, Dhaka, Jakarta, and Manila in East Asia), motor vehicles are observed as the leading sources of air and noise emissions (Desvina et al., 2019). In these cities, pollution levels frequently exceed the World Health Organisation (WHO) air quality standards by a factor of two, three or more (WRI,2023), causing severe human health risks.

Commuters in the vicinity of heavy traffic environments are exposed to higher air pollution. Exposure level of each human is different and depends on several factors such as the type of vehicles (engine/after-treatment technologies/ fuel type), meteorological conditions (Dons et al., 2011 ; Karanasiou et al., 2014) and the age group of commuter and their health status. Commuters, on average, spend 0.34 - 2.06 h for commuting in the vicinity of the traffic microenvironment in India (Sabapathy et al., 2012). Besides, traffic-related air pollution severely affects the people residing and working in the vicinity of the roadside indoor environment. Different transport modes such as three-wheelers, buses, two-wheelers, trucks, bikes, contribute to fine particles (PM_{10}, PM5, and $PM_{2.5}$) in the traffiked way (Sabapathy et al., 2012; Forehead and Huynh, 2018). Saini and Sharma (2020) reported that $PM_{2.5}$ concentration in most of the Indian cities exceeded the annual average National Ambient Air Quality Standards (NAAQS) of 40µg/m^3 and World Health Organisation (WHO) of 5 µg/m^3 by a factor of 2 - 4. Less than 0.01% population lives in places which meet the World Health Organisation's (WHO) prescribed limit of 10 μg/m^3(Chen and Lippmann, 2009). More prolonged exposure to fine particulate matter causes morbidity and mortality due to respiratory, cardiovascular, and cerebrovascular diseases (Chen and Lippmann, 2009). Han et al. (2005) studied the $PM_{2.5}$ exposure of different urban workers and they observed that the $PM_{2.5}$ exposure of bus drivers, gas station attendants and office workers was 161±8.9 μg/m^3, 64 ± 26.5 μg/m^3 and 65 ± 8.5 μg/m^3, respectively. In Asia, the highest level of $PM_{2.5}$ mortality is observed (Apte et al., 2015). According to Lim et al. (2012), ambient and household air pollution is the primary disease factors for Indian people. Around 10,000 premature deaths in India are due to air pollution (PHFI, 2014). The premature mortality related to $PM_{2.5}$ pollution in different Indian cities is 114,700 (104,100 - 125,500) deaths from ischemic heart disease (IHD), cerebrovascular disease (stroke), chronic obstructive pulmonary disorder (COPD), lower respiratory infection, and lung cancer (Saini and Sharma, 2020). Dey et al. (2012) observed, between 2000 and 2010, the increase in $PM_{2.5}$ concentration in several Indian cities, i.e. Delhi, Mumbai, Kolkata, Patna, Kochi, Amritsar and Jamshedpur. In India, most source apportionment and epidemiological studies are conducted on SPM or PM_{10} and gaseous pollutants, but studies on $PM_{2.5}$ and ultrafine particle are limited (Pant et al., 2016). Tiwari et al.(2017) studied temporal evolution, source apportionment and transport pathways of particulate matter ($PM_{2.5}$ and PM_{10}) in Guwahati city. In December - March the PM_{10} and $PM_{2.5}$ concentrations were high and in summer it was found low. The estimated annual mean ratio of $PM_{2.5}$ and PM_{10} was 0.57 ± 0.11, which indicating the dominance of anthropogenic and natural emissions during winter and spring seasons. The diurnal variation showed higher concentrations during morning and evening and lowest concentration 14:00 - 17:00 hours due to reduction in traffic activities and better meteorological effect.

Besides air pollution, unprecedented growth in vehicular population also causes severe noise pollution in urban areas, contributing to 55% of the total noise in traffic ways (Vij and Agrawal, 2013). Traffic noise pollution is an important environmental hazard of urban area and its exposure is omnipresent both in developing and developed countries (Mehdi et al., 2011; Gan et al., 2012 ; King, 2022). Noise levels in urban cities are always higher than 55 dB (A), the threshold of different delineating human health hazards (Jiménez-Uribe et al., 2020 ; Münzel et al., 2021). Near an urban roadway in Surat city, Ranpise and Tandel (2022) observed A-weighted noise level as high as 78.9 dB(A) (46.1 - 114.9 dB (A)), which is way above the CPCB recommended standard. The traffic flow, horn honking and improper landscape were contributing to the elevated noise levels. In Kanpur city of India, the average A-weighted noise levels were 44.85 - 79.57 dB (A) (Mishra et al., 2021). Jiménez-Uribe et al. (2020) observed that low frequency noise was influenced by different types of traffic throughout a day, however, high frequencies were influenced by heavy vehicles during day and night both. Can et al. (2010) noticed that the slow moving vehicle and accelerating vehicle emit low frequency noise (<1 kHz). Ishiyama and Hashimoto (2000) observed that the reduction of human annoyance perception linked with the reduction of road traffic frequency above 4.8 kHz. Caciari et al. (2013) observed a noticeable difference in hearing threshold at low - mid frequencies (250 Hz - 2000 Hz) of urban outdoor and indoor workers of Italy. Liu et al. (2016) observed the 250 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz occupational noise spectrum influenced the incidence of hypertension to the workers. 20 dB(A) increase in noise exposure at 4 kHz was related with a 34% higher risk of hypertension (relative risk (*RR*): 1.34; 95% confidence interval (*C.I.*): 1.01, 1.77). Alam et al. (2021) developed 3D noise map both vertical and horizontal with SoundPLAN model for the densely populated busy street of Delhi city. Banerjee, Das and Fouzdar (2014) used SoundPLAN CoRTN model for estimating traffic noise exposure of residents and observed that day-evening-night noise level (L_{den}) > 65 dB(A) for men and L_{den} > 60 dB(A) in women were associated with the occurrence of hypertension.

Prolonged, traffic noise exposure causes several psychological and physiological health problems, including annoyance, sleep disturbance, stress reactions, hypertension, cardiovascular events and diabetes (Dratva et al., 2010 ; Münzel et al., 2021 ; Prasad et al., 2022 ; Shamsipour et al., 2022). Some studies have reported the effect of traffic noise on the heart ; which acts on the endocrine and autonomous nervous system, increasing the probability of myocardial infarction (Ndrepepa and Twardella, 2011; Münzel et al., 2021 ; Shamsipour et al., 2022). Some researchers reported significant associations between air and noise pollution (Ögren and Molnar, 2014 ; Khan et al., 2018), although air pollutant dispersion and noise propagation pathways are different, but both of these share a common environmental receptors simultaneously. Researchers observed that combined effect of traffic-induced air and noise pollution lead to annoyance, blood pressure and cardiovascular mortality, stroke, diabetes and different severe health disorders (Beelen et al., 2009 ; De Roos et al., 2014 ; Foraster et al., 2014 ; Tonne et al., 2016 ; Héritier et al., 2018 ; SWISS TPH, 2018). Most of the air and noise pollution research has been conducted in the United Kingdom (UK), Denmark, Norway, Sweden and in Germany, indicated significant health deterioration (Klæboe et al., 2000 ; Weber et al., 2014 ; Sørensen et al., 2015 ; Fecht et al., 2016b ; Tonne et al., 2016 ; Pitchika et al., 2017b). In Delhi the combined impact of PM_{10}, TSP, SO2, NO_2 and noise leads to several health disorders related to cardiovascular, respiratory and psychological problems (Mandal et al., 2012). Exposure to $PM_{2.5}$ and noise can lead to cardiovascular diseases for youth by affecting the heart rate variability (Huang et al., 2013 ; Fuks et al., 2017).

Only a few studies were found to have been carried out in Indian environment where air and noise both together not evaluated (Bhandari et al., 2015) on the problem associated with traffic borne $PM_{2.5}$ and noise pollution at the heterogeneous urban road environments.

1.3 CONFOUNDERS OF THE RELATIONSHIP BETWEEN TRAFFIC NOISE, $PM_{2.5}$ AND HUMAN HEALTH AILMENTS

Most of the studies concluded the importance of demographic, socio-contextual and personal factors and existing human health ailments are significant confounders of the relationship between pollutants and health. Several studies highlighted the influence of demographic and socio-contextual parameters, residential characteristics including housing proximity from nearest road, building facing, window and door location, neighbourhood environment including status of traffic activities, different outdoor air and noise sources, the perception of noise event during sleeping which indicates noise induced sleep disturbances and the information on health status are the significant explanatory factors for air and noise pollution annoyance and different health ailments (Rotko et al., 2002; ISO 15666 - 2003 ; Rotko, 2004 ; Frei et al. 2014 ; Nieuwenhuijsen, 2015 ;Chung et al., 2020; Lefèvre et al., 2020). Degree of annoyance is mainly linked to personal factors (e.g. sensitivity to pollutant, fear of harm connected with the source, personal evaluation of the source, and coping capacity with respect to noise) and social factors (e.g. general evaluation of the source, trust or misfeasance with source authorities, history of exposure, and expectations of residents) (Pitchika et al., 2017). This human annoyance perception is linked with different human health ailments (Babisch et al., 2003;Miedema, 2007). Pitchika et al. (2017) observed that heavy traffic passing adjacent to the bedroom and noise annoyance in either bedroom or living room was associated with a higher prevalence of hypertension. The same researchers highlighted the low income householders are very prone to exposed with high noise and air pollutant level.

Okokon et al. (2018) observed that people who dwelled with street-side bedroom windows were very prone to use antidepressants due to higher noise exposure. It was well established that noise events can hamper sleep structure (Ebben et al., 2021 ; Sanok et al., 2022); therefore, noise event interference with sleep induces workplace annoyance. Rotko et al. (2002) and Jacquemin et al.(2007) observed the influence of $PM_{2.5}$ and different socio-demographic factors including gender, education, vehicle operation near residential area, different residential building characteristics, smoking habit on human annoyance response. Petri et al. (2021b) observed that an increase of 5 dB (A) in nocturnal noise could elevate diastolic blood pressure (DBP) among people > 65 y, residing without household noise protection and those who keep windows open. Lim et al. (2021) observed the influence of $PM_{2.5}$, NO_2 and day-evening-night noise level (L_{den}) on the heart failure issues of female nurses who had hypertension and past smoking habit. In Delhi city of India, Jain and Barthwal (2022) observed the auto-rickshaw drivers were very vulnerable than cab driver for developing various respiratory, ophthalmic, dermatological and other health problems due to high exposure to PM_1, $PM_{2.5}$ and PM_{10}. They also considered different socio-demographic factors including age, gender, BMI, information of alcohol, smoking and tobacco consumption, education, family income, vehicle ownership, working hours and different existing health ailments in their research. Prasad et al. (2022) studied the role of demographic factors (age, gender, marital status, education, and profession) on the association between the traffic noise induced psychophysiological ailments of bike riders, they concluded that blood pressure is the significant consequences of annoyance, depression, sleeping problems, tiredness and head ache. That means traffic noise indirectly influencing blood pressure. Therefore, there is a strong requirement for identifying the significant confounding variables for exploring the nexus between traffic noise and air pollution and human health ailments of different urban populations.

Thus, plethora of literatures focussed on the urbanisation driven traffic population and its' role on increasing environmental air and noise pollution. Among air pollutants $PM_{2.5}$ is identified as a serious threat to human health. Similarly, traffic noise is also a serious environmental pollution after air pollution for its' various delineating human health effects including auditory and non-auditory viz. cardiovascular, cerebrovascular and various physiological and psychological ailments. There is a serious need to characterise the road traffic noise frequencies for environmental epidemiological research. Only a few studies focused on the combined effect of $PM_{2.5}$ and noise pollution on human health. Urban workers (e.g. street vendors, office workers) are the most vulnerable group of people apart from urban residents, who used to spend a significant portion of their daily life in the polluted urban road environments, however very limited environmental epidemiological research considered them.

1.4 RESEARCH AIM

The introduction warrants that traffic borne $PM_{2.5}$ and noise pollution could be studied with their individual and combined human-health consequences in urban area. **The main objective of this research is to investigate the human health impact of urban traffic-borne noise and $PM_{2.5}$ for the workers' working in different microenvironments.** This objective was achieved by studying the following tasks:

- ✓ Selection of a suitable study area in a congested urban traffic corridor and identifying the microenvironments.
- ✓ Measurements of $PM_{2.5}$ concentrations and environmental noise levels in the office building and the street side ambient environment. The local meteorology and traffic

volume on the street side.

- ✓ Development of a social questionnaire about air and noise pollution. And to conduct the questionnaire survey for the workers working in the selected microenvironments.
- ✓ Conduct a health camp for health surveys to measure blood pressure (BP) and heart rate (HR) of the workers.
- ✓ Statistical analysis and interpretation of $PM_{2.5}$, noise, traffic volume, meteorology, the questionnaire survey responses, and the health data on BP and HR
- ✓ Assessment of $PM_{2.5}$ and noise pollution in different urban road microenvironments
- ✓ Noise level modelling using SoundPLAN
- ✓ Model validation with field data
- ✓ Identification of traffic which significantly contribute major portion of environmental noise in a typical mixed urban road environment.
- ✓ Determine the impacts of traffic noise and $PM_{2.5}$ on urban workers' annoyance.
- ✓ Determine the impacts of traffic noise and $PM_{2.5}$ on the cardiovascular health of urban workers.

1.5 NOVELTY STATEMENT AND CONTRIBUTION

- ✓ Noise and $PM_{2.5}$ pollution indices have been developed for the physiological and psychological assessment of workers working in an urban traffic corridor's microenvironments (roadside shops and the workplace).
- ✓ The relationships of $PM_{2.5}$ concentrations and 1/3rd octave frequency-dependent noise with the workers' cardiovascular health in both microenvironments have been studied.
- ✓ A combined effect of $PM_{2.5}$ and traffic noise has been studied on workers' workplace annoyance and cardiovascular health (blood pressure and heart rate).

- ✓ Several pertinent non-pollutant factors have been identified affecting the workers' annoyance and cardiovascular health indices.

1.6 ORGANISATION OF THESIS

CHAPTER 1: Introduction chapter introduces the research topic and provides the summary of urban $PM_{2.5}$ and noise pollution status and its' related human health consequences in consideration of the different mitigation measures. It describes the main goal of this research, research objectives, novelty statement, research contributions and organisation of the thesis.

CHAPTER 2: Literature review chapter highlights the background of the traffic emissions, characteristics of $PM_{2.5}$ and noise, it critically reviews the existing literatures on different measurement techniques of $PM_{2.5}$, various monitoring and modelling approaches of noise, and its' individual and combined human health consequences. It also summarise the overall findings of existing literature and its' research limitations.

CHAPTER 3: Research methodology chapter provides the detailed methodologies for measuring $PM_{2.5}$ and noise pollution in the study area and evaluating its' human health consequences and the effective mitigation approach. The chapter includes study area selection, monitoring locations, data collection techniques, and characterisation of questionnaire study and procedure of health survey and noise and $PM_{2.5}$ modelling approaches for the study environments, and the brief procedure of statistical model for linking traffic-borne $PM_{2.5}$, noise and questionnaire and health outcome. The schematic diagram of research methodology has been presented.

CHAPTER 4: Data analysis and interpretation chapter includes the in-depth analysis of the data and the interpretation. It includes of the pollutant levels, development of noise-$PM_{2.5}$ index which indicates the environmental air and noise quality of that study area, traffic, meteorological characteristics, and questionnaire and health survey outcome. Further, the statistical relationship of pollutants with traffic, meteorology, questionnaire and health survey results has been presented. Here, the descriptive statistics, Spearman-rho correlation were used to investigate the relationship between pollutants, questionnaire and health survey results.

CHAPTER 5: Traffic noise propagation modelling chapter covers the details of traffic noise propagation model for urban roadside outdoor and indoor in terms of single point receiver, façade noise map (FNM) and grid noise map (GNM). Then the model output validation with measured noise level is also discussed. This section also characterise the different traffic source contribution to the environmental noise levels in the microenvironments.

CHAPTER 6: Traffic-borne $PM_{2.5}$ and noise impacts on urban workers' annoyance chapter describes the impact of traffic noise and $PM_{2.5}$ on development of urban workers' annoyance. The demographic, socio-contextual parameters which are significantly linked with urban workers' annoyance are also addressed. Lastly, this section also covers the vulnerable traffic noise spectrum and $PM_{2.5}$ for developing annoyance perception of urban workers'.

CHAPTER 7: Traffic-borne $PM_{2.5}$ and noise impacts on urban workers' cardiovascular health chapter describes the linkage between traffic noise, $PM_{2.5}$ and cardiovascular health (blood pressure and heart rate) along with e demographic, socio-contextual parameters.

CHAPTER 8: Findings and conclusion chapter summarises the key findings of the research, general and specific conclusions, limitations and scope for future work.

CHAPTER 2

LITERATURE REVIEW

The literature has been critically reviewed on the broad topics in line with the main objective of this study. It includes basics of air and noise pollution, traffic characteristic, characteristic of $PM_{2.5}$ and ambient noise roadside, different measurement and modelling techniques, air and noise pollution trends and its' human health consequences. It has been found that air and noise together have serious health consequences both physiological and psychological and therefore need urgent attention in urban centers.

2.1 GENERAL

Urbanisation induced air and noise pollution have become a serious environmental threat. In urban areas, air and noise pollution generally originate from traffic, commercial activities and construction activities (Kumar et al., 2018). Air and noise pollution both have a common source. Therefore, people using traffic corridors in urban areas are exposed to both air and noise pollution. It is reported that urban population at large suffer from cardiovascular disease and are often annoyed with the rising particle pollution in particular and loud noise continuously emitting from vehicular traffic. This review critically identifies the causes and health consequences of people being exposed in urban areas while working and commuting in different microenvironments.

2.2 VEHICULAR POLLUTION

Vehicular emission include combustion products and particles from wear and tear of road surfaces and noise from engines (Lipfert et al., 2006). The operating and environmental conditions affect the emissions of both air and noise (Pandian et al., 2009). Vehicle parameters such as vehicle class, weight, engine size, vintage, mileage, fuel-delivery system (e.g. carburetted or fuel-injected), emission control system, and inspection and maintenance have direct influence on the air and noise emissions. Fuel characteristics have a considerable impact on vehicle tailpipe and evaporative emissions (Pandian et al., 2009). The vehicle operating conditions further impact the rate of emissions, which include average vehicle speed, modal activities, load (e.g. A/C, heavy loads, or towing), trip length and trips per day, and driver behaviour.

Road traffic emits significant portion of particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxides (NOx) carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC) (Waked and Charbel ,2012). Singh and Payra (2022) observed that in January 2019, roadside areas of Delhi city of India, highly polluted with monthly average of PM_{10} and $PM_{2.5}$ of 426.77 and 301.91 µg/m^3 in respectively.

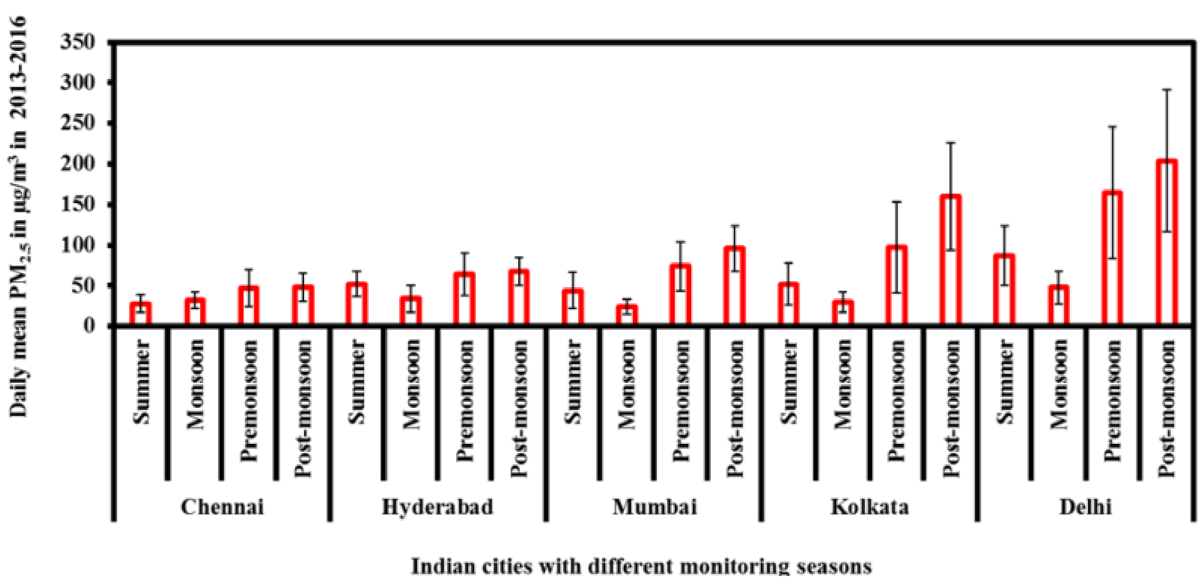


Figure 2.1 Daily average ambient $PM_{2.5}$ pollution in different Indian cities (Source :Sreekanth et al.**(2018))**

Figure 2.1 shows that almost every Indian cities shown here were highly polluted with $PM_{2.5}$ and post-monsoon season was the severely polluted by $PM_{2.5}$. Kalaiarasan et al.(2018) observed that major portion of ambient $PM_{2.5}$ originated by two wheeler, four wheeler and heavy vehicle (diesel operated) in Mangalore.

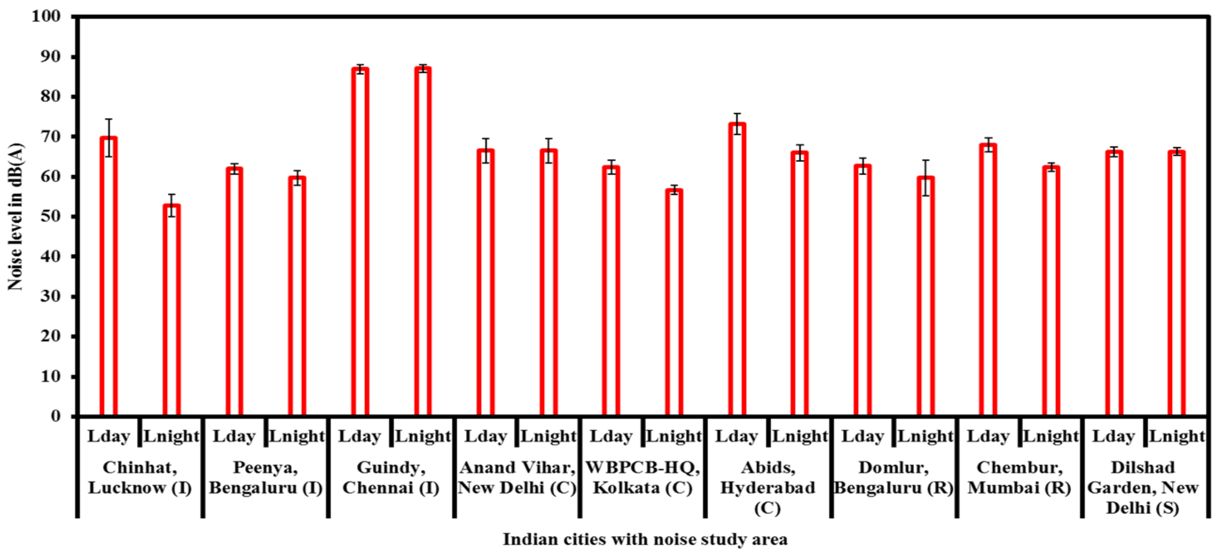


Figure 2.2 Noise level in different Indian cities (Source: Mimani and Singh (2021))

Figure 2.2 shows that noise level in most of the Indian cities was exceeded the Central Pollution Control Board (CPCB) day time allowable limit of 65 dB (A) of commercial area. In Imphal city the observed equivalent noise level (L_{eq}) of 52.2-69.9 dB(A) at morning (7 a.m. - 10 a.m.), 52.4 - 69.3 dB(A) at noon (12 noon-2 p.m.), and 54.6-71.1 dB(A) at evening (4 p.m. -7 p.m.) (Nungate and Alam ,2022). Kalawapudi et al. (2020) observed that in Mumbai majority of commercial area exposed with the day time noise level of 75-90 dB (A). Fecht et al. (2016) observed that roadside area of London highly polluted with $PM_{2.5}$ and noise.

2.2.1 $PM_{2.5}$ pollution

Ambient $PM_{2.5}$ consists of organic carbon (OC), elemental carbon (EC), ion species, trace elements and mixture of many primary and secondary aerosols. Exposure to $PM_{2.5}$ is more linked with increases in cardiopulmonary health consequences than exposure to relatively larger particles (Park et al., 2018). Particulate pollutants mainly emerge from exhaust but also from wear and degradation like tire-wear particles (such as latex and zinc), brake-wear particles, and resuspended road dust (Lipfert et al., 2006). These particles tend to occur in all size ranges, but those in the fine fraction are of more interest here because of their longer atmospheric residence times and thus greater opportunities for human exposure, i.e. $PM_{2.5}$.

Singh et al. (2021) found that $PM_{2.5}$ mass concentration was high in winter season due to combined increased emissions from biomass burning and traffic operations and meteorological condition which limits $PM_{2.5}$ dispersion. Traffic originated $PM_{2.5}$ consists elemental carbon (EC) and organic carbon (OC) with diverse functional groups, as well as few amounts of water-soluble ions, trace elements, and water (Onat et al., 2013;Wang et al., 2021). Some semi-volatile hydrocarbons consisting polycyclic aromatic hydrocarbons (PAHs) in the organic carbon (OC) are identified as human carcinogens (Mohammed et al., 2016). Traffic originated $PM_{2.5}$ comprises of redox active trace elements including Ni, Cr, Co, and As that contribute to both carcinogenic and non-carcinogenic health risk to individuals exposed to outdoor air pollution (Onat et al., 2013 ; Wang et al., 2021). Traffic-related $PM_{2.5}$ is not only related with the vehicular emissions and gas-to-particle conversion procedures, but also with tire and brake wear, asphalt, engine oil and re-suspension of road dust (Pant and Harrison, 2013). Now days, increased concentrations of $PM_{2.5}$ and metals during fog periods have been identified to cause significant health risk in humans (Liang et al., 2019).

$PM_{2.5}$ can originate from various outdoor sources (e.g. biomass burning, traffic emission, industrial emission, dust storms, etc.) and also from indoor sources (e.g. cooking activities, printing operations, etc.). Among all, vehicular traffic emission is the major contributor in cities in both developing and developed countries (Harrison et al., 2021)). In urban air pollution, $PM_{2.5}$ continues to receive remarkable focus due to its' several harmful effects including visibility reduction, adverse health effects and global climate change (Bond and Bergstrom, 2006; Harrison et al., 2021; Ryou et al., 2018). It can easily disperse from outdoor sources to indoor environment due to its effective penetration ability, considered as an important pollutant of indoor environment within 200 m radius (Jodeh et al., 2018 ; Kumar et al., 2021 ; Meng et al., 2021 ; Pant et al., 2016; Patton et al., 2014).

2.2.2 Road traffic noise pollution

Road traffic emits significant proportion of environmental noise, which is mainly originated by road-wheel interaction, engine operation, horn honking and aerodynamic interaction. Environmental noise is the sound wave created disturbance in the atmosphere while propagating through air medium. This disturbance in the propagation medium influence the velocity of sound, density of air, temperature of air, and more importantly atmospheric pressure. This atmospheric pressure variation reaches our ear as sound. The amount of pressure variation with respect to the undisturbed atmospheric pressure is called as sound pressure. This pressure fluctuation is measured by microphone. The salient properties, which can be related to the physics of sound are sound pressure, sound intensity and sound power (Gokhale, 2018).

Environmental noise is originated at different frequencies but only 20 Hz to 20 kHz frequencies are perceived by human ear. Sound frequency in outdoor environment generally below 8000 Hz. Sound pressure and sound frequency are two important parameters for finding out the outdoor noise prevention options, because sound frequency affects perceived loudness (Singal, 2005). The audible sound frequency range is usually expressed in octave bands in which the frequency range is subdivided into few intervals of frequencies. To cover entire audible frequency range, the scale is divided into 1/1 or 1/3rd bandwidths (Singal, 2005 ; Gokhale, 2018). Here, 1/3rd octave preferred for environmental noise analysis as it covers a wide range of frequencies. Sound frequency determines sound pitch which is influenced by several environmental factors. With the increase of sound frequency, sound pressure increases and a high pitch sound is perceived.

Sound divergence refers to the spreading of sound wave is an important property for outdoor or indoor noise propagation. It decreases the sound pressure as it travels distances from the sound source. This sound divergence varies with different types of sound sources (e.g. for stationary or point sources such as ceiling fan or table fan sound divergence is spherical but for line sources, sound divergence is cylindrical) (Gokhale, 2018).

Sound emanating from motor vehicles spread with equal strength in all directions. Noise level in urban area is influenced by a number of parameters such as types of vehicle, types of road, different urban elements (e.g. presence of building structure, trees etc.), and meteorological parameters (wind speed, wind direction, temperature, relative humidity etc.)(Garg and Maji, 2014 ; Patel et al.,2022). In urban spaces, sound propagation is influenced by complicated acoustics phenomena such as multiple reflections, diffraction, and diffusion due to surrounding buildings and obstacles (Patel et al., 2022).

2.3 TRAFFIC NOISE PROPAGATION

Traffic noise propagation depends on the four important factors including, sources, surface elements, meteorological condition and demographic characteristics (Pinto and Mardones, 2009). During propagation sound waves reflected, absorbed and transmitted by the surface elements (e.g. road surface, roadside buildings, trees, etc.). Road pavement materials and building facades are generally treated as rigid surface which can make multiple sound reflections in urban street canyons and increases the reverberation time. Multiple reflections of sound wave on building facades may obstruct sound wave divergence, initiating an amplification of sound (Bistafa, 2006). Multiple reflections by building facades and a road pavement in a built-up area cause a mean increase in noise level of 8 dB (A) (Okada et al., 2010). Guedes and Bertoli (2005) identified that interaction of sound waves and different urban forms can cause zone specific discomfort.

Several meteorological parameters (e.g. humidity, temperature and wind speed, etc.) play important roles on speed and direction of sound wave propagation, because these parameters change the atmospheric air density. Atmospheric absorption of sound energy depends on the air density. When temperature increases i.e. humidity decreases then sound absorption may decrease (Gozalo and Montes, 2021) .Yadav et al. (2022) observed that the reduction of noise level of 1.10 dB(A) with 10˚C increase in atmospheric temperature.

2.4 DISPERSION OF $PM_{2.5}$ IN ROADSIDE ENVIRONMENT

Air pollution hotspots are observed in small environments due to the significant spatial and temporal variations (Kim et al., 2015). In atmosphere, air pollutants movement is caused by three important processes, i.e. transport, dispersion and deposition. Transport is the movement of atmospheric pollutant influenced by a time-averaged wind flow. Dispersion is caused by local turbulence, that is, motions that last less than the time used to average the transport and the pollutant deposition occurs via precipitation, scavenging, and sedimentation processes, which influence downward movement of pollutants in the atmosphere, which ultimately remove the pollutants to the ground surface. Pollutant released from moving vehicles is determined by emission rate of pollutant from vehicles, pollutant mixing induced by vehicle movement, wind speed, direction relative to the axis of highway, atmospheric turbulence, reaction with other chemical species, pollutant deposition or pollutant removal rate to the ground surface (Watson et al., 1988 ; Pasquier et al., 2017). The increase in distance from the pollution source and the influence of meteorological conditions (Zhou and Levy, 2007) (e.g. wind direction and wind speed) on horizontal dilution and the mixing layer height, regulate the vertical dilution. There is an exponential decrease of air pollutant (e.g. traffic originated gases, ultrafine particles (UFP), black carbon (BC), and size-resolved particulate matter (PM)) concentrations with distance from roads (Hitchins et al., 2000 ; Kozawa et al., 2012). Hu et al. (2009) and Choi et al. (2012) measured ultrafine particles, particle-bound poly aromatic hydrocarbon (PAHs), black carbon (BC) up to 2500 m downwind and about 1000 m upwind of major freeways under nocturnal surface inversion conditions. Influence of wind direction and wind speed on local scale urban concentration of PM_{10} and $PM_{2.5}$ on a mass basis and gaseous pollutants have been studied by several researchers (Harrison et al., 1997 ; Charron and Harrison, 2005 ;Pateraki et al., 2019). These studies indicated weak or moderate correlations of PM mass with wind speed and the significant correlations with wind direction (Aldrin and Haff, 2005 ; Akyüz and Çabuk, 2009).

Some studies described a reduction in ultrafine particles (UFP) concentrations as a function of wind speed (Ruuskanen et al., 2001 ; Molnár et al., 2002). Kozawa et al. (2012) studied the effect of wind direction on near-freeway UFP size distributions, and they observed the effects of wind direction when the wind flow is perpendicular or parallel to the freeway. The lower wind speeds reduce the dilution of air pollutants; therefore, wind direction is a better indicator of emission dilution.

Other than the natural transport and dispersion processes, moving vehicles induce considerable pollutant mixing that influences pollutant concentrations within 100 m of a highway. The pollutant mixing depends on the shape and speed of the vehicle and it poses a remarkable impact on pollutant concentration when the wind is nearly parallel to the axis of the roadway (Watson et al., 1988). Road traffic induced pollutants are transported beyond 100 m from a highway are below any NAAQS standard (Watson et al., 1988). Although, in some urban areas and under the conditions of limited atmospheric ventilation (i.e. low wind speeds and topographical barriers), potential problems related to atmospheric pollution still exist. For example, in Los Angeles periods of limited ventilation occurred due to the topographic constraints. Schultz and Warner (1982) have revealed that the recirculation of pollutants occurred in the Los Angeles basin. Recirculation of urban air can increase the concentrations of primary pollutants (those emitted directly into the atmosphere) and secondary pollutants (those resulting from chemical reaction) (Watson et al., 1988). In urban street canyons, where the complexities of wind flow exist, which can lead to high pollutant concentrations under certain conditions. The wind flow in the street canyons is neither steady nor homogeneous, and street segments do not approximate infinite line sources. Similarly, emission from parking vehicles is rarely vented through an isolated, elevated point source. Emissions from the parking vehicles present relatively close to the ground in areas of complex wind flow due to the different adjacent structures. The initial non-buoyant plume rise is difficult to estimate and often hard to determine due to the variation of local air circulation (Hosker, 1984). Thus, pollutant dispersion in urban street canyon or in complex urban situation where different types of roadside barriers including, buildings, trees, parking vehicles exist, is totally depends on urban configuration and meteorological conditions. As a result, people working on or using different microenvironments within the traffic corridor or roadside environment may be exposed to different level of pollution and express different level of perception and annoyance.

2.5 ENVIRONMENTAL $PM_{2.5}$ AND NOISE MEASUREMENT

As discussed earlier, $PM_{2.5}$ and noise are the two main contributions from vehicular activities in urban traffic corridor and have ill effects on the people using various microenvironments upon exposure.

2.5.1 $PM_{2.5}$ measurement in urban traffic corridor

Wang et al. (2006) measured roadside CO, $PM_{2.5}$ concentration from on road vehicles in Hong Kong and they studied dispersion using general finite line source model (GFLSM). $PM_{2.5}$ was decreased 11% - 24%, with increasing 30 - 155 m distance from roadside.

In Hong Kong, Xing and Brimblecombe (2018) studied $PM_{2.5}$ and black carbon dispersion profiles from roadway into urban parks at pedestrian level by mobile high time resolution instruments and an analytical pollutant dispersion model. In the downwind direction, there was a rapid reduction of pollutants level was noticed at 17 m distance from roadway. They have explained the concept of dispersion from a line source and the transport of pollutants in the park on the downwind side (Figure 2.3).

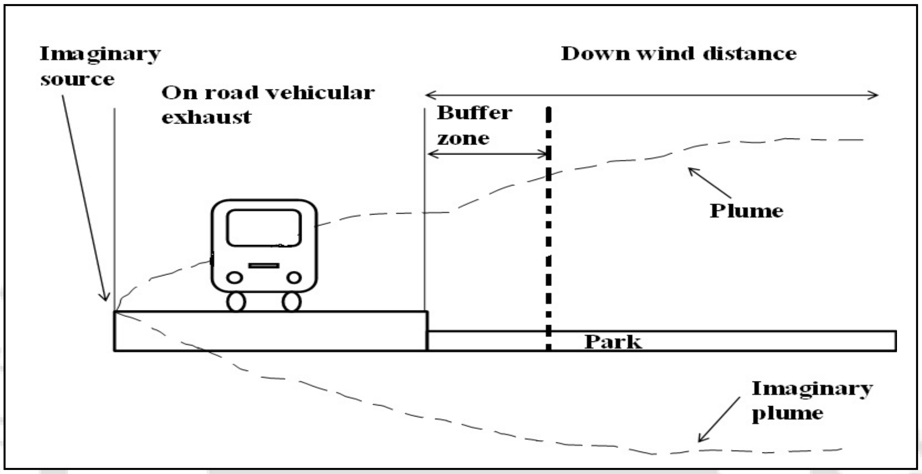


Figure 2.3 Schematic representation of dispersion of pollutants from a line source (e.g. traffic) (Source: Xing and Brimblecombe (2018))

The decay in air pollutant concentrations away from the roadside is commonly found in various researches on near-road air quality (Karner et al., 2010 ; Ducret-stich et al., 2013). The rapid decline in concentration causes heterogeneous occupant exposure (Klingberg et al., 2017). Sharma et al. (2018) studied the horizontal distribution of coarse particulate matter, fine particulate matter and gaseous pollutants near the busy highway (NH-2) in Agra, and found that the concentrations of NO_2, SO2, O3, NH3, PM_{10}, $PM_{2.5}$ and PM_1.0 were significantly decreased within 250 m distance. The diurnal trends of pollutants illustrated the impact of traffic density on the pollution level in particular, during the peak traffic density at rush hours.

Chithra and Nagendra (2012) observed that in Indian roadside school indoor polluted with PM_{10}, $PM_{2.5}$, PM_1 and CO level of 149 ± 69 $\mu g/m^3$, 61 ± 29 $\mu g/m^3$, 43 ± 24 $\mu g/m^3$, 0.10 ± 0.18 ppm at winter and 95 ± 61 μg/m^3, 32 ±16 μg/m^3, 18 ± 9 μg/m^3, 0.11 ± 0.14 ppm at summer. The mean indoor to outdoor ratio (I/O) of PM_{10}, $PM_{2.5}$, PM_1 and CO were 2.52 ± 2.71, 1.44 ± 0.67, 0.97 ± 0.18 and 0.51 ± 0.38 respectively. The higher I/O value for PM_{10} indicates that the influence of classroom activities on PM_{10} concentration and lower I/O value for finer fraction of particulate matter ($PM_{2.5}$ and PM_1) indicate the roadside vehicular contribution of fine particles to school indoor.

Plethora of literature exists on the measurements of $PM_{2.5}$ in urban areas, but there are very limited researches on the infiltration of outdoor $PM_{2.5}$ into the buildings located urban roadside. Therefore, few literatures are reviewed focussing mainly the $PM_{2.5}$ studies carried out roadside or in traffic corridor.

2.5.2 Measurement of traffic noise pollution in urban traffic corridors

Traffic noise emanating from vehicular operation is measured by sound level meter containing microphone. Memoli et al. (2008) studied the road traffic noise for a period of 15 min at streets with different geometries (Type-U and Type-L), by placing microphones at 4 m height to simultaneously measure at different distances (6.6 m to 34.0 m) from the façade. In this study, a difference of 5.7 ± 0.8 dB (95% confidence) was observed between the measured noise level with one of the microphones placed on the reflective surface on a plate and the measured noise level of another microphone positioned in free field condition. Mateus et al. (2015) measured noise level for 47 months by three microphones first placed in a free field (3.5m above the cornice of the building), another flush mounted on the facade using a metal plate and the third kept on the glass of a window of the same wall. The distance between the source and the sound level meters were 150 m. Their study showed that if the microphone is mounted on the window, the difference between the noise levels varies from 4 to 4.4 dB (A), and, if a plate of reflective material is used, the difference is about 4.9 dB (A). Hopkins and Lam (2009) positioned the microphone in their study between 1 and 2 m from the building façade, which is having dimension of < 5m, they observed that the sound field diffraction was significant for low frequency (50-200 Hz) noise. The studies of Hall et al. (1984) and Quirt (1985) concluded that, on average, a correction of −3 dB (A) in the range of 0.5 - 2 m in front of the reflecting surface is suitable. Jagniatinskis and Fiks (2014) in a study, kept 250 m distance between the microphone and the source, in which one microphone was placed 2 m from the facade, and other one on a plate in one window of the wall. It showed that the difference between the annual values of the day-evening-night noise level (L_{den}) is about 3 dB (A).

Picaut et al. (2005) used an array of microphones placed at heights between 1.2 and 6 m on a street with a U profile whose buildings are approximately 18 m high, and sound level meters were located at 6 m and 50 m from the source. Sound level meter should be place at 4.0 ± 0.5 m above the ground in case of the residential areas with multi-storey buildings. In case of residential areas with one floor buildings and recreational areas, it should be placed at 1.2 ± 0.1 m or 1.5 ± 0.1 m respectively Morillas et al. (2016). The FHWA (2018) report of the US Department of Transportation proposed the microphone height of 1.5 m as a preferred position and 4.5- 7.5 m distance for areas of multi-storey buildings.

Several studies adopted both short term (1 - 30 min) and long term (24-h) noise measurement both near traffic way and in indoors (Murphy et al., 2009 ; Zuo et al., 2014 ; Brink et al., 2019 ; Basu et al., 2021). Traditionally, in environmental noise pollution research the different noise descriptors have been used such as indicators such as L_{den}, night time equivalent noise (L_n), day-night noise level (L_{dn}), 24-h noise level ($L_{24\ h}$) (Pitchika et al., 2017; Begou and Kassomenos, 2021).

Calixto et al. (2003) studied the traffic noise pollution in roadside area of Curitiba. The measured noise level was compared with a mathematical model and German RLS 90 model. Both the model has shown good agreement with the measured noise level. Zuo et al. (2014) studied the temporal and spatial variability of traffic noise in Toronto, at 554 locations over a period of eight months. They have measured day time noise level for 30 min at each site and found that the noise level of 80% of the sampling stations were exceeded the permissible noise limit of 55 dB(A). They also noticed the spatial noise variability of about 60%, which is largely attributed to traffic volume, length of arterial road and industrial area.

Laxmi et al. (2019) studied the road traffic noise level in Nagpur city of India with the noise level meter mounted at cycle over a period of 5 min at peak traffic hour. They have estimated L_{eq}, L_{10}, L_{90}, L_{max}, L_{min} and traffic noise index (TNI) and modelled the noise level by Geographic Information System (GIS) for investigating the spatial noise map. Their findings indicated that the L_{eq} and TNI exceeded the 70 dB (A) for every monitoring locations and the GIS based noise map also has shown that the violation of Central Pollution Control Board (CPCB) allowable noise limit for various parts of Nagpur city.

Chowdhury et al. (2015) studied the day time noise level at roadside environment of Kolkata city and they observed that the violation of measured L_{eq} of 12.6 ± 2.1 dB (A) with respect to CPCB allowable noise limit. The estimated noise climate (NC) and TNI were 13 ± 1.8 dB (A) and 88.8 ± 6.1 dB (A), respectively, which indicate the serious acoustic degradation of that studied area. Kalaiselvi and Ramachandraiah (2010) conducted the road traffic noise propagation study in heterogeneous traffic condition in Chennai, by, measuring the noise descriptors (L_{eq}, L_{10}, L_{50} and L_{90}) near roadside and the SoundPLAN noise model. They observed that the high noise level > 70 dB (A) in the study area and it is influenced by vehicular horn honking. Islam and Kalita

(2017) carried out noise measurement study at various commercial, residential and silence zones (e.g. hospital, nursing home, institutional area) of Guwahati city and found that noise levels in silence zones are exceeded the CPCB prescribed noise level of 50 dB (A) day time. It concluded that the vehicular traffic noise is the major contributor to high noise levels in Guwahati city.

However, limited researches used equivalent noise (L_{eq}), peak noise level (L_{peak}), maximum and minimum average noise (L_{max} and L_{min}),peak noise component (noise level equals or exceeded 10% of study duration) (L_{10}), median noise (noise level equals or exceeded 50% of study duration) (L_{50}), background noise components (noise level equals or exceeded 90% and 95% of the study duration (L_{90} and L_{95}) and noise climate indices related to the fluctuations of noise from L_{90} and L_{95} refers as $NC_{(L90)}$ and $NC_{(L95)}$ (Prasad et al., 2022).

2.6 ROAD TRAFFIC NOISE MODELLING

Lee et al. (2014) used United States Federal Highway Administration (FHWA) traffic noise model (TNM) for highway traffic noise study in United States and they observed weak to moderate co-efficient of determination (R^2: 0.013-0.73) between modelled and measured noise level. The TNM 2.5 was observed as it accurately performed the noise prediction on an average within 2 dB(A) error (DOT, 2006). Cohn and Harris (2001) observed that TNM model decrease the over prediction of 4.3 - 3 dB (A) for road traffic noise study. For single traffic stream in highway, traffic noise can be modelled by calculation of road traffic noise (CoRTN) method (Steele, 2001 ; Garg and Maji, 2014). Ibili et al. (2022) predicted the urban road traffic noise by CoRTN model and observed that the high co-efficient of determination R^2 of 0.943 exist between the measured and modelled noise data. Alam and Ahmad (2020) used RLS 90 model to predict the urban road traffic noise of Indian city and they observed the standard deviation of 0.06 - 1.86 between predicted and measured noise level.

Several traffic noise models are used for road traffic noise prediction including ASJ RTN-Model 2008, HARMONOISE, Son Road, Nord 2000 and NMPB-Routes-2008 (Garg and Maji, 2014; Fallah-shorshani et al., 2022).

Several statistical road traffic noise prediction models are also used to forecast traffic noise in urban areas e.g. Burgess and CNOSSOS-EU model etc. (Guarnaccia et al., 2019). Calixto et al. (2003) developed a linear regression model to identify the traffic noise in Brazilian roads, which compared the measured noise levels and the modelled noise levels as per German standard RLS-90 with good agreement. The geostatistical models are also used to determine the spatial pattern of noise level in an urban environment (Zuo et al., 2014).

Traffic noise modelling with Artificial Neural Network (ANN) is a simplified approach for prediction of urban noise pollution. An ANN based traffic noise modelling adopted by several researchers (Nedic et al., 2014 ; Mann and Singh, 2022). Rahmani et al.(2011) studied road traffic noise for light, medium and heavy vehicles by genetic algorithm based approach. The results of that study indicated that both the models made good agreements with measured noise levels for flat road noise prediction. SoundPLAN model efficiently predicts noise levels in various urban scenarios by taking into account FHWA, RLS-90, CoRTN, TNM and other standards. SoundPLAN efficiently predicts the noise propagation in various complex urban scenarios (e.g. street canyon, different urban barriers), which is useful to quantify the role of these urban elements on traffic noise propagation and it can provide the impact of possible urban intervention for better environmental management (Kim et al., 2012 ;Gilani and Mir, 2022).

2.7 IMPACT OF TRAFFIC NOISE ON HUMAN HEALTH

Noise pollution affects human health psychologically and physiologically, depending upon the amount of exposure (Babisch et al., 2013 ; Frei et al., 2014 ; Nieuwenhuijsen, 2016 ; Rudolph et al., 2019 ; Lan et al., 2020 ; Cole-Hunter et al., 2022). Nearly 1 billion individuals suffered from mental health ailments worldwide in 2019, accounting for almost 13% of the world's population (Global burden of disease collaborative network, 2019; Bao et al., 2022). Noise pollution in urban areas is high and often exceeds the WHO standards of 53 dB (A), which lead to the human annoyance of varying degrees (Frei et al., 2014; Dzhambov et al., 2017). In the European context, environmental noise (especially traffic noise) is responsible for 1 million lost healthy life years (disability-adjusted life years), including traffic noise accounting for the second-highest health burden, after only air pollution (WHO, 2011 ; Bao et al., 2022). Studies concluded that a possible reduction in the urban traffic noise exposure of merely 1 dB (A) might prevent nearly 470 deaths (Tobías et al., 2015 ; Mueller et al., 2017). Noise annoyance is commonly used to illuminate the association between environmental noise and mental health risks (Rudolph et al., 2019). It is a mental perception and a disturbance to the humans exposed to noise (Dratva et al., 2010 ; Frei et al., 2014). Dratva et al. (2010) observed that noise annoyance is associated with health-related quality of life (HRQoL) and acts as a precursor for developing insomnia (Begou and Kassomenos, 2021 ; Hanibuchi et al., 2021). Dzhambov et al. (2017) studied the impact of road traffic noise on youth's psychological health. They showed that elevated noise exposure hampers the mental health of the youth population by creating noise annoyance. Agarwal and Swami (2009) studied traffic noise annoyance on people at ten commercial road networks of Delhi using a new point scale of mean dissatisfaction score to examine the correlation between annoyance and different noise indices. Khomenko et al. (2022) estimated that nearly 11 million adults suffer from high annoyance due to vehicular noise. They also reported that annual deaths from ischemic heart disease (IHD) of 3608 (95% *C.I.*: 843-6266) could be prevented by maintaining WHO noise standards. Noise is a cardiovascular risk factor for it is linked with arterial hypertension, coronary artery disease, heart failure, and arrhythmia (Münzel et al., 2021). Babisch (2008) observed that, with increasing noise levels above 60 dB(A) is associated with an increase in cardiovascular risk of people in European and Japanese cities, such as for an noise exposure of 16 h day time noise level (L_{day}) of 71 -75 dB(A) is associated with the odds ratio (*OR*) of cardiovascular risk of 1.19 (95% *C.I.* : 0.90 - 1.57) and 16 h L_{day} of 76 - 80 dB(A) is associated with the *OR* of 1.47 (95% *C.I.* : 0.79 - 2.76).

Short-term simulated traffic noise reduces sleep quality and raises stress hormone levels, blood pressure, endothelial dysfunction, and oxidative stress, according to translational field investigations in healthy people and cardiac patients (Münzel et al., 2021). Besides noise discomfort and sleep, there is sufficient evidence of substantial health repercussions such as hypertension, risk of ischemic heart disease, and death (Huss et al., 2010). Petri et al. (2021) observed that an increase of 5 dB (A) in nocturnal noise can elevate diastolic blood pressure (DBP) among people > 65 y, residing without household noise protection and those who keep windows open. However, for young adults in Austria, noise exposure reduced systolic blood pressure (SBP) and heart rate variability (HRV) (Moshammer et al., 2019). Powazka et al. (2002) found that higher SBP is linked with traffic noise exposure but has no significant association with the DBP. Park et al. (2018) found an elevation in heart rate (HR) when exposed to noise between 40 - 60 dB (A) for 0.5 - 5 min. For Indian cities, a study found that blood pressure (BP) can increase due to traffic noise for bike riders (Balasubramanian and Jagannath, 2014 ; Prasad Das et al., 2022).

2.8 IMPACT OF AIR POLLUTION ON HUMAN HEALTH

Air pollution has a significant linkage to cardiovascular morbidity and death. Studies comparing the burden of disease show that air pollution is the leading source of lost disability-adjusted life years (DALYs). The significant association between air pollution and different health ailments are investigated and documented by different researches (Beelen et al., 2008 ; Li et al., 2021). Traffic-related air pollution is critically associated with different cardiovascular health ailments, including BP and heart rate variability (HRV) (Zhang et al., 2022). $PM_{2.5}$ causes several human health problems, including BP, stroke and other psychological and physiological ailments (Martins and Carrilho, 2018). Kheirbek et al. (2016) observed the impact of on-road traffic borne $PM_{2.5}$ emission on human health in the NYC region, the result showed that $PM_{2.5}$ contribute to 320 (95% Confidence Interval (*C.I.*): 220–420) deaths and 870 (95% *C.I.*: 440–1280) hospitalizations and emergency department visits annually within NYC due to $PM_{2.5}$ exposures, accounting for 5850 y (95 % *C.I.*: 4020–7620) of life lost. Trucks and buses within NYC accounted for the major share of ambient $PM_{2.5}$, contributing up to 14.9 % of annual average levels across 1 km grid cells, and were associated with 170 (95 % *C.I.*: 110–220) $PM_{2.5}$ attributable deaths each year.

2.9 COMBINE EXPOSURE TO TRAFFIC BORNE AIR AND NOISE AND RELATED HUMAN HEALTH

Near about 54% of the world's population resides in urban area (UN, 2014), and affected by air and noise pollution from various sources (e.g. traffic operations, industrial activities and different anthropogenic activities). Among all these pollution sources vehicular traffic contribute major portion of both air and noise pollution in an urban environment (Khan et al., 2018). Traffic related air pollution is usually associated with the noise, emanating from the same source

(Shepherd et al., 2016). Air pollution and noise can independently pose significant health disorders to wellbeing, for that reason these air and noise pollution have been recognised as top two stressors in terms of environmental burden of disease (Khan et al., 2018). Many years ago, some researchers have considered air and noise in their study for examining the spatial relationship between these two stressors and reported the confounding nature of these two stressors (Allen et al., 2009). Combine exposure of both traffic related air and noise pollution lead to cardiovascular, respiratory and neuro-behavioural disorders to human being (Hoffmann et al., 2007 ;Tonne et al., 2008; Babisch et al., 2014; Nieuwenhuijsen, 2021; Hao et al., 2022). This is a great challenge now days, when attempting to determine the negative contribution of each environmental stressor (air or noise) to human health, and to measure whether these two (air and noise) affect human health independently (i.e., unique effects) or in combination (Shepherd et al., 2016). It is proved that exposure to ambient air pollution ($PM_{2.5}$) and/or noise causes increase in BP (Liu et al., 2014). Particulate matter and traffic noise are low to moderately correlated (0.05-0.74), which may pose combine impact to the human being who is very frequent in commuting that polluted microenvironments of cities worldwide (Khan et al., 2018).

In an urban environment several factors influenced the correlations between air and noise pollution such as, traffic attributes, building configuration and meteorological parameters. Building acts as a screen restricting dispersion of air pollutants and in the case of noise propagation building causes significant reduction of sound energy. Whereas, meteorological parameters (e.g. wind speed, wind direction, relative humidity) influence air pollutant dispersion as a noticeable means as compared to noise (Khan et al., 2018). Some studies found strong combined impact of noise and air pollution on human annoyance ratings (Stansfeld, 2015). There are difficulties in disentangling the effects of the two exposures on account of their substantial covariance, therefore, that independent effects may be more readily assessed by seeking out geographical regions with weaker correlations. A further consideration lies on the mechanisms by which each exposure may affect health as there are key differences between the two exposures. The two types of exposure utilise different biological pathways to affect human health.

Plethora of research carried out modelling for investigating human exposure related to air and/or noise pollution. Roswall et al. (2017) determined the long term traffic-originated NO_2 and noise exposure to human being residing near roadside environment in Copenhagen, Denmark by associating street canyon pollution model and Nordic prediction based commercial noise mapping method. In Bulgaria, Dzhambov and Dimitrova (2016) studied regional air and noise pollution exposure by using US Environmental Protection Agency (US EPA) standard air quality model and European Union directive based commercial noise mapping techniques. Some modelling studies found a moderate positive to slightly higher positive correlation between air and noise exposure (Ögren and Molnar, 2014 ; Sørensen et al., 2015).

Several statistical modelling studies also have linked the pollution exposures and its' human health impact by using statistical relationships. Apparicio et al. (2016) used land use regression (LUR) modelling approach for studying NO_2 and noise pollution exposure on cyclist, showed a negative correlation (R^2= -0.07; p= 0.005) between both NO_2 and noise exposure. Boogaard et al. (2009) conducted a study to investigate cyclist's combine short term exposure due to particle number concentration (PNC) which refers the ultrafine particulate matter, $PM_{2.5}$ mass concentration and noise. It showed a moderate correlation between PNC and noise but weak correlation between $PM_{2.5}$ and noise. Silva and Mendes (2012) developed city noise-air index for a Portugese city by considering noise (L_{den}) and air pollutants (CO, NO_2, O3, C6H6) emanating from domestic, industrial and vehicular activities. They have used computational simulation model applied in GIS based platform. Study results indicate that air pollutants and noise exceeded the allowable limit of that city, and the city noise-air index becomes zero indicating red colour, meaning polluted status of the atmosphere. When all the pollutants are under acceptable limit then that city noise-air index may be considered for trade off. This city index is useful for urban planning. King et al. (2016) studied combined impact assessment of $PM_{2.5}$ and noise for pedestrian at a high line elevated corridor and at a footpath near a traffic way in New York using linear regression analysis and introduced air-noise pollution reduction index (ANP_r) to quantify the status of exposure reduction. The important finding of this study show that, at high-line combine exposure of pedestrian to $PM_{2.5}$ and noise can reduce by 35% than the footpath located near the traffic way. This ANP_r index is also very useful for urban planning and policy making (King et al., 2016). Aspect ratio (the ratio of street width to height of adjacent flanked buildings) plays an important role for combine exposure of air and noise pollution in an urban area (King et al., 2016). King et al. (2009) observed that introducing a wall between roadway and footpath used for pedestrian decrease the air-noise exposure. Receptor position with respect to the vehicular activities is an important factor for assessing the stressors exposure. Receptor nearer to the road edge is verily affected by traffic induced air pollutants, as the pollutant dispersion pattern is exponential with the distance from the source (McNabola, et al., 2006). On the other hand, in a free traffic way noise exposure decreases by the square of the distances from the source (King et al., 2016). Beelen et al.(2009) investigated ischaemic cardiovascular risk associated with black smoke, traffic intensity and noise exposure with the Cox Proportional Hazard Model. It shows that the association of black smoke and traffic intensity with cardiovascular risk but not noise. However, traffic noise above 65 dB (A) were related with elevated risks for ischemic heart disease (IHD) (Relative Risk (*RR*): 1.15 (95% *C.I.*: 0.86 - 1.53)) and heart failure mortality (*RR*: 1.99 (95% *C.I.*: 1.05 - 3.79)).

Stansfeld (2015) found that noise increases morbidity and mortality independently of air pollution exposure; though air pollution constituted a greater burden of disease, whilst noise exposure had a greater impact on quality of life. However, anatomical and physiological findings indicate that the two separate pathways may share a common destination as both are associated with an increase in sympathetic activity (Stansfeld, 2015) and ultimately, both noise and air pollution can be considered environmental stressors (Klæboe et al., 2008). Stress responses, in turn, are known to be better predicted by subjective assessments of the stressor, by resilience levels, and by an individual's coping style.

Allen et al., (2009) studied spatial relationship of traffic originated ultrafine particle (UFP), NO_2 and noise in nine US communities. $PM_{2.5}$ is significantly associated with SBP and for DBP, a significant association of both $PM_{2.5}$ and 24-h noise level (L24 h) is observed (Pitchika et al., 2017b). Lim et al. (2021) observed the influence of $PM_{2.5}$, NO_2 and day-evening-night noise level (L_{den}) on the heart failure issues of female nurses who had hypertension and past smoking habit. They observed the hazard ratios (HRs) of 1.17 (95% *C.I.*, 1.01-1.36), 1.10 (95% *C.I.*, 0.99-1.22), and 1.12 (95% *C.I.*, 0.99-1.26) per increase of 5.1 $\mu g/m^3$ in $PM_{2.5}$, 8.6 $\mu g/m^3$ in NO_2, and 9.3 dB (A) in L_{den}, respectively.

Moderate correlation between air pollutants and noise indicated the chances of associated exposure of these pollutants, but roadway proximity and wind characteristics play an important role in minimising the chances of combine exposure.

Vienneau et al. (2015) studied combined exposure of PM_{10} and noise (L_{den}) on mortality and morbidity of human being in Switzerland. They conducted meta-analysis for deriving cause specific exposure response function and adopted years of life loss (YLL) calculated from life table method, population attributable fraction is used to identify rate of hospital admission for several disease. The results indicated that years of life loss (YLL) and morbidity are influenced by air pollution and quality of life of human being is affected by noise. Short term combine exposure of $PM_{2.5}$ and noise can lead to heart rate variation (HRV) for young healthy people, which is the indication of cardiovascular disorders (Huang et al., 2013). Associated long term exposure of $PM_{2.5}$ and traffic noise, mostly night time equivalent noise level (Lnight) led to atherosclerosis (Kälsch et al., 2013). Authors have investigated relationship between combine exposure of $PM_{2.5}$ and noise and thoracic aortic calcification (TAC), which is a measure of subclinical atherosclerosis by multiple linear regressions. Singh et al. (2016) evaluated concentration of CO, O3, $PM_{2.5}$, VOC, TVOC and noise at indoor and outdoor of a commercial shopping complex and estimated health risk associated with VOCs. The results indicated that quality of indoor environment is deteriorated more than outdoor due to the presence of high concentration of each air pollutants and noise originated from several indoor activities including cooking, photocopying and several anthropogenic activities. This study also concluded that people who are above 60 years and kids are at high risk of air pollutants and noise combine exposure.

2.10 IMPACT OF DEMOGRAPHIC, SOCIO-CONTEXTUAL AND EXISTING HEALTH ISSUES ON AIR, NOISE RELATED HUMAN HEALTH IMPACT STUDIES

Some studies investigated the role of socio-demographic, psychosocial, and contextual factors on noise annoyance (Paiva et al., 2019 ; Bouzid et al., 2020 ; Pinsonnault-Skvarenina et al., 2021) and these research revealed that socio-demographic factors such as building orientation, noise sensitivity and psychosocial factors are the important predictors of noise annoyance. Population survey draws a detailed picture of the community and identifies disparities in the relative importance of socio-demographic factors (age, gender, marital status, education, occupation, building attributes, family income etc.) in predicting various degrees of annoyance and other health ailments (Prasad et al., 2022). Prasad et al. (2022) observed that education to be a negligible factor in annoyance. According to Lipowicz and Lopuszanska (2005), never married people have a higher risk of hypertension than married people. However, Prasad et al. (2022) did not find any impact of marital staus on annoyance. They observed the influence of profession on annoyance. Petri et al. (2021) observed that an increase of 5 dB (A) in nocturnal noise could elevate DBP among people > 65 y, residing without household noise protection and those who keep windows open. According to Reckelhoff (2001), at similar ages, men have higher BP than women. However, Prasad et al. (2022) observed, women have higher BP after being exposed to traffic noise than men.

2.11 SUMMARY OF LITERATURE REVIEW

Vehicular traffic contributes major portion of ambient air and noise pollution in urban area both at day and at night times. Although, both air and noise pollution share a common source, the exposure pathways of these two environmental stressors are different and ultimately the destination of these two stressors are same i.e. the environmental receptors (e.g. human being). Among all gaseous and particulate emissions fine fraction of particulate ($PM_{2.5}$) and traffic noise individually and in association can hamper human health by various means including psychological, respiratory, cardiovascular and cerebrovascular disorders. Air pollutant dispersion, more specifically fine particulate matter ($PM_{2.5}$) and traffic noise propagation in urban roadside area and into roadside indoor buildings depends on air flow pattern, presence of barriers (e.g. noise barrier, tree canopies, parked cars with various angle and any elevated obstruction including flyover), pavement type (elevated or depressed), building characteristics (e.g. types of building facade, crack geometries on building surface, ventilation of building), meteorological parameters and traffic characteristics. Different studies used various approaches for modelling the traffic noise in urban environment including deterministic, statistical and numerical modelling approaches (e.g. Spatial regression, SoundPLAN, TRANEX, CadnaA, CNOSSOS-EU, ANN and GA etc.) by maintaining different standards like FHWA, TNM2.5, RLS90, CoRTN, NORD2000, NMPB2008 etc. (Khan et al., 2018). Among all these traffic noise modelling approaches SoundPLAN better predict the human exposure of traffic noise and its' propagation pattern in the urban environment due to its high end simulation techniques (Khan et al., 2018). SoundPLAN can model traffic noise by following different traffic noise modelling standards including US's FHWA and TNM2.5, Germany's RLS90, UK's CoRTN, France's NMPB 2008 etc. (Khan et al., 2018).

The commonly used noise descriptors in traffic noise modelling and exposure calculations are, equivalent noise level (L_{eq}), percentile exceedance of noise level (L_{10} ,L_{50}, L_{90}), day-evening-night equivalent noise level (L_{dn}), % human annoyance (% HA), % sleep disturbance (%HSD), traffic noise index (*TNI*), noise climate (*NC*), noise exposure index (*NEI*), equivalent exposure time factor (*EETF*), time weightage average (*TWA*) and noise dose (*ND*).

City air-noise index and is used to indicate ambient air-noise pollution and combine exposure of air and noise pollution, respectively. This combine pollution and exposure indicators are the base for combine health risk assessment of humans to air and noise. Different techniques including questionnaire survey, epidemiological studies are carried out by various researchers all over the world for investigating combine health impact due to air and noise pollution. They used meta-analysis, cox-proportional hazard model, logistic regression approach for calculating combine risk of traffic induced air and noise pollution to human being. Besides the air and noise pollution, demographic, socio-contextual and habitual factors and existing health ailments could also explain the link between different health problems of the receptors and air and noise exposure.

2.12 RESEARCH LIMITATIONS

- ✓ Most studies considered PM_{10} and coarser fraction of particulate matter and gaseous pollutants for research on atmospheric transport phenomena and its' human health impact in urban street canyon. Limited studies exist in India and across the globe, for fine or ultrafine fraction of particulate transport phenomena and its' human health impact.
- ✓ In Indian heterogeneous traffic context, urban traffic corridors (microenvironments) are not focused much to study exposure and health problems.
- ✓ In Indian context there is almost no study till date has characterised the contribution of traffic noise spectrum for different vehicular operation

- ✓ As there is a high potential health impact of both traffic originated particulate matter and noise on humans, especially on different urban workers who exposed to high level of air and noise pollution over a significant portion of their daily life for their working and commuting, study of traffic induced noise and fine ($PM_{2.5}$) or ultra-fine fraction (PM_1, $PM_{0.7}$) particulate matter for heterogeneous vehicular activities are still less explored in India and across the globe.
- ✓ There are very limited studies, which investigated the city air-noise pollution index by considering fine or ultra-fine fraction of traffic borne particulate and noise.
- ✓ A few studies have explored the combined dose-response functions for traffic originated $PM_{2.5}$ and noise and its' corresponding psychological and physiological human health consequences in complex urban microenvironments both for outdoor and indoor urban workers.
- ✓ Very limited research considered the role of traffic noise frequencies on different human health burden.
- ✓ The role of demographic and socio-contextual factors on traffic noise and air pollution related human health research is not studied clearly in Indian urban road environments.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 GENERAL

To achieve the main objective of this research the study area containing the microenvironments was selected and the $PM_{2.5}$ concentration, noise levels, traffic volume, meteorological parameters were collected. The questionnaire cum health survey, which has been an important part of this research, was conducted for the volunteer respondents. The combined noise and $PM_{2.5}$ index was developed to describe the exposure of people roadside and in indoor microenvironments to determine the impacts. The statistical models were developed to investigate the impact of traffic noise and $PM_{2.5}$ individually and jointly on the urban workers' annoyance and different cardiovascular parameters (blood pressure and heart rate). Traffic noise modelling using SoundPLAN was done to investigate the traffic noise propagation at the traffic corridor. The model validation was done by different statistical measures by comparing with the measured noise level. Figure 3.1 shows the research methodology of this research.

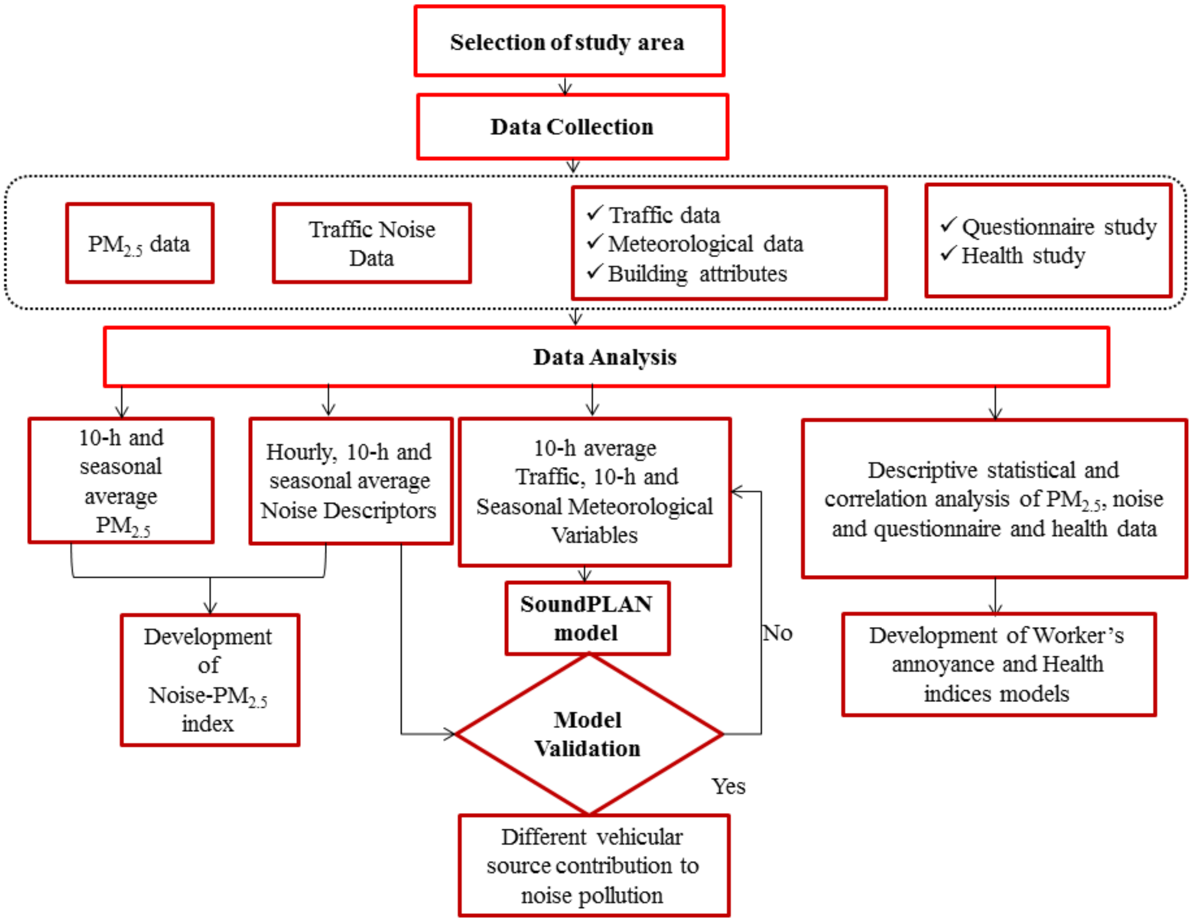


Figure 3.1 Flow chart of research methodology

3.2 SELECTION OF STUDY AREA

Guwahati city (26.1445°N, 91.7362°E) is the heart of the north-east (NE) India, situated in Brahmaputra river valley (BRV), with the hills on the three sides and river Brahmaputra on one side. The city has humid climatic condition and hilly fogs most of the portion of year. The traffic noise study was conducted inside and outside of office building (EPFO office) with brick façade and $PM_{2.5}$ monitoring was conducted inside and outside of that same office building at Bhangagarh location (26.1709° N, 91.7673° E) along the busiest road of Guwahati i.e. Guwahati-Shilong road (GS road) where the more than 10,000 vehicles per hour throughout the day observed. Many people share of the road stretch for their different needs of their daily life including study, office, shopping, business and living. In this location, several heights of different types of commercial, residential and institutional buildings exist in both direction of the roadway. Due to various busy activities and heavy traffic operations, both air and noise pollution act as detrimental stressors to the people who use this corridor regularly.

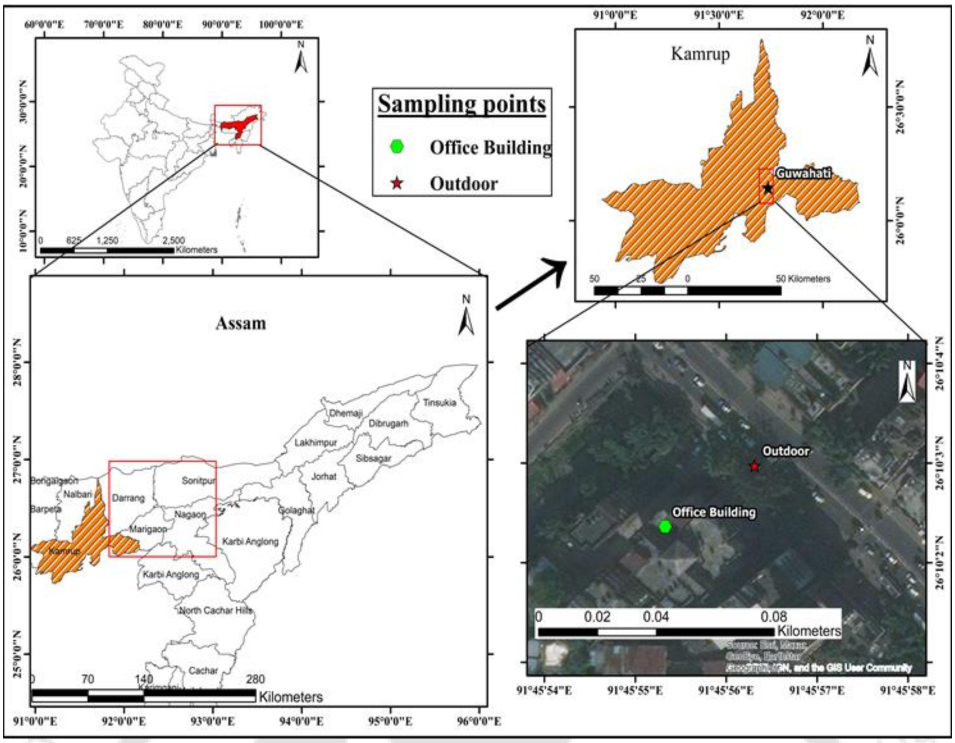


Figure 3.2 Sampling locations in the selected study area (Google Earth, accessed on 11.10.2022)

3.3 DATA COLLECTION

The noise and $PM_{2.5}$ monitoring was conducted for the year 2019, divided into four seasons, namely winter (December-February), pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October-November) as per Barman and Gokhale (2019).

3.3.1 $PM_{2.5}$ data collection

The $PM_{2.5}$ concentrations were collected by using two air samplers (Make: Mesa Labs; Model: OmniTM FT and Make: Envirotech; Model: APM 550) in indoor and outdoor with the inlet height 1.5 m above the ground for indoor sampling and approximately 16.7 m above the ground (at rooftop) for outdoor sampling (Figure 3.3 and Figure 3.4). The pump associated with this instrument draws air sample at a rate of 5 l /min and 16.667 l / min through a particle size separator, then through 24-h desiccated and pre-weighted PTFE filter medium with 47mm diameter and 2 µm pore size. The 10 µm, 2.5 µm particle separation is achieved by the impaction principle. Then again the weight of the exposed and re-desiccated filter paper was measured in a microbalance. After that, weight difference was divided by average of initial and final air-flow volume drawn by the pump associated with the ambient air sampler to calculate the concentration of $PM_{2.5}$ in μg/m^3. The $PM_{2.5}$ sampling was carried out in both indoor and outdoor for over 10-h (10 a.m. - 8 p.m.) on five weekdays (Monday-Friday) for a period of one year in 2019 (N=180 days) and for three days from 12 p.m. - 4 a.m the sampling was done for background due to lean traffic.

(a) (b)

Figure 3.3 $PM_{2.5}$ sampling in (a) outdoor and (b) indoor environments

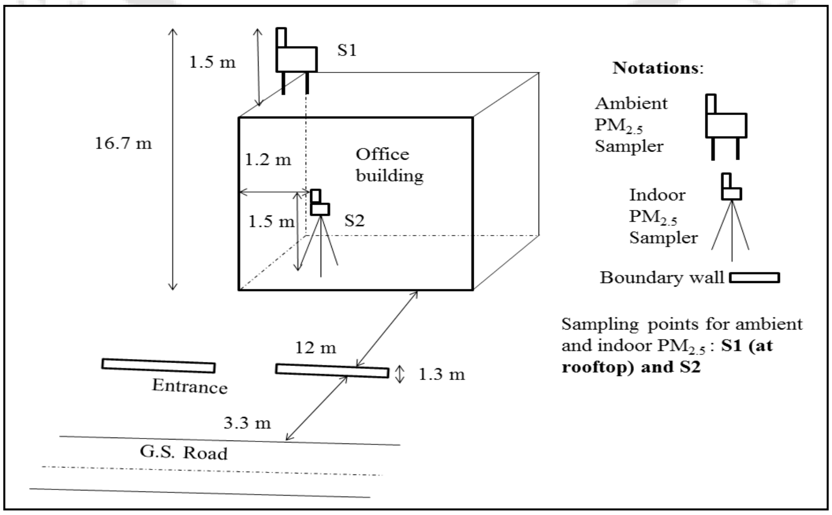


Figure 3.4 Schematic of $PM_{2.5}$ sampler position

3.3.2 Traffic noise data collection

Simultaneously, outdoor and indoor traffic noise levels were measured by two Type-1 sound level meters (SLM) (Brüel & Kjær type 2250) (Make: SVANTEK, Model: 977) (Figure 3.5). The SLM was placed at 1.5 m height from ground level and 1 m away from the sound sources (e.g. kerbside for outdoor and door, window for indoor) and any reflective surfaces indoors and outdoors (Figure 3.6). The indoor noise measurement was carried out inside the most exposed road facing building façade which is in line with many previous studies (Bouzid et al., 2020). The weekdays (Monday-Friday) noise was monitored in time segments each of 4 h from 10 a.m. – 2 p.m., 1 p.m. – 5 p.m., and 4 p.m. – 8 p.m. in the outdoor road environment and in the indoor of the office (N=180 days) and repeated throughout the specified monitoring duration. Similarly, for three days from 12 p.m. - 4 a.m the noise study was done for background due to lean traffic. The SLM were calibrated after each monitoring period. This noise monitoring procedure was in line with the study of Kundu Chowdhury et al. (2015) on Indian urban roadway.

(a)

(b)

Figure 3.5 Noise monitoring at outdoor roadside (a) and inside the office building (b)

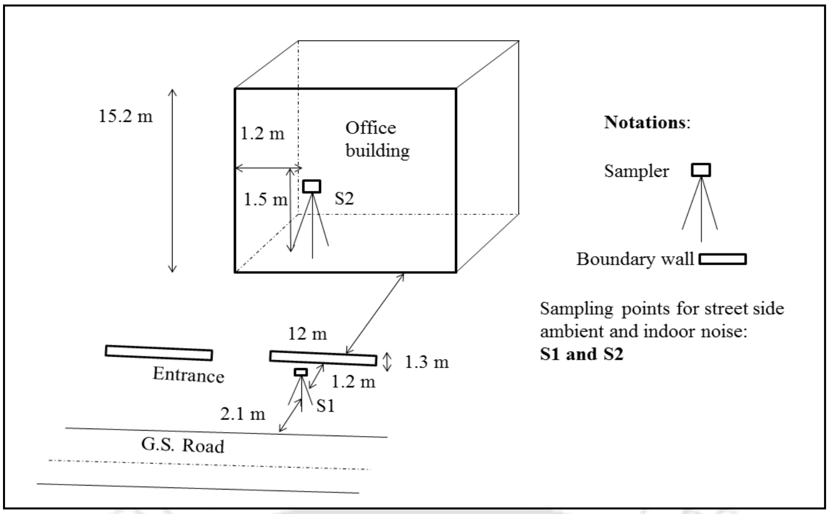
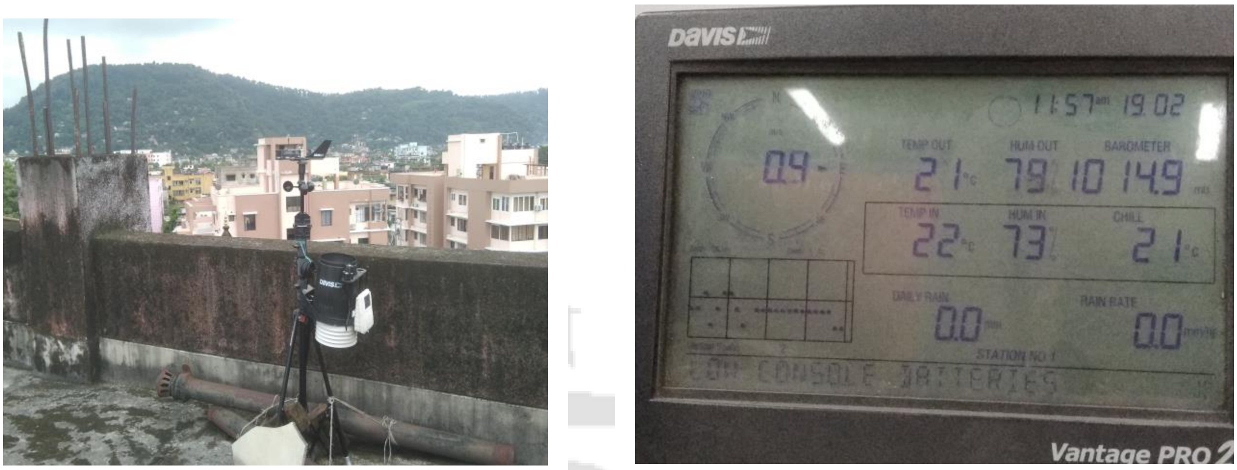


Figure 3.6 Schematic diagram of traffic noise monitoring

3.3.3 Meteorological data

Daily meteorological parameters such as temperature, relative humidity (%RH), atmospheric pressure, solar radiation, wind attributes (wind speed and wind direction) were monitored by using a weather monitoring station (Model: Vantage Pro 2 weather station, Make: Davis) (Figure 3.7). This sensor sensed the data for 10 min resolution. Temperature, relative humidity and atmospheric pressure have been used for SoundPLAN traffic noise modelling (CHAPTER 5).

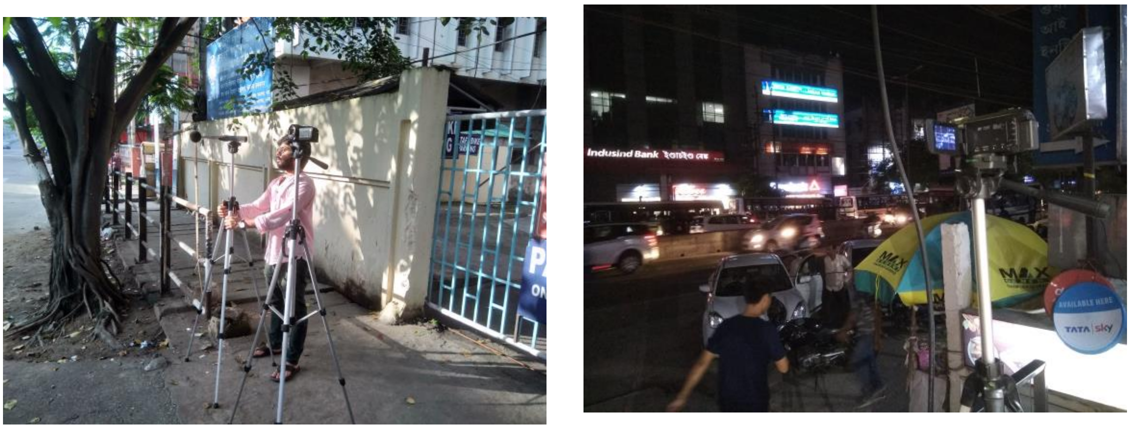


(a) **(b)**

Figure 3.7 Location of (a) weather station and (b) weather console box

3.3.4 Traffic data

Traffic speed for different vehicular composition (bike, car, bus, truck, auto and multi utility vehicle (MUV)) was collected by radar gun, a Doppler radar unit (Make: Bushnell), which determines the vehicular speed by detecting the frequency change of reflected radar signal produced by Doppler shift of vehicle (Figure 3.8). Traffic recording captured by digital video camera (Model: HC-V180; Make: Panasonic) over 20 min hourly interval throughout the study period. Then traffic counting including traffic composition was carried out from traffic video for SoundPLAN traffic noise modelling (CHAPTER 5).



(a) (b)

Figure 3.8 Locations of traffic attribute study (a)-(b)

3.3.5 Questionnaire survey

3.3.5.1 Selection of participants

The participants were selected after ensuring they work in the study area and commute daily between their residences and workplaces. A similar approach was suggested by Paiva et al. (2019). The 50 representative samples from the same study area were initially considered for the pilot study (Nieuwenhuijsen, 2003; Paiva et al., 2019). This pilot study showed that the observed frequency of abnormal BP and HR was nearly 20% by considering a maximum error of 5% in 95% of the samples using Eq.(3.1):

$$n = \frac{(p \cdot q \cdot z^2)}{d^2} \quad (3.1)$$

then, $n = \frac{(0.20)\cdot(0.80)\cdot(1.96)^2}{(0.05)^2}$; $n \cong 246$

where, n is the sample size; p the probable proportion of annoyance response; q is the (1- p); z indicates the percentile of normal distribution, which is 1.96; and the d denotes the maximum allowable error in the absolute result.

The Eq. (3.1) provided the value of n = 246. Therefore, 250 workers from different microenvironments with tenure of working > 6 months were randomly selected who also voluntarily participated in the questionnaire study. Only completely answered questionnaire (N=154) responses were screened for the analysis. The responses, obtained based on the profession, were classified as office workers (108) and street vendors (46) for this study (Figure 3.9).

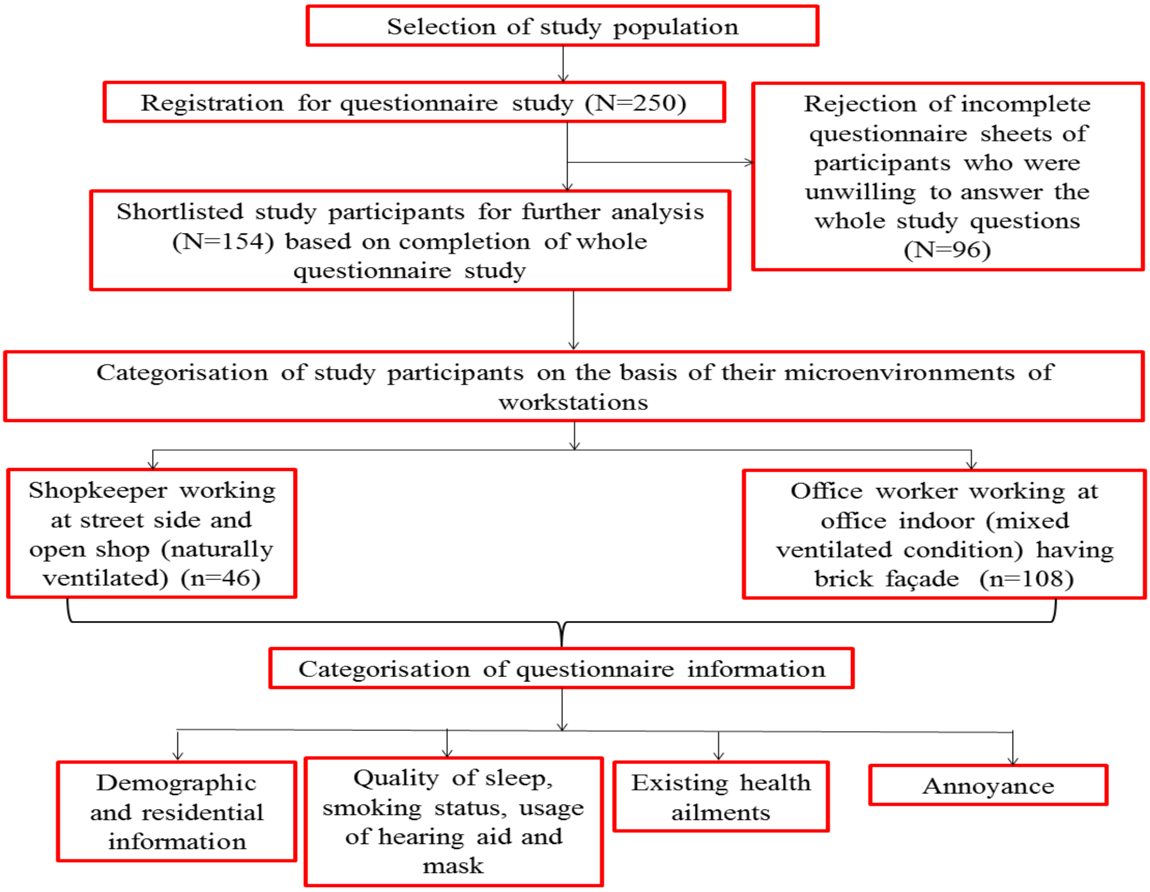


Figure 3.9 Design of questionnaire study

3.3.5.2 Design of the questionnaire study

The questionnaire (Table A-1) includes demographic and socio-contextual parameters, residential characteristics, neighbourhood environment, perception of noise during sleeping indicating noise-induced sleep disturbances and perception of annoyance at home, workplaces, and street side, health status, smoking habit, cooking fuel, protective hearing aids, mask usage and overall stressor of urban roadside. This questionnaire was developed from the standard questionnaire adopted in the studies of Rotko et al. (2002), ISO 15666 -

2003 , Rotko (2004), Frei et al. (2014), Nieuwenhuijsen (2015), Chung et al. (2020) and Lefèvre et al. (2020). The demographic and socio-contextual parameters include gender (marked as male by 0 and female by 1) and age category of < 20 y, 20 - 40 y, 41 - 60 y, and > 60 y (denoted by 0,1,2,3 respectively), family income (in INR) categorised as, < 20k, 21k-40k, 41k-60k, 61k-80k and > 80k (denoted by 0,1,2,3,4 respectively). The residential parameters include living duration and the building age categorised as <10y, 10-20y and >20 y (denoted by 0, 1, 2, respectively), building facing, window and door location (indicated as roadside by 0 and 1 as on opposite), and building vicinity categorised as < 2 m, 2-3 m and > 3 m (denoted by 0,1,2, respectively). The residential indoor noise sources are denoted by 0-10. Noise perception during sleep is categorised as 'no' denoted by '0' and 'yes' denoted by '1'. Traffic activity status during the day, evening, and night near the residence (e.g., no traffic as 0, slight, medium and high traffic indicated by 1, 2, 3, respectively), traffic flow pattern including no-flow, free-flow, moderate-flow and congested-flow (marked by 0-3).

The reported health ailments include speech interference, stress, fatigue, annoyance, cardiac problems, hypertension and other ailments, individually and in the combination of many diseases marked by 0-17. The frequency and duration of health disorders were marked by verbal scores ranging from 0-4. The responses on facing breathing troubles of participants near roadside were classified as no and breathing problem denoted by 0, and 1, respectively. The participants marked their air and noise perception at home, workplace, and roadside by the standard verbal scale-like, no annoyance, slightly annoyance, medium annoyance, and high annoyance, which were designated by the numerical scale of 0, 1, 2, and 3, respectively (Frei et al., 2014; Paiva et al., 2019; Bouzid et al., 2020; Lefèvre et al., 2020). Although most authors reported their findings using a 5-point verbal scale to avoid confusion between high and extreme annoyance, both were labelled as high annoyance in this study. The response of problematic traffic emission in terms of respondents' bothering was categorised as air, noise, combined air and noise and not bothered (labelled by 0,1,2,3, respectively). Usage of cooking fuel was categorised as LPG, a combination of LPG and electric cook stove, a combination of LPG and other air pollution creating cooking fuel including kerosene, cow dung and other biomass burning and others marked by 0-3. The usage of hearing aid was categorised as never, since few days, months and years (denoted by 0,1,2,3, respectively). Using masks was categorised into never use, sometimes use and regular use, denoted by 0, 1, 2, respectively. Simple arithmetic questions (i.e., simple addition, subtraction, division, and multiplication) were asked to ensure the participants' attentiveness. Each participant took about 10 min to complete this face-to-face interview-based entire questionnaire survey.

Figure 3.10 Questionnaire and health survey

3.3.5.3 Blood pressure (BP) and heart rate (HR) monitoring

The participants who used to take antihypertensive medicine were removed from the analysis. The BP and HR were monitored by digital BP monitor, which was calibrated with the manual sphygmomanometer. The BP and HR were recorded thrice at the sitting position after arrival to the workplace and before departure from the workplace after sufficient rest (Figure 3.10). The follow-up BP and HR were measured twice on a weekly basis for four weeks. The average Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP) and HR of the whole monitoring duration were considered for each participant for further analysis. For the analysis, the SBP was classified as SBP1, which is hypotension < 100 mm Hg, SBP2 near normal BP between 100-120 mm Hg, SBP3 is the pre-hypertensive BP which lies between 122-140 mm Hg and SBP4 is the hypertension which >140 mm Hg (WHO, 2015; Pitchika et al., 2017). The DBP was classified as DBP1 is the hypotension BP, which is < 80 mm Hg and DBP2 in the range between 80-90 mm Hg, indicating the combination of normal and pre-hypertensive BP and DBP3 is > 90 mm Hg indicating hypertensive BP (WHO,2015; Pitchika et al., 2017). HR is also categorised as HR1, which <72 beats/min i.e. bpm, indicates low HR, HR2 lies in 72-80 bpm indicates normal HR and HR3 is > 80 bpm indicates fast HR. Any fractional value of average SBP, DBP and HR was treated as the nearest integer value as per the above classification.

3.3.6 Building attributes

In this study one office building was considered based on their building materials (brick façade), ventilation (mixed ventilated) and proximity of the roadside. Window and door locations were also taken care during this study. The building windows and doors are located towards the traffic way.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 GENERAL

In this chapter, the traffic, $PM_{2.5}$, noise, meteorological, questionnaire and health data collected during field study have been analysed and discussed in details. The process of data illustration and interpretation helps to convert the data into significant evidence.

4.2 CHARACTERISTICS OF TRAFFIC ATTRIBUTES

The traffic data videotaped at the study area along with the speed monitoring throughout the study duration have been analysed for traffic flow, composition, and speed (Figure 3.8). The traffic counts are categorised into light vehicle (bike, car, multi-utility vehicle (MUV), auto) and heavy vehicle (bus, truck). Figure 4.1(a) shows that in that study duration (10 a.m. - 8 p.m.), observed speed of different traffic including bike, car, bus, truck, MUV and auto were, 28.5 ± 2.2 km/h, 28.2 ± 2 km/h, 26.4 ± 1.6 km/h, 25.1 ± 3.1 km/h, 25.6 ± 1.8 km/h and 26.4 ± 1.6 km/h, respectively. While, at midnight (12 a.m. - 4 a.m.), the observed speed of bike, car, truck, MUV and auto were 30.4 ± 0.8 km/h, 29.8 ± 0.9 km/h, 27.6 ± 3.5 km/h, 26.9 ± 2.1 km/h, 27.6 ± 1.8 km/h respectively (Figure 4.1 (b)). In Figure 4.2 (a), shows that, out of 101,865 of total traffic, 45 % of bike, 36 % of car, 3 % of bus, 0.29 % of truck, 6 % of MUV (multi utility vehicle), 10 % of auto was observed throughout the study hour (10 a.m. - 8 p.m.). While during 12 a.m. - 4 a.m. midnight out of 6144 of total traffic, 30 % of bike, 56 % of car, 5 % of truck, 4 % of MUV and 5 % of auto was observed (Figure 4.2 (b)). This finding indicate that bike and car were the dominating traffic in the fleet and both of these were moved with relatively faster speeds than other traffic. Thakre et al. (2020) observed similar trend of traffic fleet in Indian road.

(a)

(b)

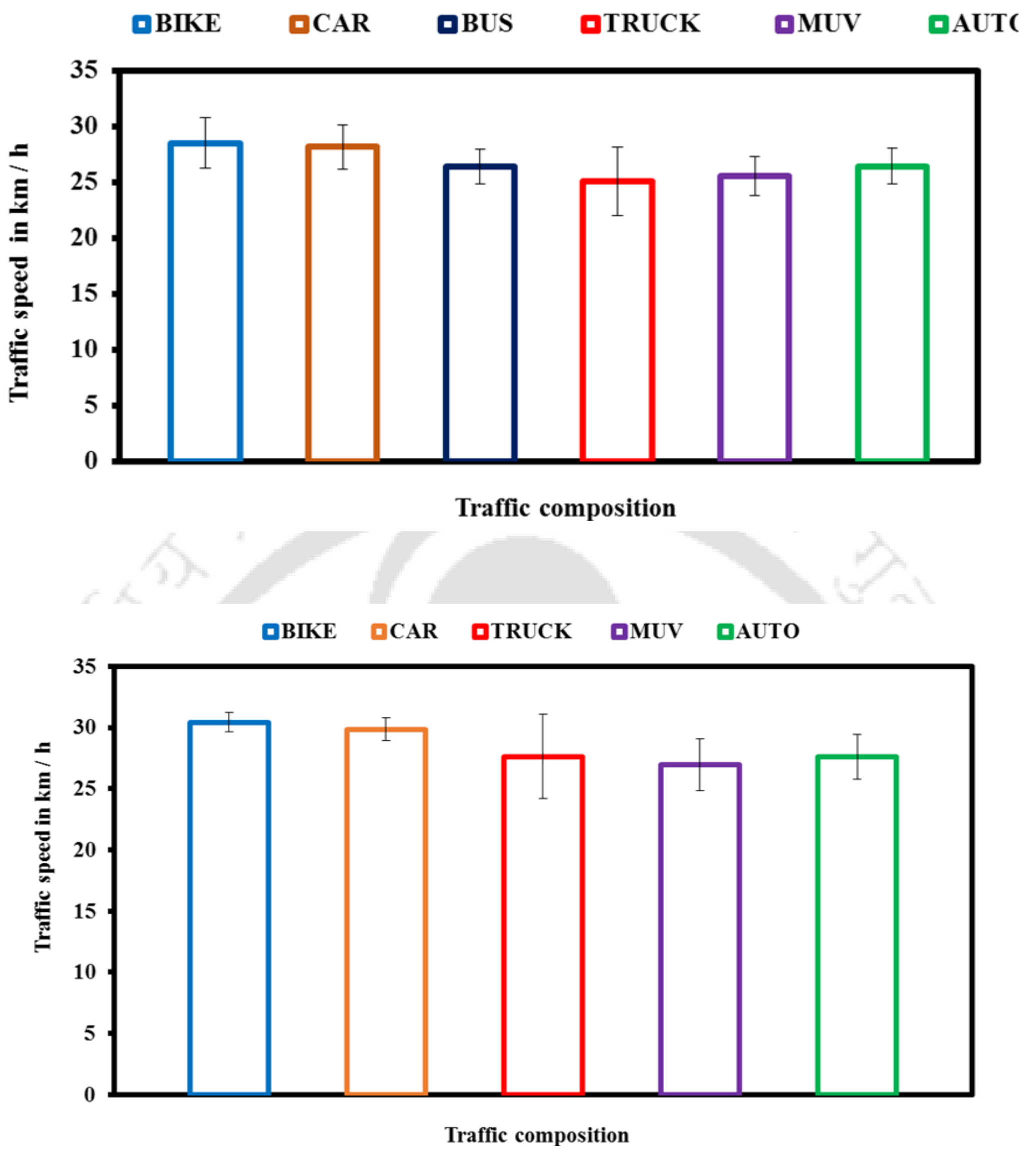
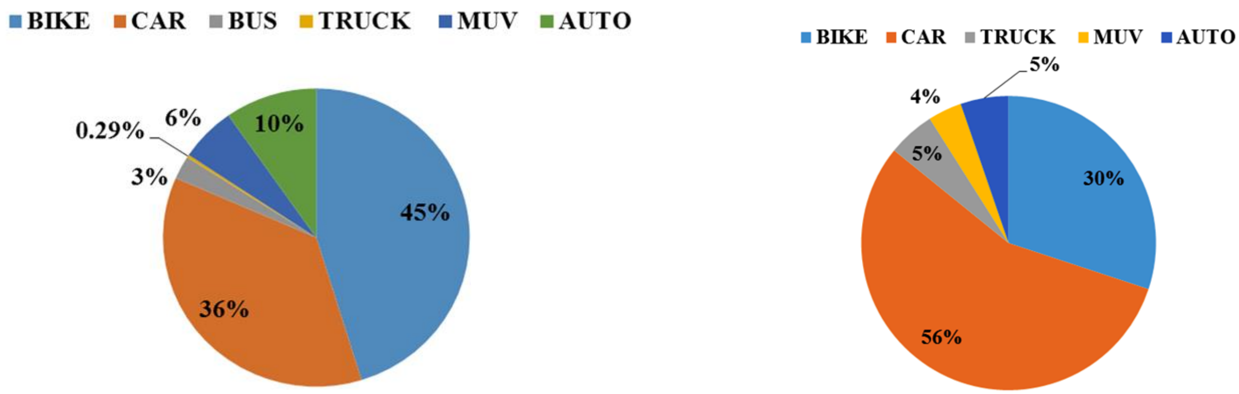


Figure 4.1 Traffic speed (a) at 10 a.m. - 8 p.m. and (b) at 12 a.m. - 4 a.m. of different traffic in the fleet



(a) **(b)**

Figure 4.2 Traffic composition (a) at 10 a.m. - 8 p.m. and (b) at 12 a.m. - 4 a.m.

4.3 TRAFFIC NOISE POLLUTION

The noise exposure at the workplaces (indoors and street-side) for the work duration was estimated from the observed noise as hourly , 10-h and seasonal average of L_{peak}, L_{max}, L_{min}, L_{eq}, L_{10}, L_{50}, L_{90}, and L_{95} respectively by Eq. (4.1).

$$L_{ai} = 10 \cdot log \sum_{i=1}^{n} f_i \left(10^{\frac{Li}{10}}\right) \tag{4.1}$$

where, a_i is the acoustic indicator, f_i the time fraction and L_i is the noise level at each time fraction.

The hourly, 10-h and seasonal average $NC_{(L90)}$ and $NC_{(L95)}$, have been calculated using Eq. (4.2) and Eq. (4.3).

$$NC_{(L_{90})} = L_{10} - L_{90} \tag{4.2}$$

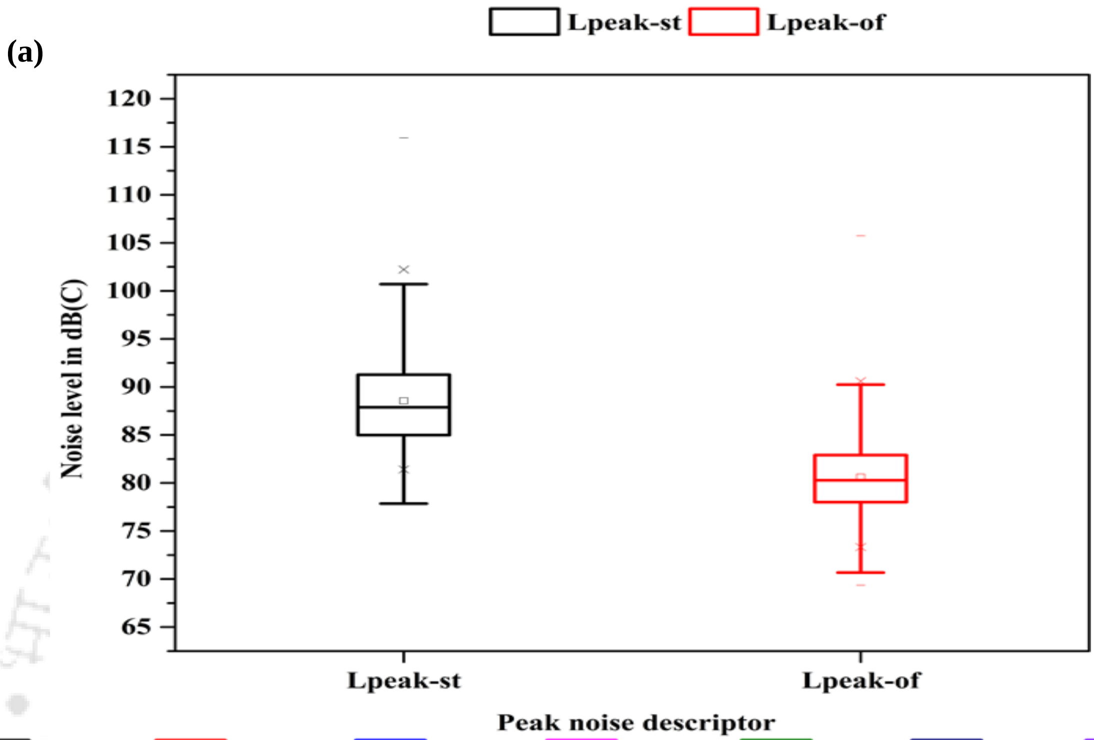
$$NC_{(L_{95})} = L_{10} - L_{95} \tag{4.3}$$

The low frequency band is designated at 125 Hz and lower medium frequencies, which includes the bands centered at 250 and 500 Hz, while the high frequency contains bands of 1000 Hz and above (Ross et al., 2011).

In this study monitoring seasons have been classified as winter (December-February), pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October-November). This seasonal classification is in line with the study of Barman and Gokhale (2019).

4.3.1 Noise exposure throughout the working hour

Figure 4.3 indicates the noise exposure of the workers' in the study area. In the outdoor roadside area, the median of L_{eq} was 71.35 dB (A), while in the indoors of the office building, it was 65.78 dB (A). The median L_{peak} values in the roadside area and indoor office were 84.94 dB(C) and 79.86 dB(C), respectively (Figure 4.3 (a)). The L_{max} and L_{min} along the roadside were 73.42 dB (A) and 70.01 dB (A), respectively, and in the office, the levels were 68.16 dB (A) and 62.97 dB (A), respectively. The L_{10}, L_{50}, L_{90}, and L_{95} near the roadside exceeded the national ambient noise standards (NAAQS) for daytime of 65 dB (A) (CPCB, 2000), and in the office building, the levels exceeded the WHO prescribed limit of creating annoyance of 55 dB (A). The NC (L_{90}) and NC (L_{95}) were found to be 3.50 dB (A) and 3.85 dB (A), respectively in the roadside area, while, in the office indoor, 5.0 dB (A) and 5.50 dB (A), respectively (Figure 4.4).



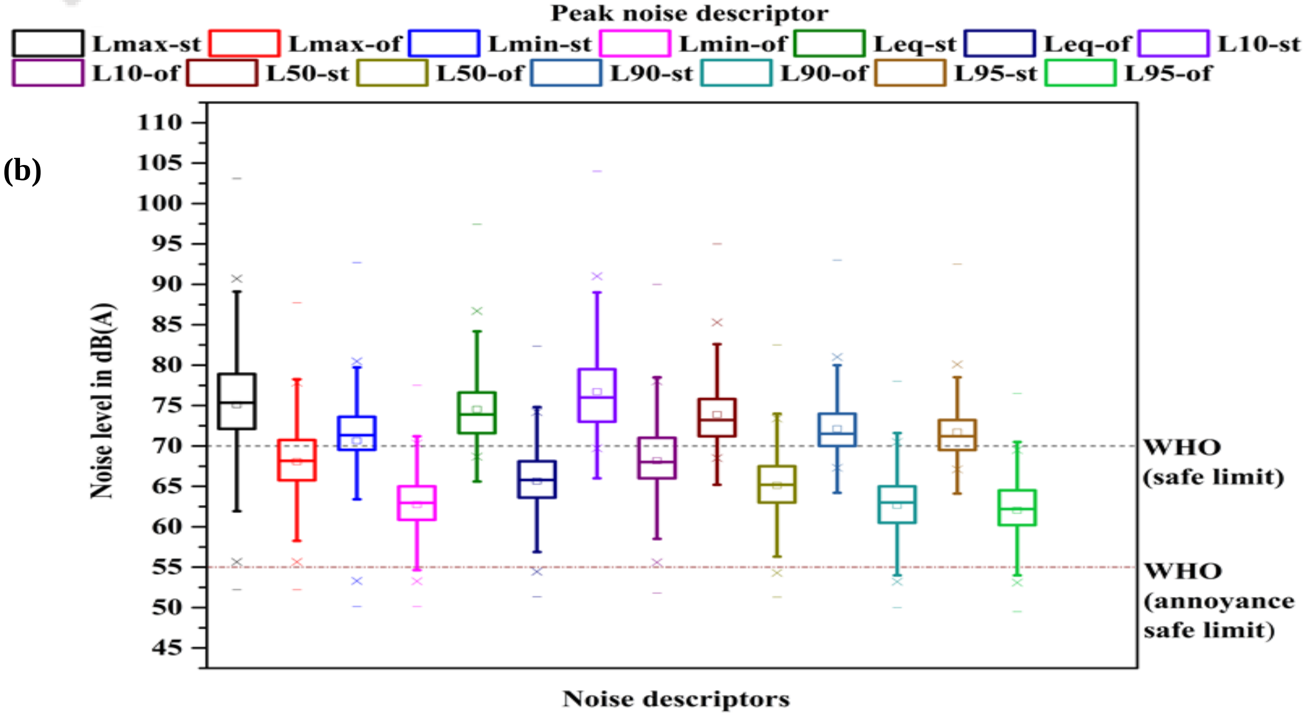


Figure 4.3 Comparison of (a) peak noise (b) noise descriptors including statistical noise of street side and indoor office

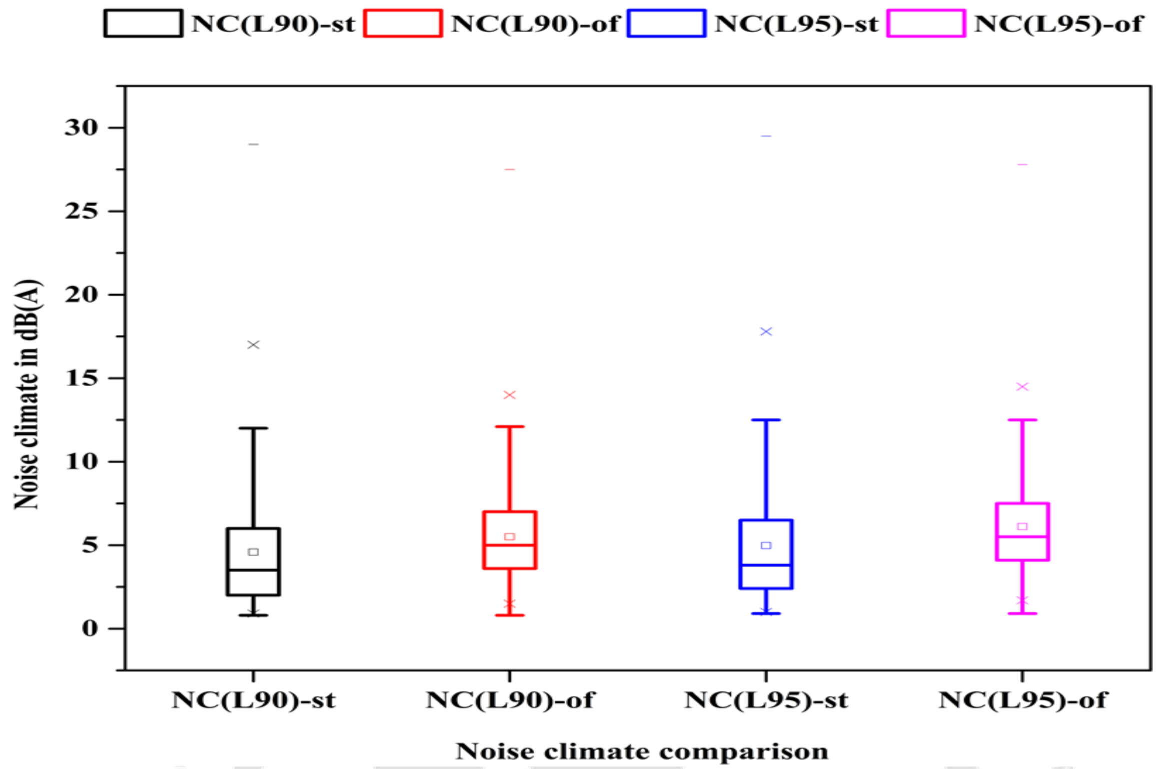


Figure 4.4 Comparison of noise climates of street side and indoor office

Figure 4.5 (a) shows along the road side the noise at low frequencies (25 - 500 Hz) exceeded about 40 dB (A) sound pressure level (SPL). Wang et al. (2016) reported similar findings in roadside of Taiwan city. The noise at mid frequencies (630 - 4000 Hz) exceeded 50 dB (A) SPL. And the noise at higher frequencies lies within 40 dB (A) SPL. Can et al. (2010) and Chang et al. (2019) also observed that at 1 kHz noise level reaches peak, which might be attributed to vehicle wheel and road pavement interaction (i.e. rolling noise). In this study, similar conclusion could be drawn as the traffic fleet with varying speed throughout the study period was observed which contributes a significant proportion of rolling noise, horn honking, and multiple reflections of noise due to the presence of different urban forms. Vijay et al. (2015) observed similar findings in Indian road environments where horn honking exacerbate noise level by about 2-5 dB (A). On the other hand, inside the office the noise at 31.5 - 125 Hz frequencies exceeded the 30 dB (A), while the noise at remaining frequencies till 5000 Hz mostly exceeded 40 dB (A) SPL. The noise at rest at higher frequencies was obtained within 40 dB (A) (Figure 4.5 (b)). Huang et al. (2017) observed that the low frequency noise influenced the noise level at lower floors of a high rise building near urban expressway. In this study, inside the office apart from ingress of outdoor traffic noise, operation of wall mounted fan, public speaking and different public activities might have contributed the noise.

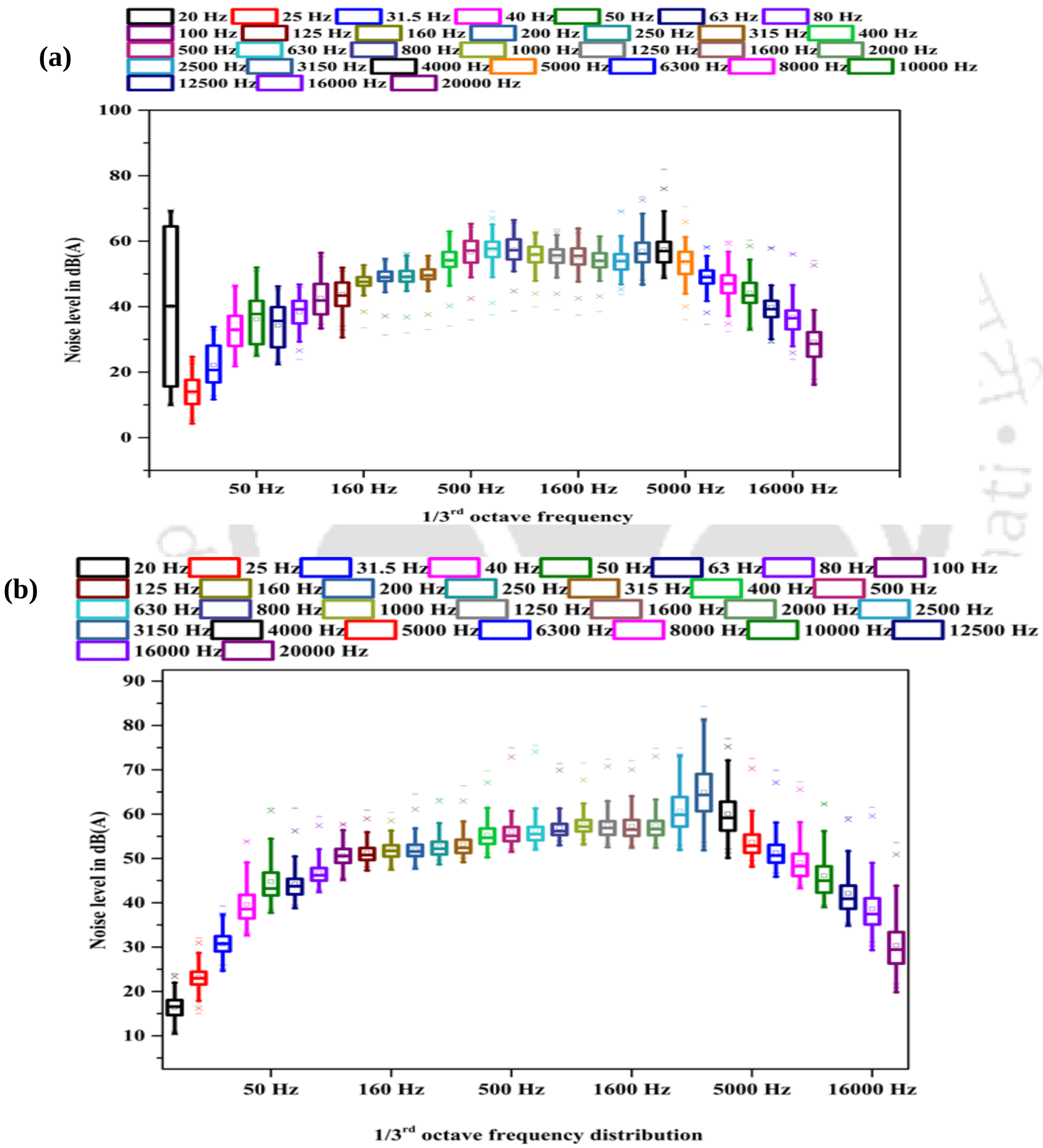


Figure 4.5 1/3rd octave band noise frequency of (a) street side and (b) office indoor

4.3.2 Temporal Noise Exposure

The noise levels were found to have been exceeded all the hours the CPCB and WHO standards (Figure 4.6). For ex, the peak noise component, L_{10} exceeded 74 dB (A), which can cause significant annoyance to the noise receptors. Chauhan et al. (2023) and Ranjan et al. (2023) also reported the similar findings in their studies.

Similarly inside the office, the entrance door's opening cases were studied as – i) fully open between 10 a.m. and 6 p.m. and ii) frequent open-close between 6 p.m. and 8 p.m. It is found that some significant influence of outdoor traffic noise increased the indoor noise levels for the "door fully open case". Besides, office activities added some noise in the indoor.

Most of the time L_{eq} violated the CPCB standard 65 dB (A) for commercial area. From 11 a.m. to 12 noon and 4 p.m. to 5 p.m. traffic congestion, movement of office employees, outsiders led to the high noise level. From 5 p.m. to 6 p.m. during office closure time, private car operation at adjacent parking area and high level of outdoor traffic increased the indoor noise level. Figure 4.7 showed that the $NC_{(L90)}$ and $NC_{(L95)}$ were always higher for office than the street ambient environment for the higher on street background noise level (L_{90} and L_{95}).

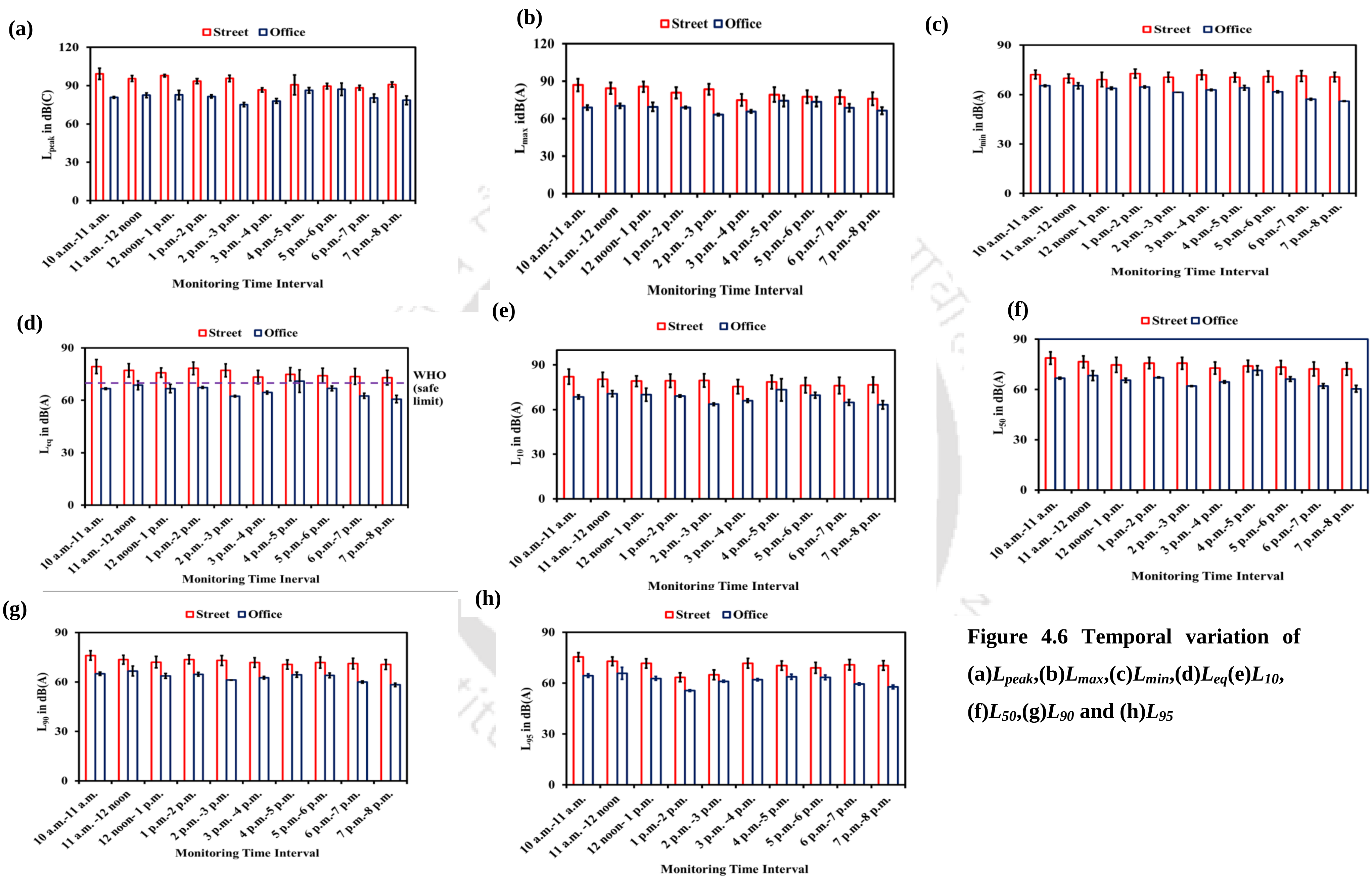


Figure 4.6 Temporal variation of (a)L_{peak},(b)L_{max},(c)L_{min},(d)L_{eq}(e)L_{10}, (f)L_{50},(g)L_{90} and (h)L_{95}

(a)

(b)

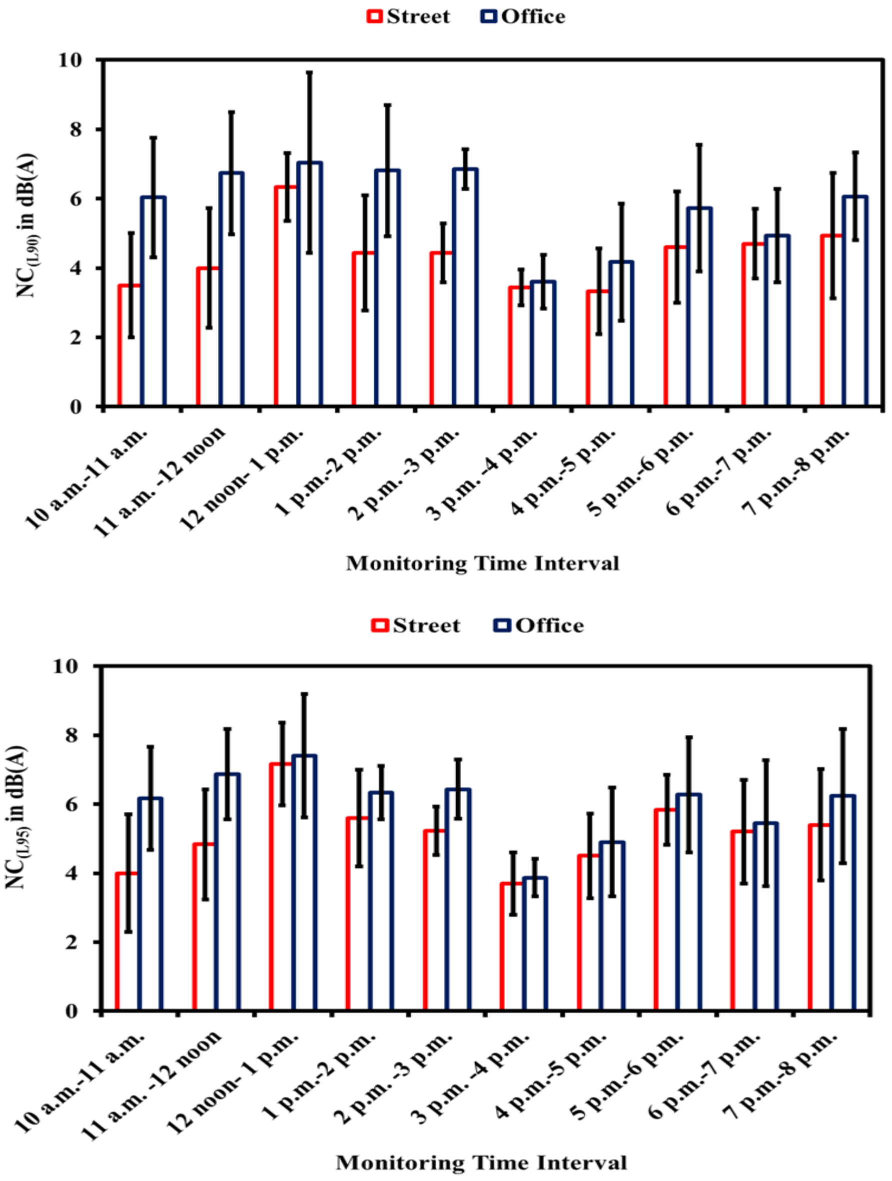


Figure 4.7 Temporal variation of (a) $NC_{(L90)}$ **and (b)** $NC_{(L95)}$

At midnight (12 a.m. - 4 a.m.) the observed street side ambient and office indoor noise level were 65.51±7.57 dB(A) and 51.16 ± 5.84 dB(A), respectively (Figure 4.8). Mostly some extent of traffic activities could be the reason for the night time noise.

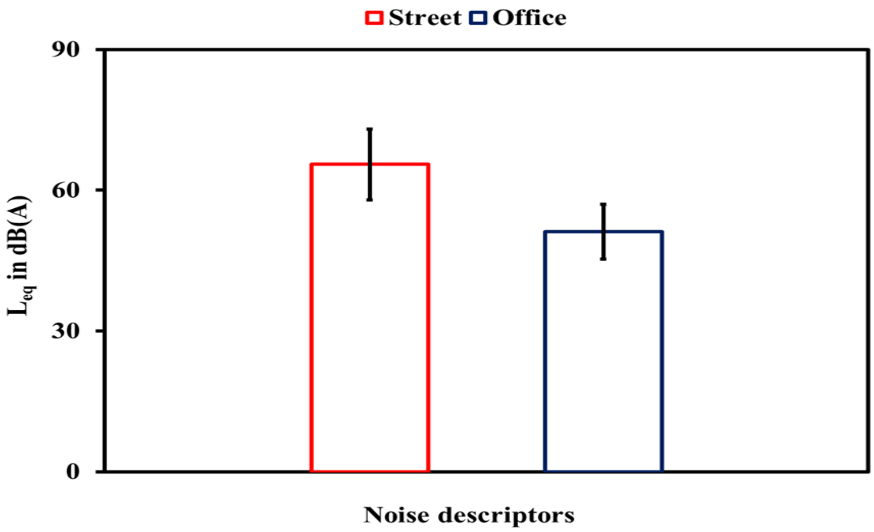


Figure 4.8 Midnight noise level at street side ambient and office indoor microenvironments

4.3.3 Seasonal variation of noise exposure

Figure 4.9 showed that the street side equivalent noise level (L_{eq}) was the highest in winter (78.28±3.91 dB(A)), followed by post-monsoon (73.32±6.52 dB(A)), pre-monsoon (73.26±2.81 dB(A)) and monsoon (73.17±3.09 dB(A)) seasons, violated the WHO safe limit of 70 dB(A). The other noise indices including peak noise component (L_{10}), median noise (L_{50}) and background noise components (L_{90} and L_{95}) were also increased during winter seasons than other seasons, which reflects the increase in L_{eq} during winter seasons. Wang et al. (2016) and Munir et al., (2021) also observed similar rise in winter noise levels than other seasons in China and Pakistan. This is basically due to intense public and tourist activities along with road traffic movement during winter led to increase L_{eq} level.

However, inside the office the observed L_{eq} was greater than WHO annoyance level of 53 dB (A) in every seasons. The obtained highest monsoon on street noise climates ($NC_{(L90)}$ and $NC_{(L95)}$) of 8.66±3.28 dB(A) and 9.62±3.71 dB(A), respectively, due to irregular public activities during rain and when there was no rain in monsoon season. However, for consistent public activities during pre-monsoon season induced high level of L_{10}, L_{90} and L_{95}

which results in lowest pre-monsoon street side $NC_{(L90)}$ and $NC_{(L95)}$ of 2.9±1.59dB(A) and 3.06±1.54 dB(A), respectively. Inside the office the $NC_{(L90)}$ and $NC_{(L95)}$ were increased during winter (11.4±5.36 dB(A) and 12.03± 5.39dB(A)) and pre-monsoon (9.65±3.03 dB(A) and 10.4± 3.12 dB(A)) seasons due to irregular window operation of office and different public activities.

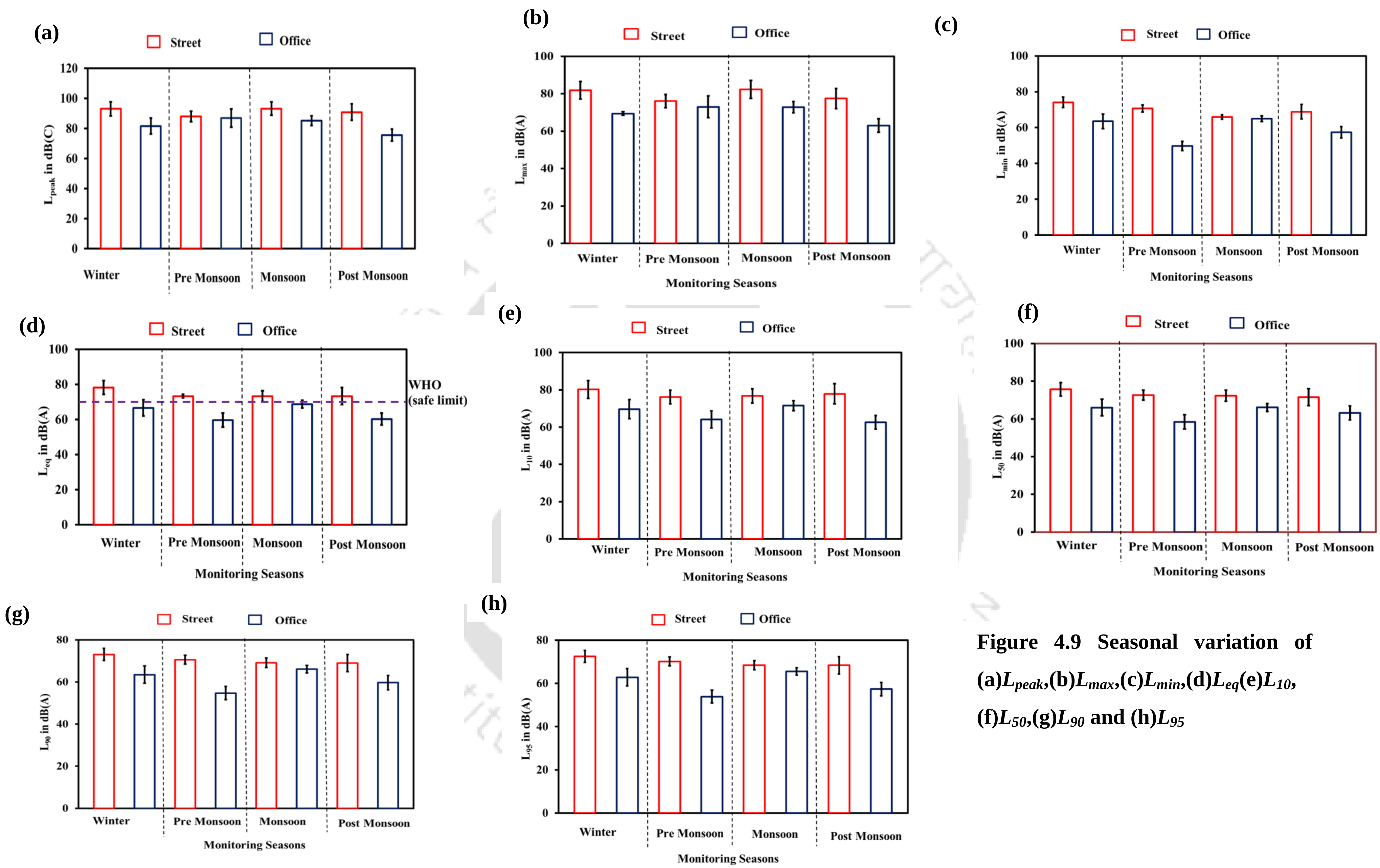


Figure 4.9 Seasonal variation of (a)L_{peak},(b)L_{max},(c)L_{min},(d)L_{eq}(e)L_{10}, (f)L_{50},(g)L_{90} and (h)L_{95}

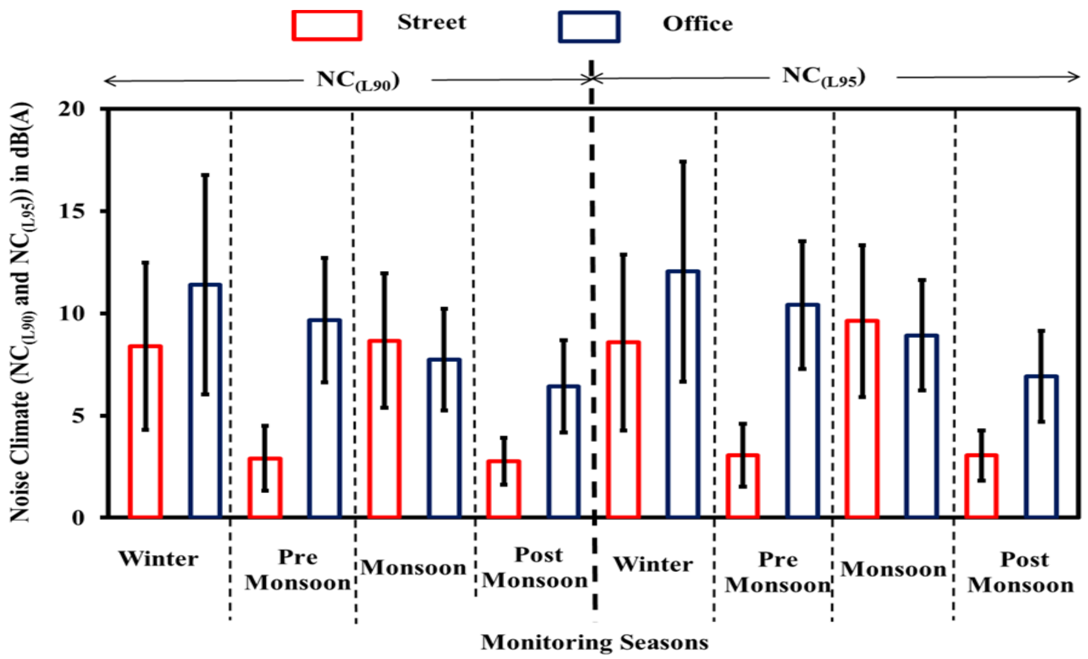


Figure 4.10 Seasonal fluctuations of $NC_{(L90)}$ and $NC_{(L95)}$

The results of the noise analysis conclude that there is a serious deterioration of acoustic quality both on street-side and inside the office, mainly due to the road traffic movement and to some extent also by public activities and a few minor indoor sources.

4.4 $PM_{2.5}$ POLLUTION

The $PM_{2.5}$ exposure was calculated by the following Eq. (4.4)

$$PM_{2.5} = \frac{W_f - W_i}{V} \tag{4.4}$$

where, $V = \left(\frac{Q_i + Q_f}{2}\right) \cdot T$ (4.5)

where, W_i and W_f denotes the initial and final weight of filter paper in g and V is the total volume of air flow (in m^3) drawn by the instruments, Q_i and Q_f denotes the initial and final air flow rate (in m^3/min) drawn by the instruments, and T refers the each sampling duration.

4.4.1 $PM_{2.5}$ exposure throughout the working hour

Figure 4.11 shows that the observed 10-h average median $PM_{2.5}$ concentrations at roadside and in office indoors were 106.67 and 33.33 µg/m^3, respectively, which violated the road side $PM_{2.5}$ concentration for the 24h CPCB and WHO permissible limits of 60 µg /m3 and 15 µg/m^3, respectively (WHO, 2021). At midnight (12 a.m.- 4 a.m.) the observed $PM_{2.5}$ concentration at ambient street side and indoor were 57.63±17.67 µg /m^3 and 24.54±4.25 µg /m^3. Pant et al. (2016) and Singh et al. (2021) observed similar trend of $PM_{2.5}$ pollution in Indian urban environment. Traffic emission contributes to this alarming $PM_{2.5}$ pollution. While inside the office, outdoor infiltration, public activities including movement inside the room with shoes, environmental tobacco smoke, cooking activities in pantry may be contributing to the indoor $PM_{2.5}$ concentrations. There is some similar observation drawn by Tiwari et al. (2017) in their study for $PM_{2.5}$ pollution in Guwahati city.

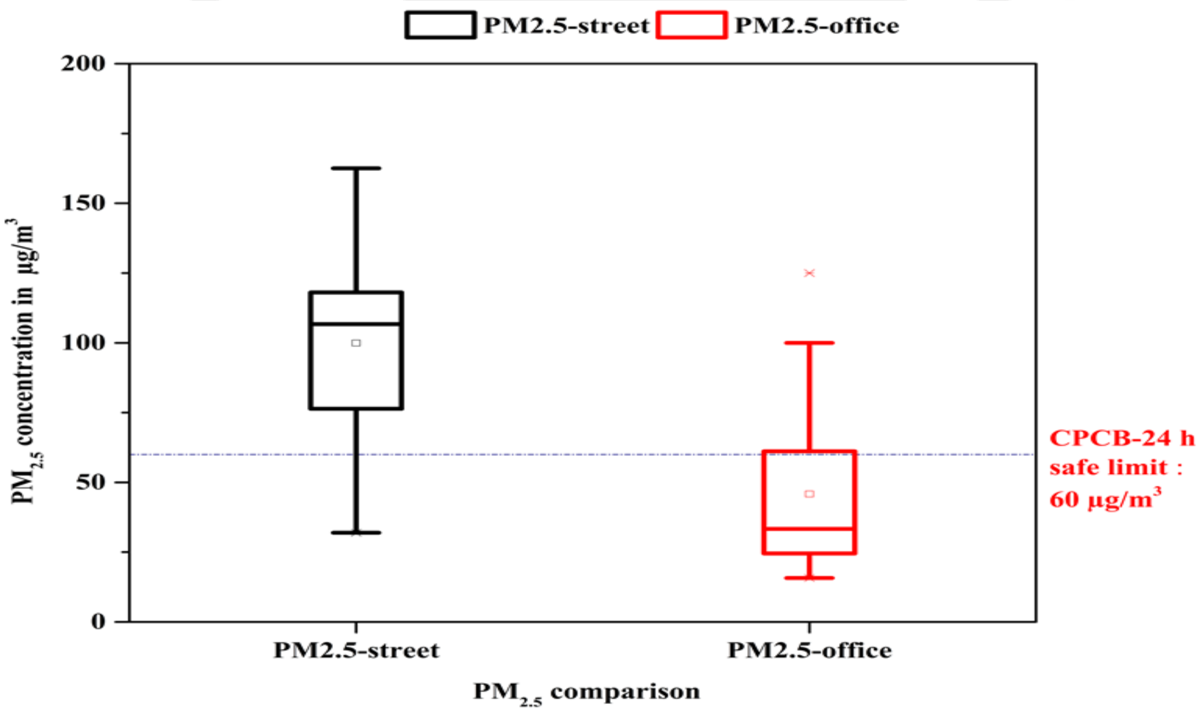


Figure 4.11 $PM_{2.5}$ concentration in different microenvironments

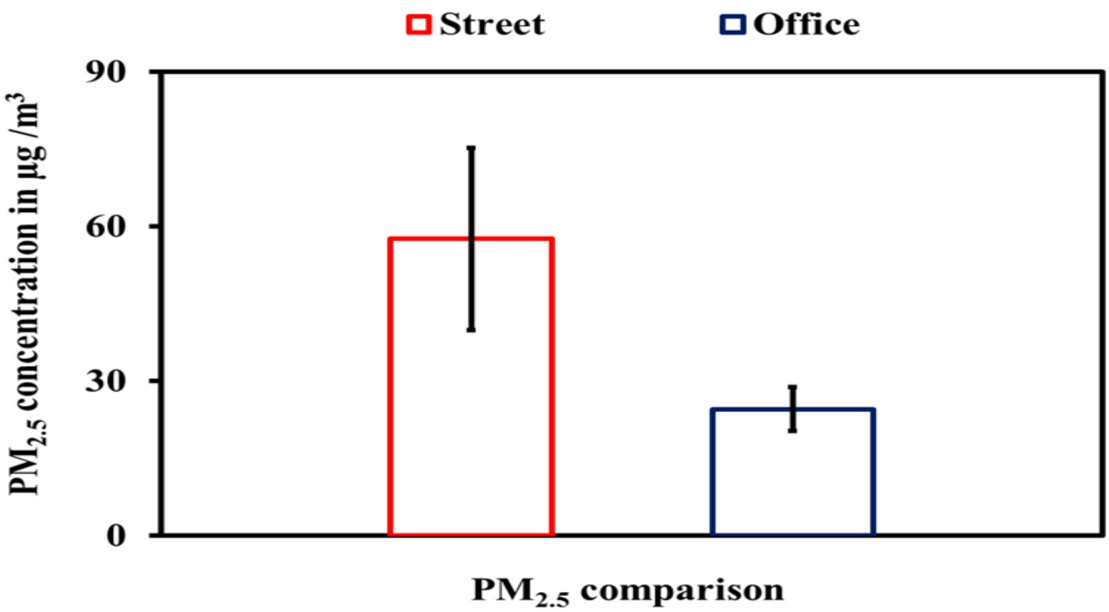


Figure 4.12 $PM_{2.5}$ concentration at midnight (12 a.m. – 4 a.m.) in different microenvironments

4.4.2 Seasonal trend of $PM_{2.5}$ concentration

Figure 4.13 shows that the highest $PM_{2.5}$ was observed in winter (131 ± 39 µg/m^3), followed by pre-monsoon (91.67± 21.6 µg/m^3), post-monsoon (64.97± 29.68 µg/m^3) and monsoon (38.49±7.98 µg/m^3). Except the monsoon season, $PM_{2.5}$ values violated the NAAQS for the 24 h average concentration of 60 µg/m^3. In winter, the main reason for the poor street-side $PM_{2.5}$ was due to the burning of biomass in the early morning (garbage and fire wood burning for heating) and the high vehicular activities throughout the day, which is in addition to the low-level fog restricting the dispersion of pollutants. Tiwari et al. (2017) also observed similar seasonal trends of $PM_{2.5}$ concentrations in Guwahati. In office indoor, the $PM_{2.5}$ concentrations in winter, post-monsoon, pre-monsoon and monsoon of 111.31±15.9 µg/m^3, 57.82±6.6µg/m^3, 39.3±3 µg/m^3 and 22.56±3.51 µg/m^3, respectively.The on street vehicular activities also contribute significantly to indoor $PM_{2.5}$ (Datta et al. 2017).

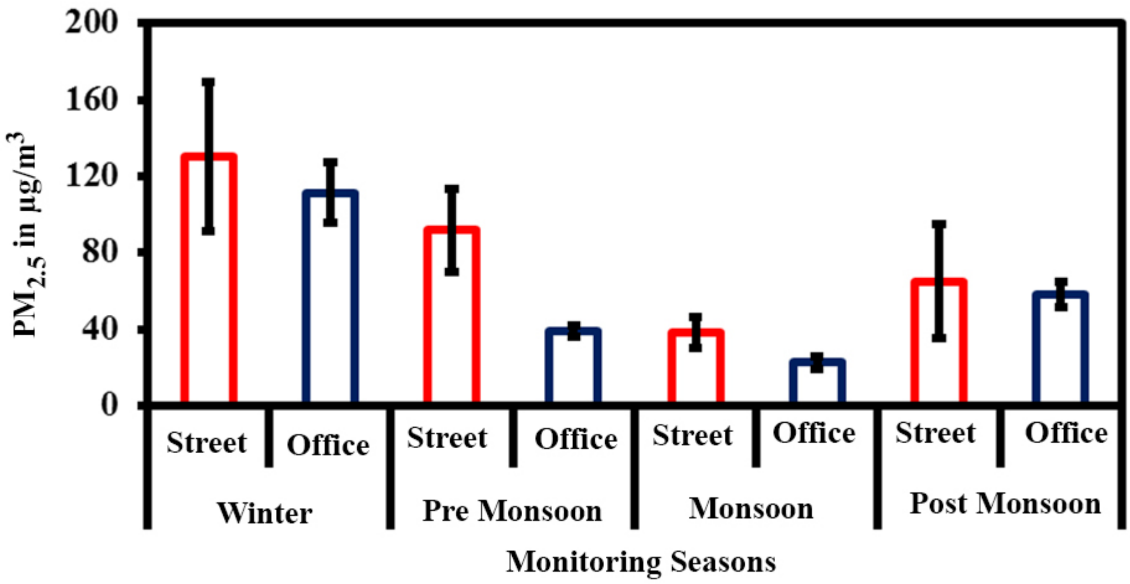


Figure 4.13 Seasonal trend of $PM_{2.5}$ concentration

4.5 RELATIONSHIP BETWEEN TRAFFIC NOISE AND $PM_{2.5}$

The correlation analysis of noise indicators showed that minimum average noise level (L_{min}) of the office was negatively correlated with all the noise climate indices $NC_{(L90)}$ (ρ=-0.343; p=0.020) and $NC_{(L95)}$ (ρ=-0.325; p=0.028) found in the outdoor at the street side.

The observed correlation (ρ=0.384; p=0.008) between $NC(_{L95})$ of office and L_{min} of street side indicated that with increasing the minimum noise level of street side could slightly increase the noise climate of office indoor. This is due to the possible influence of street side L_{min} on peak noise component (L_{10}) of office indoor.

The street-side $PM_{2.5}$ was slightly correlated with street-side peak noise (L_{peak}) (ρ=0.344; p=0.019) and background noise components (L_{90} and L_{95}) (ρ=0.299; p=0.044 and ρ=0.313; p=0.034), which might be because the noise and the particles are originated from the same source. There was a positive and negative correlation observed between street side $PM_{2.5}$ and $NC_{(L90)}$ (ρ=0.301; p=0.042) and L_{min} (ρ=-0.374; p=0.010).

$PM_{2.5}$ concentration of office indoor was negatively correlated with the noise indices of office viz. L_{peak} (ρ=-0.337; p=0.022), maximum average noise level (L_{max}) (ρ=-0.380; p=0.009), equivalent noise level (L_{eq}) (ρ=-0.4; p=0.009), L_{10} (ρ=-0.369; p=0.012) and median noise (L_{50}) (ρ=-0.37; p=0.001). This shows that the partial or full closure of windows could hinder the dispersion of indoor $PM_{2.5}$ and through the entrance of ambient noise can lead the increase in the indoor $PM_{2.5}$ concentration and decrease indoor noise indices.

No significant correlation was observed between $PM_{2.5}$ of street and $PM_{2.5}$ of office indoor and between the L_{eq} of street and the L_{eq} of office. This may be attributed to the fact to the significant influence of multiple factors (pollution source, meteorology and different surface roughness and various anthropogenic activities) on air and noise pollution of both street side and office indoor microenvironments.

4.6 NOISE-$PM_{2.5}$ INDEX

The Noise-$PM_{2.5}$ index has been calculated by the linear combination of two equally weighted normalised urban stressors i.e. Noise and $PM_{2.5}$. This index indicates the traffic pollution status in urban areas, which plays a crucial role for urban planning and policy making (Silva and Mendes, 2012). The weights are assigned as per the number of pollutants. Since two pollutants were studied together i.e. $PM_{2.5}$ and noise, the weights were taken as 1 each as per the study of Silva and Mendes (2012).

$$Noise - PM_{2.5}\ index = 0.5 \cdot a\ + 0.5 \cdot b \qquad (4.6)$$

where, 'a' and 'b' denotes the noise index and $PM_{2.5}$ index which is the normalised noise and $PM_{2.5}$ level, respectively.

The normalised pollution levels were calculated by standardising the pollutant which basically transforms any scale into a normalised scale i.e. 0-1. Here, 0 indicates the bad air and noise quality and 1 indicates the opposite.

A sigmoidal function has been adopted for standardisation of the pollutant level

$$Score = \cos^2 \alpha \qquad (4.7)$$

where, $\alpha = \frac{(x-x_a)}{(x_b-x_a)} \cdot \pi/2$ (4.8)

where, 'x_a' and 'x_b' are the control points which were 70 dB(A) and 53 dB(A), respectively for noise, and 60 μg/m^3 and 15 μg/m^3, respectively for $PM_{2.5}$, and 'x' is the observed pollutant level which has been considered for normalisation.

Score is 0 if noise level and $PM_{2.5}$ concentration > 70 dB (A) and 60 μg/m^3, respectively and score is 1 if noise level and $PM_{2.5}$ concentration < 53 dB(A) and 15 μg/m^3, respectively.

Numerical value of Noise-$PM_{2.5}$ index varies between 0-1. For very poor or unacceptable quality of environment this index become zero and in the case of acceptable or healthy condition of environment this index become one (Silva and Mendes, 2012).

Figure 4.14 shows that city noise-air index of office and street-side was 0.19 ± 0.05 and 0.25 ± 0.68, respectively. It indicates the deterioration of environmental quality in respect of air and noise quality. Silva and Mendes (2012) and Kundu Chowdhury et al. (2016) reported similar findings for the roadside area.

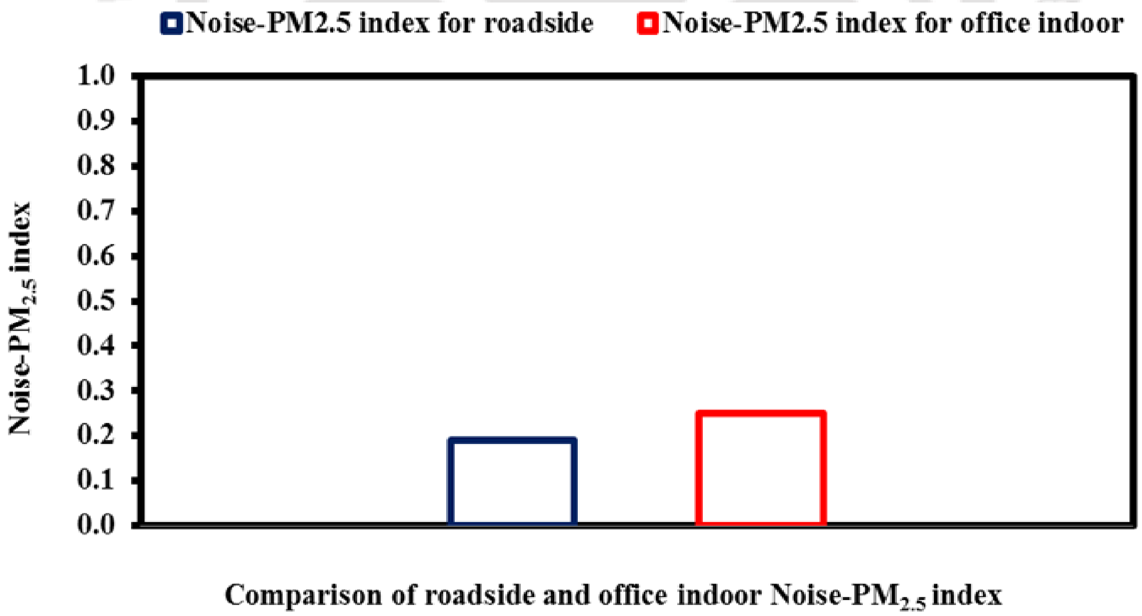


Figure 4.14 Noise-$PM_{2.5}$ index for roadside and office indoor

The results indicated that noise-$PM_{2.5}$ index were close to 0 for both the study areas, although for indoors, it was relatively higher. However, indicating severe degradation of atmospheric environmental pollution based on $PM_{2.5}$ and noise. These pollutants could be detrimental to human health that used to share that traffic corridor daily. There is a need for continuous monitoring of other air pollutants, including $PM_{2.5}$, with noise and meteorological parameters for developing integrated environmental quality and its' mitigation strategies. The findings of this study could help in urban planning and policy-making for developing cities.

4.7 METEOROLOGICAL DATA ANALYSIS

Using the weather station, meteorological data were recorded from 10 a.m. to 8 p.m. in weekdays at the indoor and outdoor of a commercial office building located at Bhangagarh, Guwahati along G.S. road. The 10-h and seasonal averaged meteorological data includes the ambient outdoor and indoor temperature, relative humidity, atmospheric pressure, solar radiation and wind attributes (wind speed and wind direction) were monitored.

4.7.1 Meteorological parameters during the study period

The street-side ambient temperature was 27±4.29 ˚C and inside the office the temperature was nearly 25.65±3.55˚C throughout the study duration (Figure 4.15(a)). Figure 4.15 (b) shows that due to high relative humidity in the ambient (73.84±14.85%) the observed indoor air relative humidity (72.98±7.31%) was high. Throughout the study duration the observed average solar radiation, atmospheric pressure and wind speed were 423.60±33.29 W/m2, 722.84 ±3.91 mm Hg. and 1.71±0.35 m/s, respectively. The observed average predominant wind direction was south-west (SW) with frequency > 55% (Figure 4.16(c)).

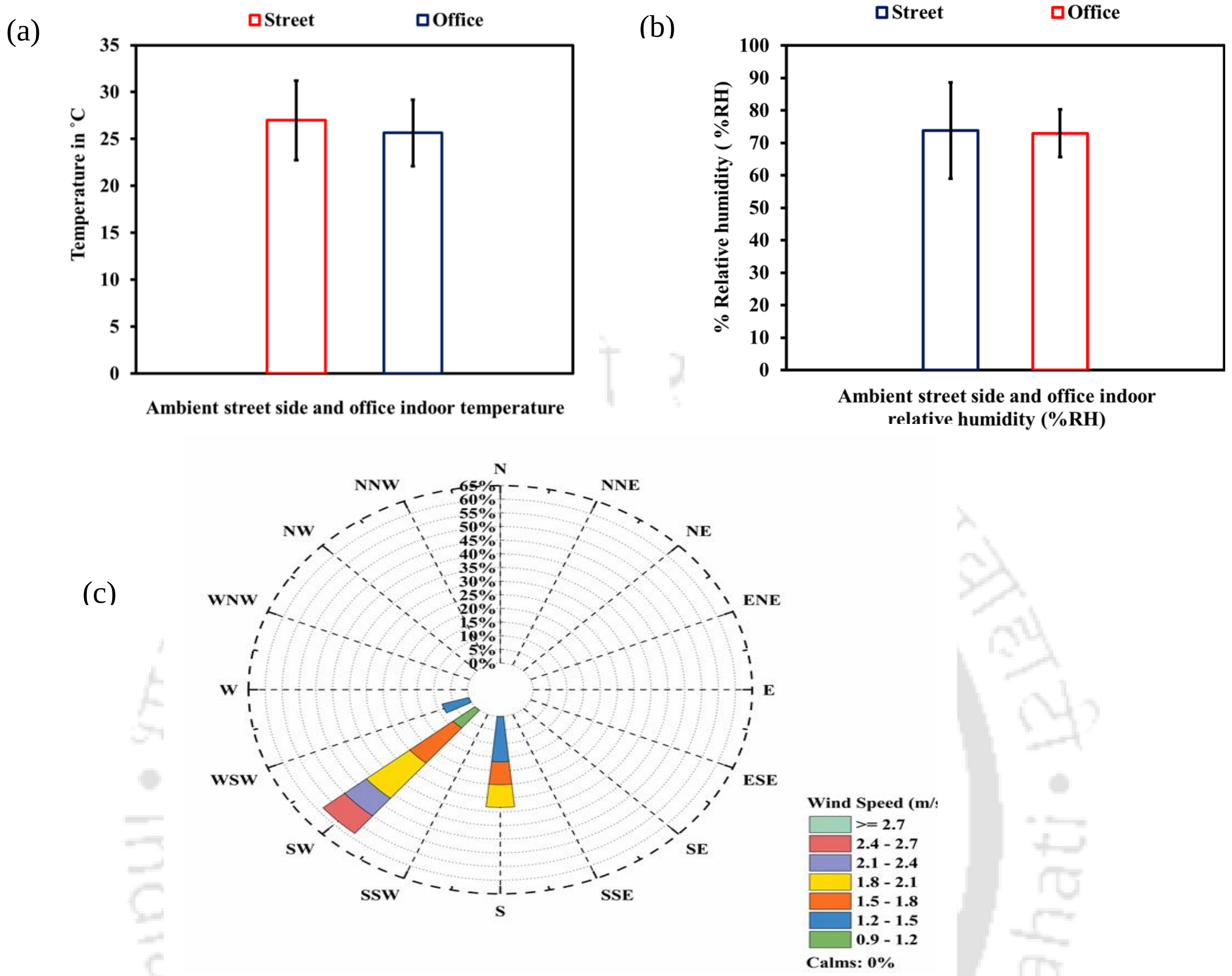


Figure 4.15 Temperature (a) and relative humidity (b) and (c) wind rose during the study period

4.7.2 Seasonal trend of meteorological parameters

Figure 4.16 (a) shows that the street side ambient temperature was the highest in monsoon (29.47±5.30 ˚C) followed by pre-monsoon (25.77±3.59 ˚C), post-monsoon (24.63±0.64 ˚C) and winter (19.06±2.35˚C). And, in the office during winter (20.95±0.97˚C) and post-monsoon (27.44±0.58˚C) seasons the observed temperatures increased than on street temperature. This could be due to the often closure of window during the above seasons and intense public activities inside the office.

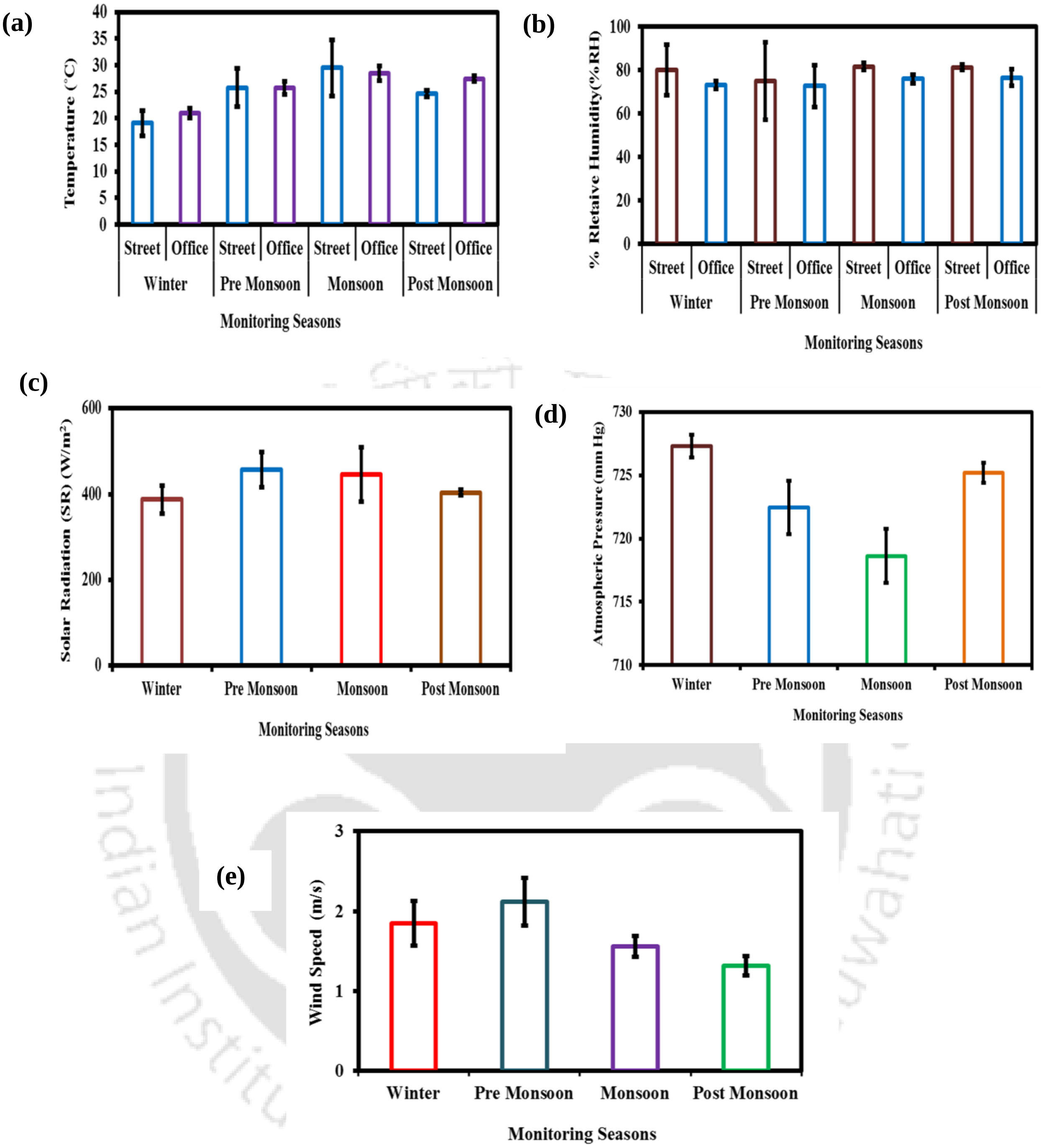


Figure 4.16 Seasonal trend of (a) temperature, (b) relative humidity (%RH), (c) solar radiation, (d) atmospheric pressure and (e) wind speed

In street side ambient environment the observed relative humidity (RH) in monsoon, post-monsoon, winter and pre-monsoon were 81.67±1.67 %, 81.33±1.18 %, 80.10±11.75%, and 75 ±17.75%, respectively (Figure 4.16 (b)). And, inside the office in every monitoring seasons the RH was >70%. Barman and Gokhale (2019) also have reported the similar findings.

Figure 4.16 (c) shows that the highest solar radiation (SR) observed during pre-monsoon season (457 ± 41.15 W/m^2) followed by monsoon (446.25± 63.09 W/m^2), post-monsoon (403.5± 6.36 W/m^2) and winter (387.67± 33 W/m^2). This is basically due to the clear sky exists during pre-monsoon months, due to which solar insolation reaches the earth surface. Similar observation was found by Deka (2012) in Guwahati city.

The observation depicts that atmospheric pressure was the highest in winter (727.31 ± 0.89 mm Hg) followed by post-monsoon (722.43± 2.11 mm Hg), pre-monsoon (718.62± 2.14 mm Hg) and monsoon (725.20± 0.80 mm Hg) (Figure 4.16 (d)). This happens due to the denser air during winter season. Srinivas and Kumar (2006) observed similar findings in Indian city.

The wind speed was found to be the highest in pre-monsoon (2.12±0.3m/s), followed by winter (1.85±0.28 m/s), monsoon (1.56±0.13 m/s) and post-monsoon (1.32±0.12 m/s) (Figure 4.16(e)). Figure 4.17 show that the observed predominant wind direction in winter and post-monsoon was the East (E) with > 60% and > 25% frequencies, respectively. In pre-monsoon and monsoon, the predominant wind was south-west (SW) with > 70% and > 60% frequencies, respectively.

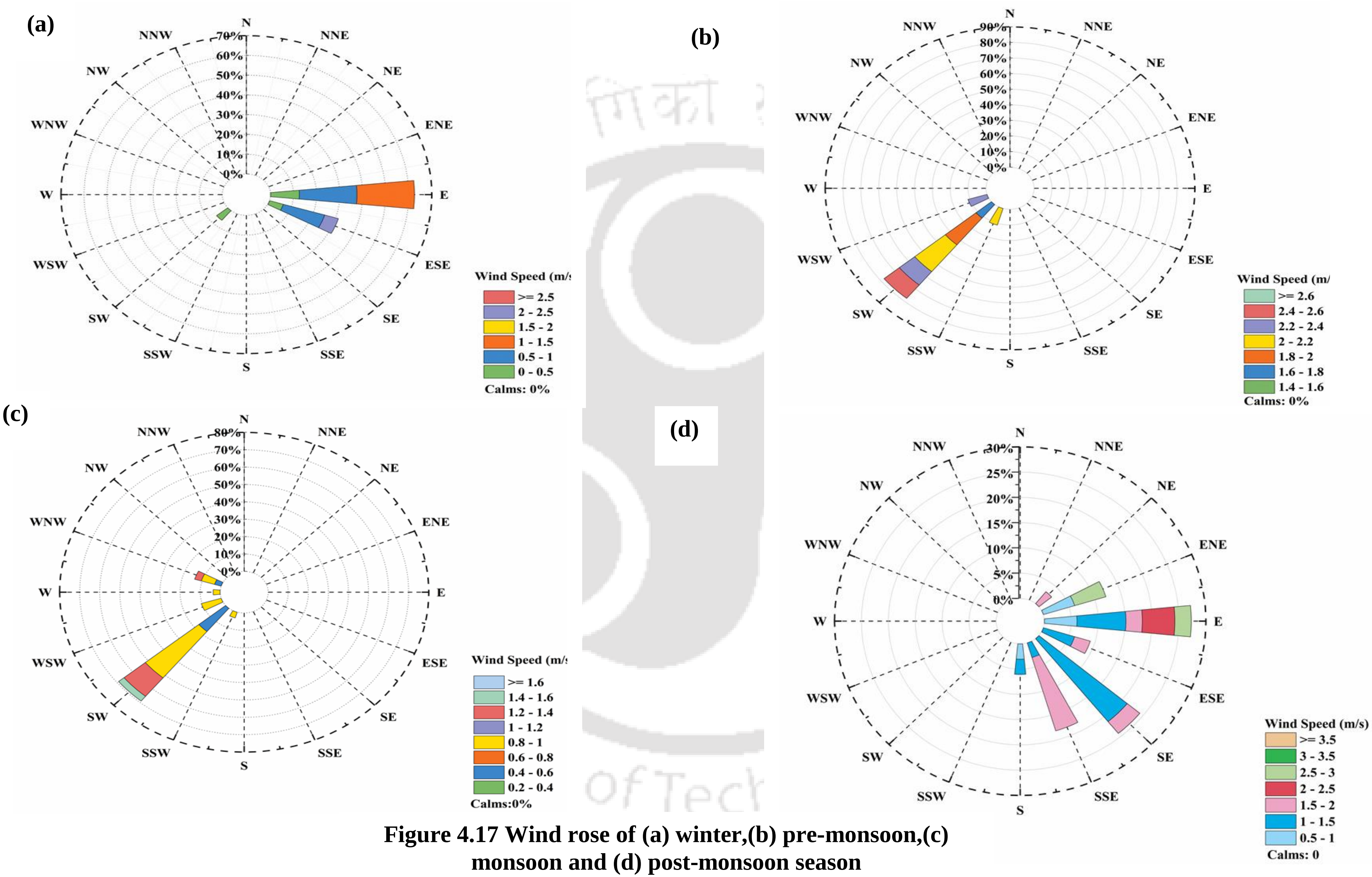


Figure 4.17 Wind rose of (a) winter,(b) pre-monsoon,(c) monsoon and (d) post-monsoon season

4.8 IMPACT OF METEOROLOGICAL PARAMETERS ON TRAFFIC NOISE AND $PM_{2.5}$

Table A-2 shows that street side ambient temperature was negatively correlated with street side equivalent noise (L_{eq}) (ρ=-0.355; p=0.015), which could be the reason for lesser public activities during warmer days. However, ambient temperature was found to be slightly correlated with indoor $PM_{2.5}$ concentration (ρ=0.345; p=0.019), this could be the due to the probable entrance of temperature induced ambient dispersed particle inside the office building. Temperature inside the office was slightly correlated with indoor L_{eq} (ρ=0.314; p=0.034), this happens possibly due to intense public activities inside the office room. Yang et al. (2018) also observed similar increase of indoor noise with temperature.

Wind speed was negatively correlated with indoor L_{eq} (ρ=-0.431; p=0.003), which depicts that high windy condition could force the office workers' to close the windows and doors which eventually decrease the indoor noise level. Whereas atmospheric pressure was slightly correlated with street side ambient L_{eq} (ρ=0.377; p=0.010) and negatively correlated with indoor L_{eq} (ρ=-0.386; p=0.008). On the other hand, atmospheric pressure was slightly correlated with street side ambient $PM_{2.5}$ (ρ=0.395; p=0.007). This is basically happens due to stable atmospheric condition. Solar radiation (SR) was positively correlated with street side L_{eq} (ρ=0.356; p=0.015) and $PM_{2.5}$ (ρ=0.441; p=0.002) and negatively correlated with indoor L_{eq} (ρ=-0.45; p=0.002).

4.9 SoundPLAN MODEL SOFTWARE CONFIGURATION CUM MODEL INPUT

Table 4.1 shows different building, road pavement attributes and receiver properties which have been used to model traffic noise propagation by SoundPLAN software.

Table 4.1 Configuration cum input for SoundPLAN traffic noise model

Configuration cum input variables	Characteristics
Geographical data	• **Coordinate system** : Universal Transverse Mercator (UTM) • **Coordinates**: Northern hemisphere • **Reference system** : World-wide GPS geocentric (GS84) • **Zone**: 46 • **Latitude**: 26.1709 ˚ N • **Longitude**: 91.7673˚ E
Pavement	Average grade asphaltic bitumen
Traffic data	Discussed at section 4.2 in Chapter 4 on Page 53
Meteorology	Discussed at section 4.7.1 in Chapter 4 on Page 72
Building dimension	Height (H) = 16.90 m, Length (L) = 14.85 m, Width (W) = 5.75 m
Building floor dimension	Floor height (h) = 2.65 m, floor slab thickness (t) = 0.65 m
Number of floor	4
Façade material	Brick work
Door	Double glazed glass door
Window	Sliding glass window
Noise Standards and Regulations	Federal Highway Administration (FHWA) Traffic Noise Model (TNM 2.5)
Calculation Settings	• **Time intervals**: Two (6 a.m.-10 p.m.; 10 p.m. - 6 a.m.) • **Frequency bands**: 1/1 octave frequency • **Weighting**: dB(A) • **Receiver property for point receiver**: Distance between road and receiver at 2.1 m ; receiver height 1.5 m • **Indoor receiver property**: Receiver height 1.5 m from floor and distance between receiver and adjacent indoor wall 1.4 m • **Receiver position for FNM**: Centre of each façade • **Grid property for GNM**: 5 m spacing with height of the 1.3 m elevation from ground. • **Reflection order**: 1 • **Reflection loss**: 1 dB(A) • **Field size**: 9 m × 9 m

4.10 CHARACTERISATION OF QUESTIONNAIRE AND HEALTH SURVEY RESPONSES AND ITS' RELATIONSHIP WITH $PM_{2.5}$ AND NOISE INDICATORS

The questionnaire and health data were put to descriptive statistical and Shapiro-Wilk tests to determine the distribution of each predictor variable. The non-parametric Spearman-rho correlation was estimated between the noise descriptors, $PM_{2.5}$ and the questionnaire variables for multicollinearity, and the relationship of the variables with the workplace annoyance and health parameters of the studied participants. The tolerance and variance inflation factor (VIF) were estimated to examine the multicollinearity. The average annoyance score (AAS) was calculated by averaging each respondent's home, workplace, and roadway annoyance scores. By considering demographics, socio-contextual, traffic activities near residence, smoking habit, and the collected acoustical indicators and $PM_{2.5}$ concentration, the ordinal regression analysis was used to predict the workplace annoyance of different microenvironments (Paiva et al.,2015; Camusso and Pronello,2016). The SPSS (v.20) was used to conduct the statistical analysis. By considering questionnaire outcome, $PM_{2.5}$ concentration and acoustical indicators, the ordinal regression analysis was done to predict SBP, DBP and HR of different microenvironments (Beutel et al., 2016; Camusso and Pronello, 2016). In this ordinal regression study, SBP4, DBP3 and HR3 treated as the thresholds of dependent variables. The combined dose-response functions were developed by identifying the significance impact of $PM_{2.5}$ and noise on health indices (SBP, DBP and HR) for the respondents, which has discussed in the chapter-5 and chapter-6. The SPSS (v.20) was used to carry out the statistical analysis.

4.10.1 Street vendors' scenario

The street vendors (n=46) participated in the questionnaire study, shown in Table A-4, in which 2.17% were < 20 y, 20-40 y (67.39 %), 41-60 y (21.74 %), and 8.7% were older than 60 y. The 89.13% were male and 10.87% were female. The 34.78% of street vendors dwelled at their current residences for < 10 y, 17.39% for 10-20 y, and 47.83% dwelled for > 20 y. The street vendors who had houses facing roadside traffic were 15.22% and the houses of those not facing the roadside were about 84.78 % and 19.57% had houses within the proximity of road (< 2 m) and 80.43% had > 3 m. Here, 84.78% and 80.43% of respondents' residential window and door locations were toward the road and 15.22% and 19.57% reported the opposite. During sleeping, 36.96 % of street vendors were disturbed by noise events and 63.04 % did not perceive the annoyance due to noise while sleeping. In this study, 76.09 %, 34.78 %, and 2.17 % of respondents were not annoyed at home, at the workplace, and during commuting roadside. The slight annoyance was reported by 8.70 %, 6.52 % and 2.17 % of respondents during their home staying, at the workplace, and on the street side, respectively. Similarly, medium annoyance at home and workplace was felt by 8.70% and the same at the roadside was felt by 69.57% of respondents. Here, 6.52%, 50%, and 26.09% of respondents were highly annoyed at residence, at their workplace, and during roadside travel respectively. For street vendors, the 40.65% male of 20-40y age expressed medium home annoyance whereas 30.43% expressed high workplace annoyance and 50% expressed no roadside annoyance. While, 11.29% female of same age band expressed medium home annoyance and 4.35 % of slight workplace annoyance and 4.35% medium roadside annoyance. The 18.52%, 17.39% and 4.35% of male respondents of 41-60y age group expressed high annoyance during home staying, working at workplace and roadside commute, respectively. The 18.52% of female street vendors of 41-60y age group expressed medium home annoyance (Figure 4.18). The average annoyance score (AAS) of the street vendors' was 1.41±0.62, indicating very prone to feel highly annoyed throughout their daily life. The 39.13%, 30.43% and, 17.39% street vendors were respectively reported their problems with only air pollution, noise pollution, both air and noise, while, 13.04% reported no problems. The breathing problem near traffic signal was reported by 82.6%, while 17.4% reported the opposite. Table A-4 showed the temporal variations of traffic activities in terms of day, evening, and night time traffic activities and the characteristics of traffic flow near the participants' residences. Table A-4 showed that the indoor and outdoor acoustic environments of participant's dwelling significantly dominated by noise originated from home appliance, human conversation, different furniture movements and traffic activities.

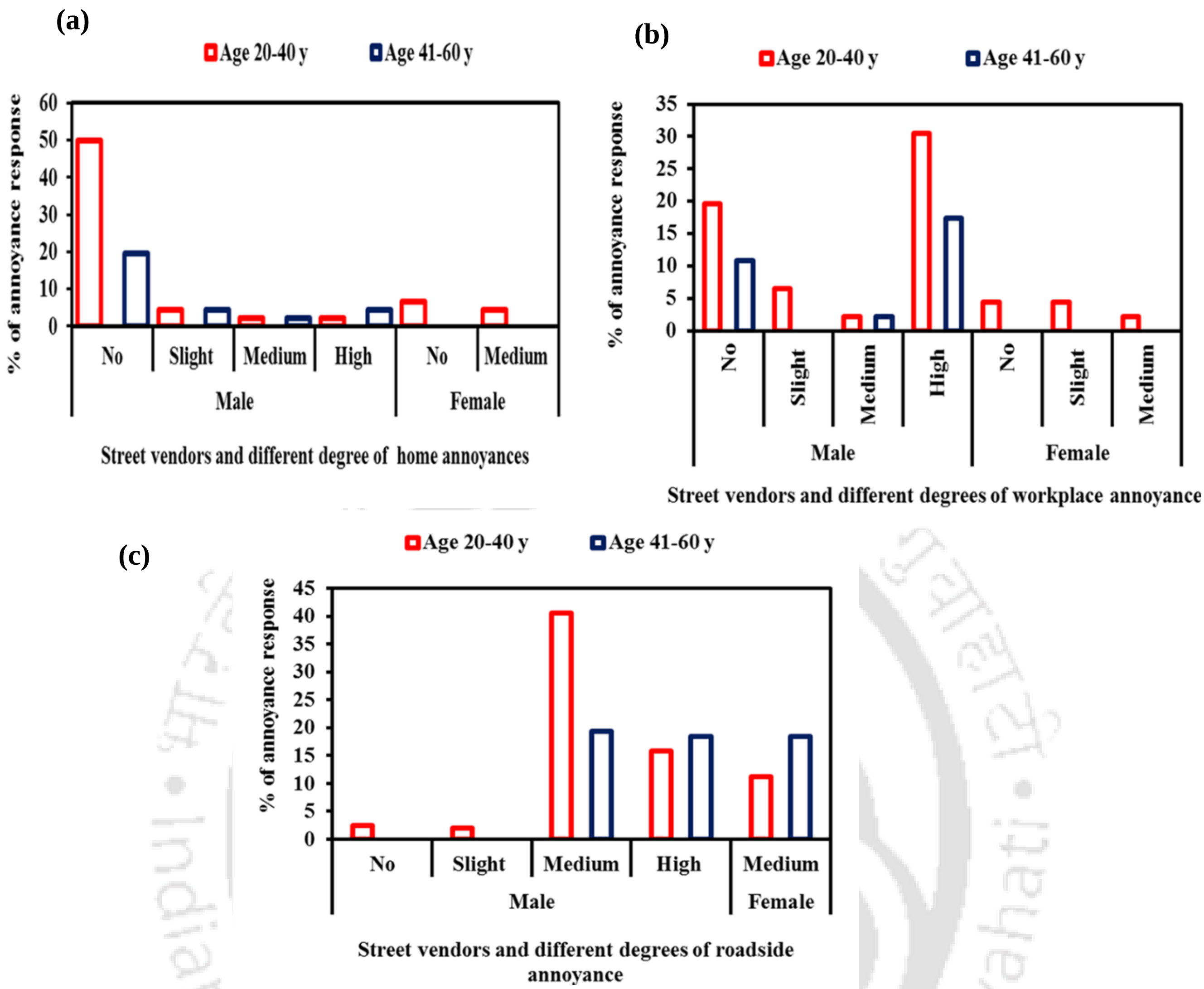


Figure 4.18 Age and gender wise characterisation of (a) home annoyance, (b) workplace annoyance and (c) roadside annoyance response of street vendors

4.10.2 Office workers' scenario

The responses for the office workers (n=108) are shown in Table A-5. The 80.49 % of the respondents were in the age of 41 - 60 y, 17.07 % were in the age of 20 - 40 y, and only 2.44 % were > 60 y. Of the 108 respondents, 85.37% were male, and 14.63% were female. Regarding the dwelling at the current residences and the building age, 53.66% of respondents were dwelling > 20 y, and their houses were also equally old, 24.39% of respondents were dwelling < 10 y, and 21.95% revealed their living tenure at their home within 10-20 y. On the other hand, among the study participants, 24.39% replied their building age was 10 - 20 y old and 21.95 % answered their building age was < 10 y old. The 53.66% of the office workers had their houses in the interior, away from the busy roads and 46.34% had their houses near the busy roads. The 56.10% had their houses >3 m from the nearest road, 36.59% had within 2 m and 7.31% had their houses located at 2-3 m from the nearest road. The 58.54% and 60.98% of respondents' house windows and doors were not facing the roadside, while, the same for 41.46% and 39.02% of respondents' were facing towards the road. The 56.10% of respondents did not sense nuisance due to noise and 43.90% sensed the disturbance due to noise. The results of the perceptive annoyance in the form of psychological irritation or disturbance showed that 39.02%, 41.50%, and 24.39% of workers were not annoyed due to noise and air pollution while at home, at the workplace, and while commuting, respectively. The 41.46%, 34.10%, and 39.02% of respondents experienced slight annoyance due to air and noise in these microenvironments. Similarly, 17.07%, 19.50%, and 21.95% of office workers perceived medium annoyance, and 2.44%, 4.90%, and 14.63% of respondents perceived high annoyance at home, at the workplace, and at the roadside, respectively.

Figure 4.19 shows that for office workers' the 10.19% male of 20-40y age band expressed slight home annoyance whereas 7.41% and 6.48% expressed slight workplace and roadside annoyance, respectively. However, 2.78% female of same age band expressed medium home and workplace annoyance, respectively. The 26.85%, 25.93% and 23.15% of male respondents of 41-60y age band expressed slight annoyance, respectively at home, at workplace and at roadside. The 2.78%, 1.85% and 2.78% of female office workers of 41-60y age group expressed medium annoyance, respectively at home, at workplace and during roadside travel.

The AAS of the office workers' was 0.88±0.65, indicating very prone to feel highly annoyed throughout their daily life. The 20.4%, 12% and, 64% office workers were respectively reported their problems with only air pollution, noise pollution, both air and noise, while, 2.8% reported no problems. The breathing problem near traffic signal was reported by 63 %, while 37 % reported the opposite.

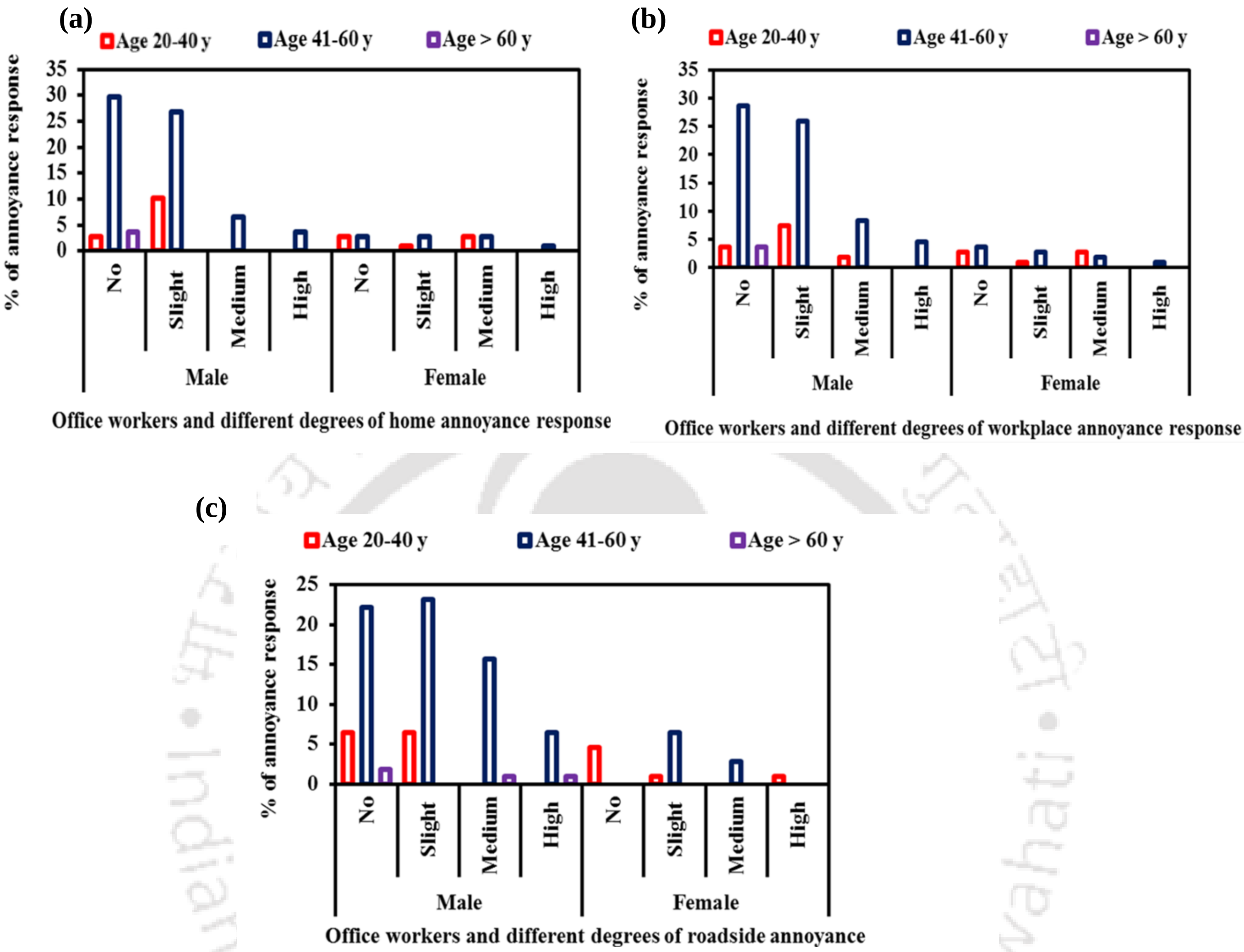


Figure 4.19 Age and gender wise characterisation of (a) home annoyance, (b) workplace annoyance and (c) roadside annoyance response of office workers

4.10.3 Cardiovascular health status of respondents

From Figure 4.20 this can be concluded that distance of workplace from nearest roadside does not notably influence the cardiovascular health, as both groups of the respondents shows somewhat similar cardiovascular health status in terms of systolic and diastolic blood pressure, and heart rate.

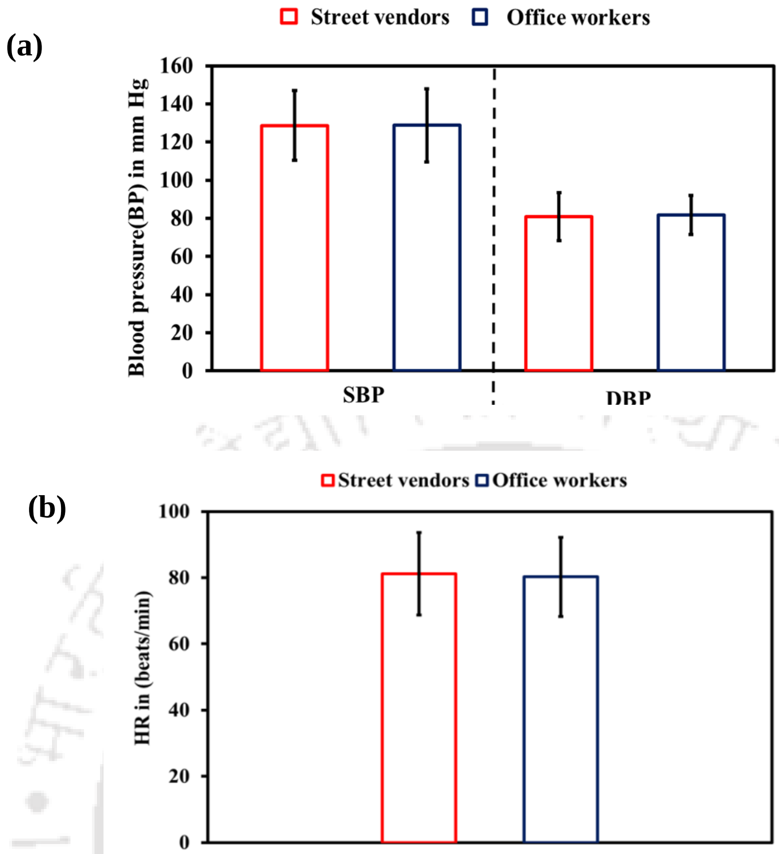


Figure 4.20 Comparison of (a) blood pressure (BP) and (b) heart rate (HR) of street vendors and office workers

4.10.3.1 Street vendors' scenario

Figure 4.21 shows the observed median SBP of 20-40 y street vendors' was 129.75 mm Hg (Min: 96; Max: 166.50), DBP was 81.50 mm Hg (Min: 53.50; Max: 109) and the obtained HR was 84.50 bpm (Min: 45.50; Max: 101). While, for 41-60 y age group the median SBP, DBP and HR were 122.50 mm Hg (Min: 101; Max: 172), 80.25 mm Hg (Min: 57.50; Max: 97) and 79 bpm (Min: 60; Max: 104.50), respectively.

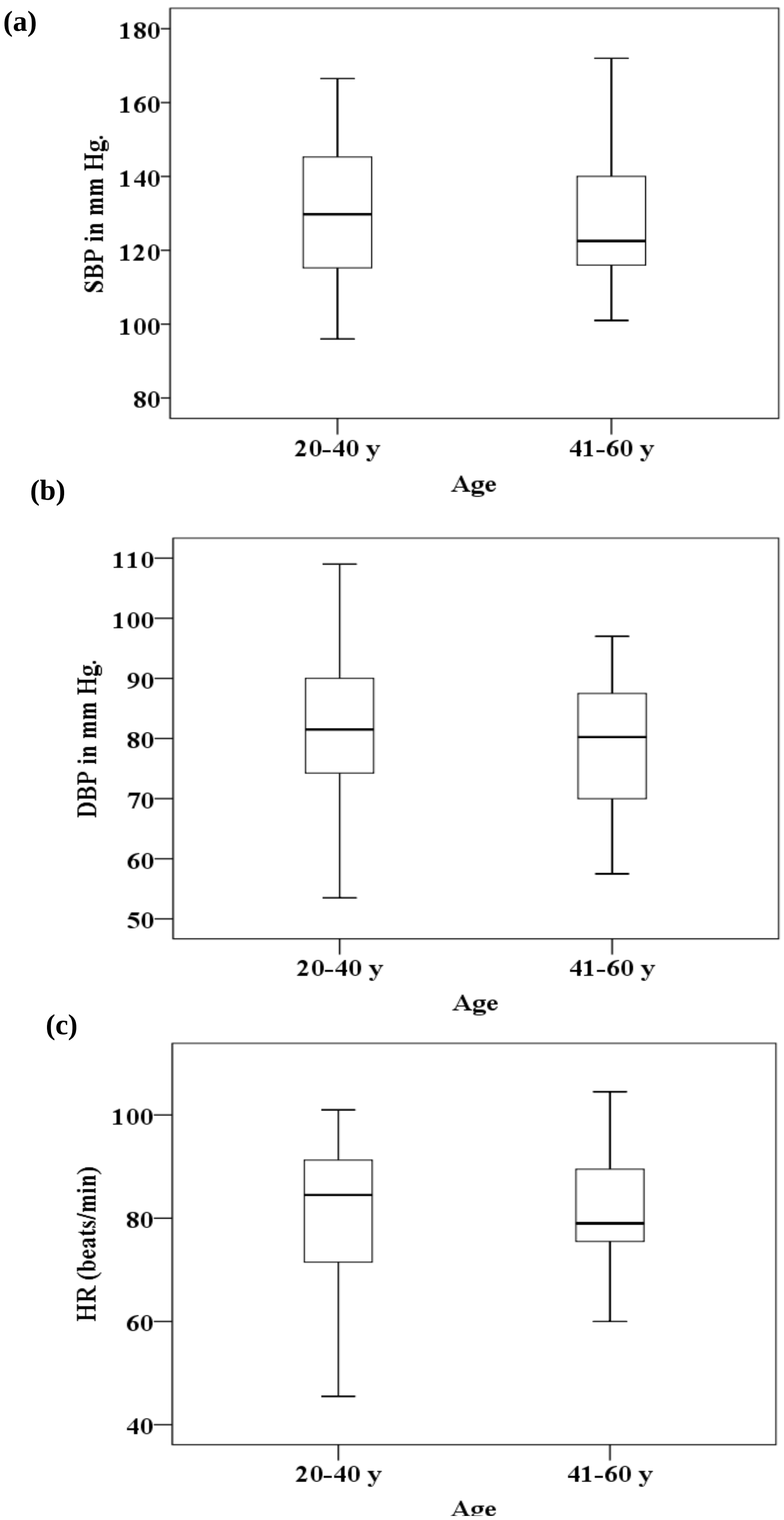


Figure 4.21 Age wise characterisation of cardiovascular parameters (a) SBP, (b) DBP and (c) HR of street vendors

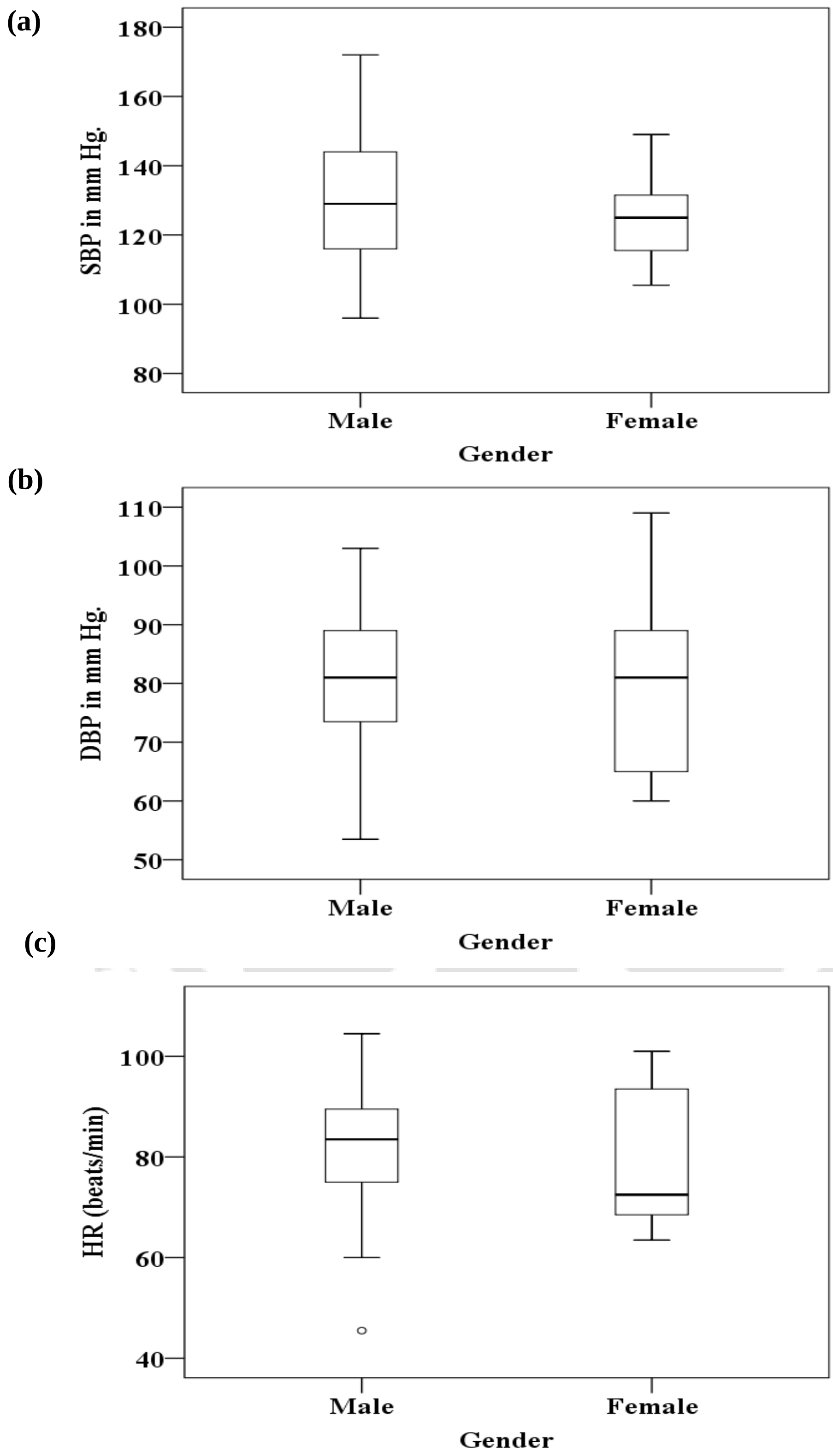


Figure 4.22 Gender wise characterisation of cardiovascular parameters (a) SBP, (b) DBP and (c) HR of street vendors

Figure 4.22 (a) Male street vendors' median SBP was 129 mm Hg (Min: 96; Max: 172) and for female the same was 125 mm Hg (Min: 105.50; Max: 149). It shows that the median DBP of male respondents was 81 mm Hg (Min: 53.50; Max: 103) and for female it was 81 mm Hg (Min: 60; Max: 109) (Figure 4.22 (b)). The median HR of male and female participants' were 83.50 bpm (Min: 45.50; Max: 104.50) and 72.50 bpm (Min: 63.50; Max: 101) respectively (Figure 4.22 (c)). It indicates insignificant influence of aging on the SBP, DBP and HR, while male respondents' SBP and HR were more than female but DBP was almost in similar range for both male and female participants.

4.10.3.2 Office workers' scenario

Figure 4.23 (a) shows the median SBP of 20-40 y, 41-60 y and > 60 y officials' were 122.5 mm Hg (Min: 94.5; Max:167.5), 129 mm Hg (Min: 87; Max: 215) and 147 mm Hg (Min: 119.5; Max: 168), respectively. Similarly, the median DBP of the same respective age bands were 80 mm Hg (Min: 58; Max: 112), 80.5 mm Hg (Min: 59.5; Max: 110) and 81 mm Hg (Min: 72; Max: 88.5), respectively (Figure 4.23 (b)). The median HR were 77 bpm (Min: 60; Max: 104), 82 bpm (Min: 49; Max: 115) and 72 bpm (Min: 58; Max: 86), respectively (Figure 4.23 (c)).

Figure 4.24 (a) shows that the median SBP of male officials' was 129.5 mm Hg (Min 87; Max: 215) and the same of female officials' was 112.5 mm Hg (Min: 94.5; Max: 139), respectively. The median DBP of male officials' was 81.5 mm Hg (Min: 59.5; Max: 112) and for female it was 70.5 mm Hg (Min: 58; Max: 84.5) (Figure 4.24 (b)). The median HR of male and female were 82 bpm (Min: 49; Max: 115) and 78 bpm (Min: 63; Max: 104), respectively (Figure 4.24(c)). This indicated that male respondent had elevated SBP, DBP and HR than female. Very little influence of aging on SBP, DBP and HR was observed.

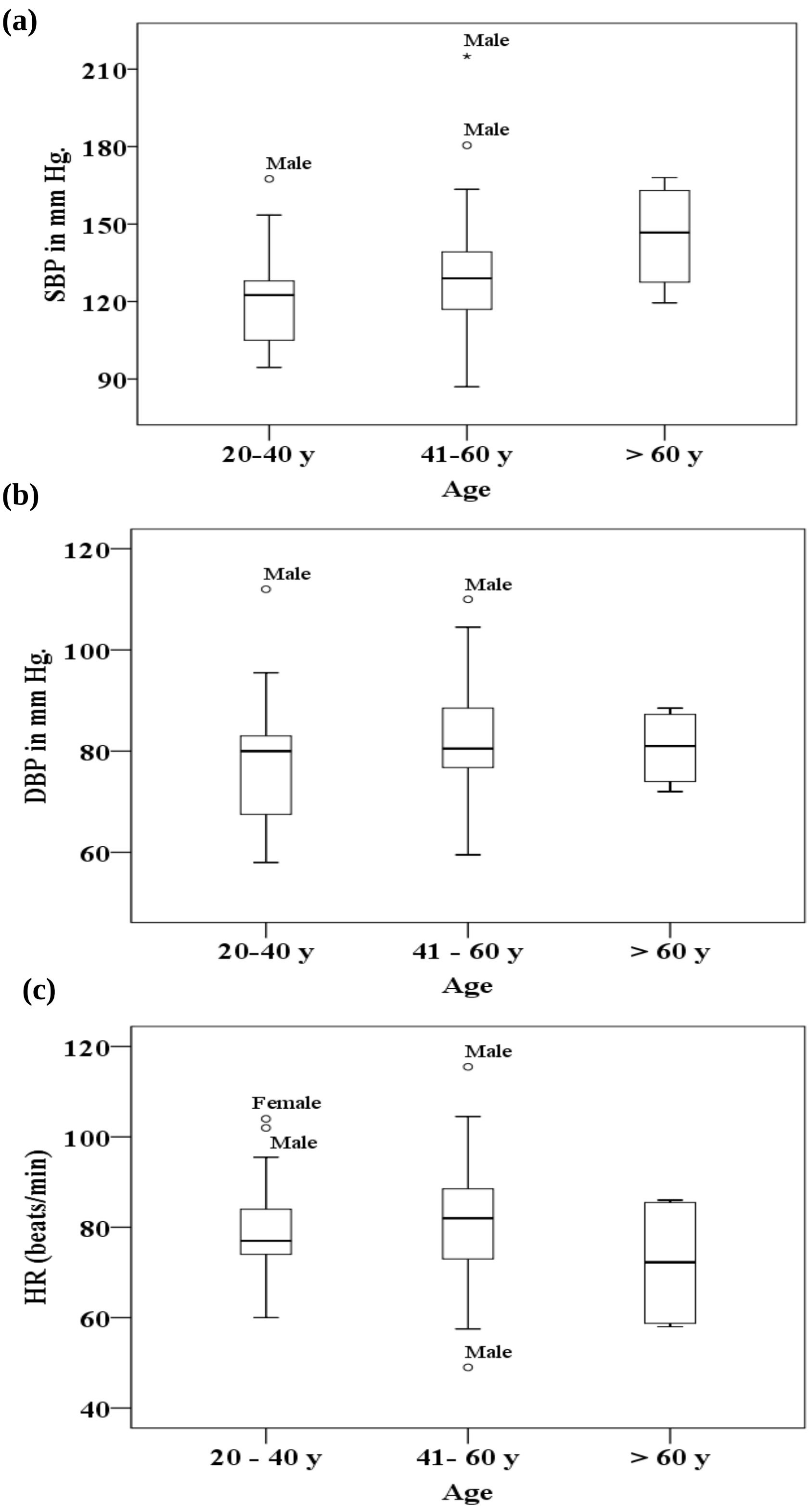


Figure 4.23 Age wise characteristic of cardiovascular parameters (a) SBP, (b) DBP and (c) HR of office workers'

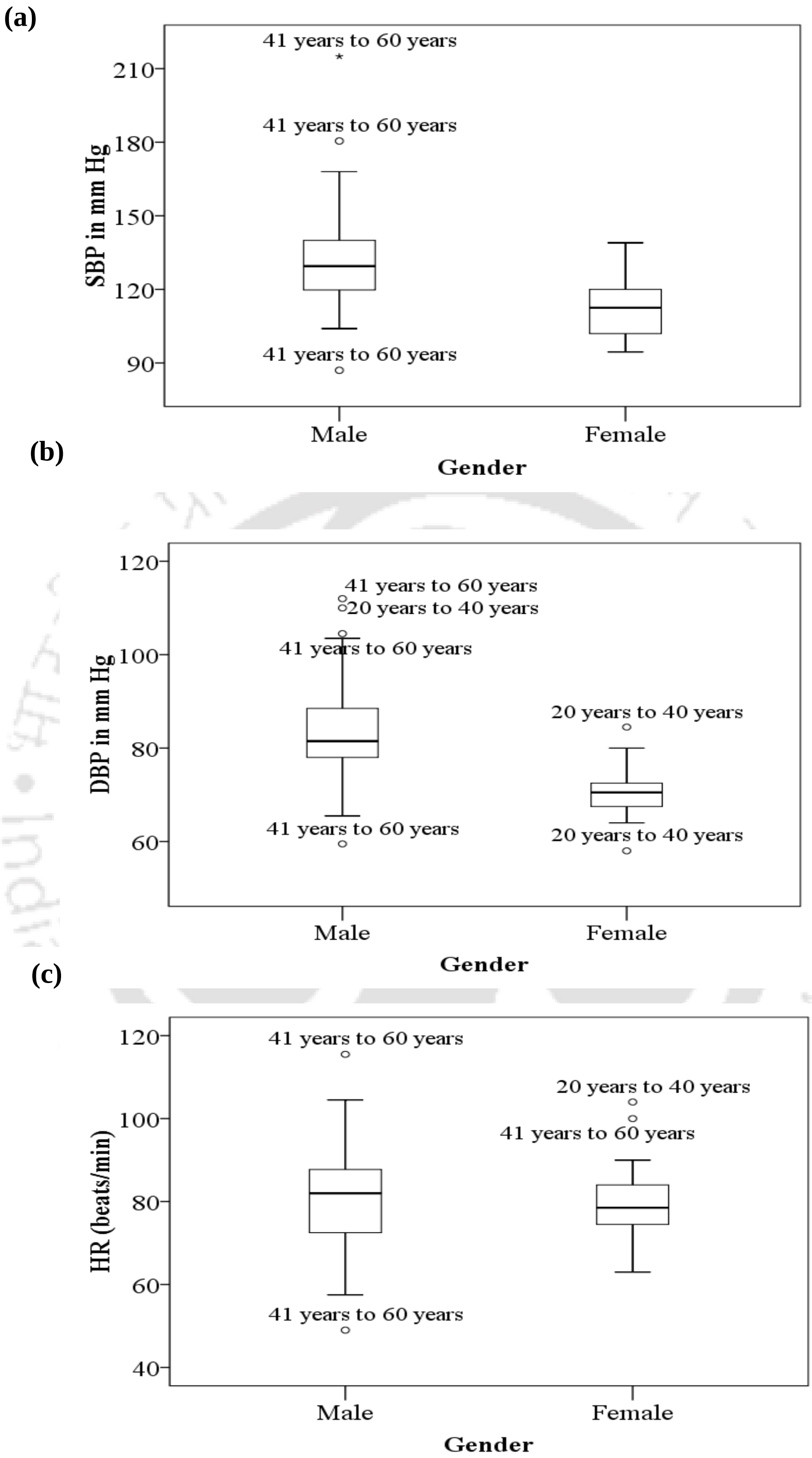


Figure 4.24 Gender wise characterisation of cardiovascular parameters (a) SBP, (b) DBP and (d) HR of office workers'

4.10.4 Interrelationship of noise indicators, $PM_{2.5}$ with questionnaire outcomes on health parameters

4.10.4.1 Street vendors' scenario

In the Spearman-rho correlation analysis (Table A-6 - Table A-8), except 160 Hz frequency the L_{eq} was significantly correlated with rest of the frequencies of 1/3rd octave band ($\rho > 0.2$). Only 31.5 Hz and 40 Hz frequencies were negatively correlated with $NC_{(L90)}$ and $NC_{(L95)}$, respectively. These findings indicate that increasing low frequency noise was associated with the decrease in noise fluctuations in road side. L_{10} was significantly correlated with (250 Hz - 20 kHz). It means the peak noise component was influenced by mid to higher spectral frequencies. In this analysis, 630 Hz noise frequency and traffic flow near residence were negatively correlated with SBP, (ρ=-0.295, $p < 0.05$) and (ρ=-0.303, $p < 0.05$), respectively. This indicates with increasing 630 Hz frequency noise at workplace and traffic flow near residence decrease the SBP. However, no significant correlation was observed between DBP, HR with pollutants and questionnaire outcome. The workplace annoyance was slightly correlated with the home annoyance (ρ=0.364, $p < 0.05$). The residential living duration of the participants was slightly correlated with their home (ρ=0.299, $p < 0.05$) and workplace (ρ=0.309, $p < 0.05$) annoyance perception. The workplace annoyance of the street vendor's was slightly correlated with acoustic indices of the workplace e.g. L_{peak} (ρ=0.294, p=0.048), L_{min} (ρ=0.306, p=0.039), L_{eq} (ρ=0.419, p=0.004), L_{10} (ρ=0.343, p=0.019), L_{50} (ρ=0.418, p=0.004) and L_{90} (ρ=0.310, p=0.036). This shows that the workplace annoyance of the street vendors' significantly influenced by the demographic factors, home annoyance which basically the results of traffic noise originated near residential area and the impact of workplace's acoustic quality.

4.10.4.2 Office workers' scenario

In the Spearman-rho correlation analysis of the office worker's (Table A-9 - Table A-11), L_{eq} was highly correlated ($\rho > 0.7$) with L_{peak}, L_{max} and L_{10} respectively. Except 125 Hz, the entire noise spectrum was significantly correlated with L_{eq} ($\rho > 0.2$). L_{10} was significantly correlated with 160 Hz - 20 kHz frequencies. This denotes the influence of low to high frequencies could elevate the L_{10}. The $NC_{(L90)}$ and $NC_{(L95)}$ indices were negatively correlated ($\rho <- 0.2$) with 50 Hz, 100 Hz, 160 Hz and 200 Hz frequencies and positively correlated ($\rho > 0.1$) with 250 Hz and 16 kHz frequencies. This indicates that low frequency lead to decrease in noise climate and 250 Hz and 16 kHz frequencies slightly increase noise climate. The Spearman-rho correlation analysis (Table A-9) indicated that average SBP and DBP were slightly correlated with $NC_{(L95)}$, ($\rho=0.213$, $p < 0.05$) and ($\rho=0.245$, $p < 0.05$), respectively. The noise perception during sleeping was moderately correlated with home annoyance ($\rho=0.440$, $p < 0.05$), workplace annoyance ($\rho=0.438$, $p < 0.05$), residential outdoor pollution source ($\rho=0.524$, $p < 0.05$), day ($\rho=0.441$, $p < 0.05$), evening ($\rho=0.481$, $p < 0.05$) and night traffic activities ($\rho=0.460$, $p < 0.05$). The home annoyance was moderately correlated ($\rho=0.333$, $p < 0.05$) with night time traffic activities near residence. The workplace annoyance reported by office workers was highly correlated with home annoyance ($\rho=0.937$, $p < 0.05$) and slightly correlated with evening ($\rho=0.344$, $p < 0.05$) and night traffic activities ($\rho=0.422$, $p < 0.05$) and traffic flow ($\rho=0.418$, $p < 0.05$) near the residential areas. There was moderate correlation ($\rho=0.471$, $p < 0.05$) found between the night time traffic activities and the roadside annoyance perception. The results of this analysis revealed that the annoyance of the workers greatly influenced by the traffic activities near their residential areas. This finding also indicates that sleep quality was significantly impacted by outdoor noise sources and traffic near office worker's residence and their respective discomfort at home, workplace and during roadside travel.

4.11 DISCUSSION

In this research, both bike and car were the key traffic components. In the study area there was a humid meteorological condition and average temperature was around 30˚C throughout the year.

The street-side L_{eq} was observed to be 71 dB(A), and in the office building, it was 66 dB(A). The noise level (hourly average, 10-h average and seasonal average) of street-side and indoor office exceeded the national ambient noise standard of CPCB for commercial areas of 65 dB(A) (CPCB, 2000) and also exceeded the WHO prescribed limit of 70 dB(A) for safe listening (WHO, 2018) and 53 dB(A) for annoyance creation. Kalawapudi et al. (2020) observed similar deterioration of acoustic quality in the urban roadside areas of Indian cities. In all the microenvironments, the L_{10} exceeded 75 dB(A), which is high, and exposure to it may cause significant health effects on humans (USDT, 1995). The noise descriptors L_{max}, L_{50}, L_{90} and L_{95} also exceeded 53 dB (A) during the study period; this elevated noise could significantly impact human health (Laxmi et al., 2019). Tandel and Macwan (2017), Kamineni et al. (2019) and Laxmi et al. (2019) also reported similar findings for the urban roadside areas of Nagpur, Surat and Andhrapradesh of India, respectively. Vijay et al. (2015) observed similar findings in Indian road environments where horn honking exacerbate noise level by about 2-5 dB (A). At road side the noise at low (25 - 500 Hz), at mid (630 - 4000 Hz) mostly exceeded 40 dB (A) and high frequencies (> 4000 Hz) lies within 40 dB (A) sound pressure level (SPL) indicating extreme deterioration of acoustic environment. In this study, similar conclusion could be drawn as the traffic fleet with varying speed throughout the study period was observed which contributes a significant proportion of rolling noise, horn honking, and multiple reflections of noise due to the presence of different urban forms. Inside the office the noise at 31.5 - 125 Hz frequencies exceeded the 30 dB (A), while the noise at remaining frequencies till 5000 Hz mostly exceeded 40 dB (A) SPL. The noise at rest at higher frequencies was obtained within 40 dB (A). Huang et al. (2017) observed that the low frequency noise influenced the noise level at lower floors of a high rise building near urban expressway.

In all study microenvironments the noise climates $NC_{(L90)}$ and $NC_{(L95)}$ indicating the noise fluctuations were 4 to 6 dB (A), inside the office and street producing severe annoyance and constant speech interference at work. It directly hampers work productivity. The noise sources were mainly outdoor activities such as traffic, parking lot, and public speaking, along with minor indoor sources such as noise from wall-mounting fans and office equipment. The primary sources of noise pollution in the shops were the outdoor activities such as vehicular and commercial activities. The current acoustic quality in both work environments' significantly deteriorated, which may cause severe annoyance to the workers (Khomenko et al., 2022).

Slight correlation between L_{min} and NC of office and street depicts the influence of fluctuation of noise level of street side on minimum noise of office indoor. Street side $PM_{2.5}$ was slightly correlated with L_{peak}, L_{90} and L_{95} which attributes the fact that significant portion of noise and $PM_{2.5}$ have been originated by road traffic activities in the study area. $PM_{2.5}$ of office indoor was negatively correlated with street side ambient noise, which illustrates that sometimes due to partially closing or closing of windows could hamper the indoor $PM_{2.5}$ dispersion and propagation of ambient noise into office indoor which leads to increase the indoor $PM_{2.5}$ and decrease indoor noise level.

On the other hand, 10-h $PM_{2.5}$ concentration of street side ambient environment and office indoor were 106.67 and 33.33 µg/m^3 respectively. Similarly increase trend of winter season $PM_{2.5}$ was observed due to possible atmospheric stability. This finding indicating serious deterioration of air quality, which could be the effect of traffic activities, biomass burning, environmental tobacco smoke (ETS). Limaye et al. (2019) modelled the $PM_{2.5}$ concentration in Indian cities, their results revealed that by 2030 annual mean $PM_{2.5}$ concentration will be 74 μg/m^3, which could be responsible for the national average loss in statistical life expectancy (SLE) of 32.5 months (95% *C.I.*: 29.7–35.2, regional range: 8.5–42.0). Srimuruganandam and Nagendra (2011) observed the similar violation (> 60 μg/m^3) of NAAQS 24-h permissible limit of $PM_{2.5}$ near traffic intersection in Chennai city of India.

Noise-$PM_{2.5}$ index was close to zero, indicating the severe degradation of noise and air quality in both study microenvironments.

The following preventive measures could improve the present scenario of environmental pollution with respect to air and noise:

- **Control at source**

Gozalo et al.(2022) has been reported the reduction of noise level of 1-4 dB(A) by proper taffic management. The same author has reported that introducing electric vehicles could also reduce noise level of about 1-10 dB(A). Low noise tyres could also reduce noise level of 3-5 dB(A). Building quite road surface (porous asphalt, rubberised asphalt, poro elastic road surface, very thin asphalt) could resuce noise level of 3-7 dB(A).Probhibition of unnecessary horn honking could also reduce 2.1 dB(A) (Chauhan et al., 2021).

In Indian context, hotspot specific intervention led to decrease the $PM_{2.5}$ of about 11%-28% (Sharma et al., 2022). By reducing emission of construction and musnicipal waste burning led to reduce the 12% of $PM_{2.5}$ concentration (Sharma et al., 2022).

- **Control at medium**

Installing noise barrier could reduce noise level of 3-20 dB(A) (Gozalo et al.,2022). There was about 5-10 dB(A) of noise level reduction has been achieved by planting trees near roadside area (Gozalo et al.,2022).

Hu et al. (2021) reported > 20% $PM_{2.5}$ reduction after introducing electric vehicle in China. Li et al. (2021) reported that by combining solid noise barrier with vegetation could reduce 50% of $PM_{2.5}$ near roadway.

- **Control at receiver**

Building insulation with sound absorptive building materials (ex-glass wool, rock wool, closed cell foam aerogel etc.) and its' design could reduce noise level of 2-15 dB(A) (Kumar et al., 2020; Gozalo et al.,2022).

Incorporating air filter at building has been identified as significant indoor $PM_{2.5}$ reduction strategies (Martenies and Batterman, 2018).

In this study street side street side ambient and office indoor temperature exhibit negative and positive correlation with L_{eq} of street and office, respectively. This basically depicts the lesser public activities during warmer days near street side and intense public activities inside the office could lead to influence the acoustic quality of both microenvironments. Ambient temperature was slightly correlated with $PM_{2.5}$ of office indoor which attributes the ingress of temperature induced ambient particulate inside the office indoor microenvironments. Wind speed was negatively correlated with office L_{eq} refers the variation of office window operation during windy days could influence the indoor acoustic quality. Atmospheric pressure and solar radiation were positively correlated with ambient $PM_{2.5}$ and L_{eq}, respectively. However, the correlations between meteorological variable and noise and $PM_{2.5}$ were slight, which could be the reason for < 100 m distance between source and monitoring points as this is very difficult to assess the meteorological influence on traffic noise and $PM_{2.5}$ (Tezel-Oguz et al., 2023).

In questionnaire study, most of the respondents reported a moderate traffic flow at various times of the day near their residences. Thus, the traffic-borne noise influenced the sleeping quality at night, as was revealed by 43% and 37% of office workers and street vendors, respectively. The 50% of the street vendors, and 11% of office workers complained of high annoyance during their work. It indicates that outdoor street vendors were exposed the most to the noise produced by vehicular activities such as honking during frequent traffic interruptions and congestion and to other commercial activities in the traffic corridor. Therefore, the outdoor and indoor microenvironments within the traffic corridor were mainly subjected to traffic noise, resulting in severe annoyance and developing noise sensitivity during the working period. Jamir et al. (2014) observed the related findings in their research. However, nearly 8% of outdoor traffic noise was shielded by the brick façades indoor of the office building.

The results also show that a significant percentage of respondents did not perceive annoyance due to noise exposure, even during peak traffic. This might be attributed to the fact that these participants were constantly exposed to high noise levels throughout the day for a long time, which might have affected and shifted their hearing threshold. This state is referred to as noise induced permanent threshold shift (NIPTS). Further, many respondents revealed that they experienced stress, fatigue and hypertension mainly due to the annoyance caused by traffic noise.

No statistically significant correlation was observed between questionnaire outcome and noise descriptors for the office workers. The annoyance at workplaces was highly correlated with the annoyance perceived at home and traffic flow near their residences. It indicates that demography and socio-contextual factors also might be influencing the workplace annoyance. In the correlation study of street vendor's analysis, it was observed that workplace annoyance slightly correlated with noise descriptors (L_{peak}, L_{max}, L_{eq}, L_{10}, L_{50} and L_{90}), living duration and traffic operation at night near the respondent's residence. This indicated the slight influence of acoustic quality of the workplace and demographic variables and socio-contextual factors on workplace annoyance.

There was moderate warm temperature and highly humid meteorological condition throughout the study duration at both study microenvironments. From the questionnaire study and health it was revealed that participants were annoyed towards the noise and $PM_{2.5}$ pollution although a significant proportion of participants didn't experience any annoyance perception due to their habitual adjustment and NIPTS. Blood pressure (BP) and heart rate (HR) of male participants were high and 21-40 y old participants' BP and HR were significantly higher in range than others. Very poor correlation was observed between $PM_{2.5}$ and workplace annoyance but there was no significant correlation was observed with noise spectrum. Low frequency noise spectrum and $PM_{2.5}$ were significantly correlated with BP and HR.

CHAPTER 5

TRAFFIC NOISE PROPAGATION MODELLING

5.1 GENERAL

The traffic noise propagation has been modelled by SoundPLAN (version 8.2), using traffic attribute (traffic count and traffic speed), building attributes, receiver properties (receiver height), pavement characteristics and meteorological input as discussed in Chapter 4. There are five key steps in SoundPLAN traffic noise modelling which consist, creating a new project, incorporating geo data base, run the calculation kernel, displaying the result and along with its' graphical representation (Figure 5.1).

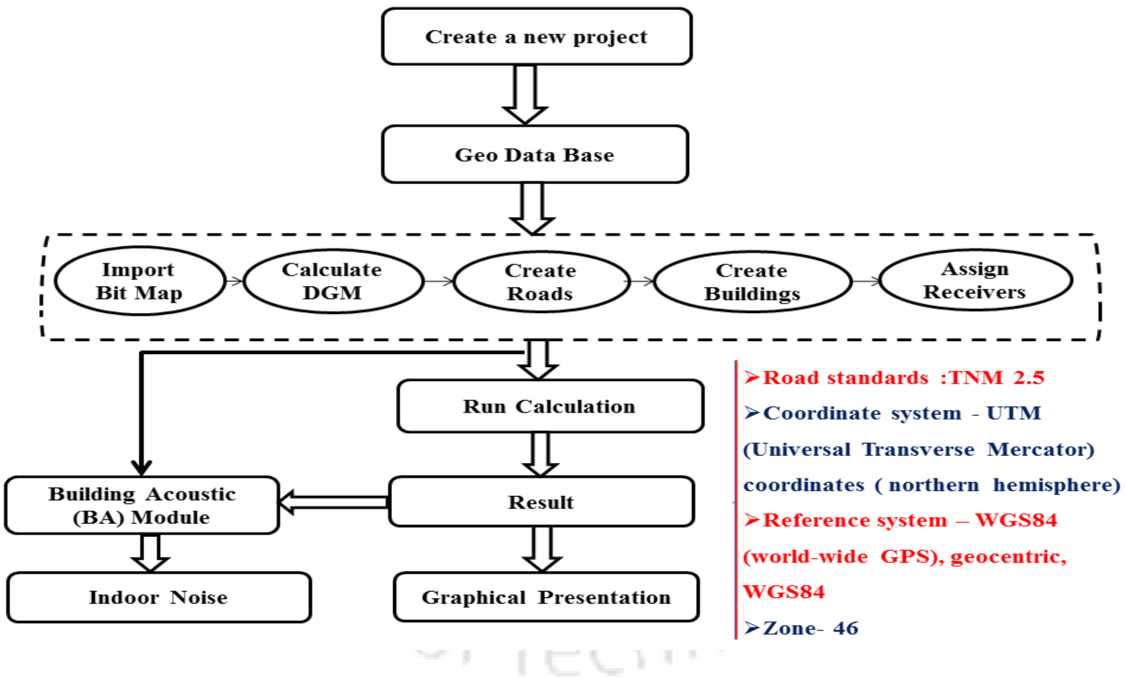


Figure 5.1 Process flow chart of SoundPLAN traffic noise model

SoundPLAN process the georeferenced data through its' in built geographic data processing module and it creates the digital ground model (DGM) by converting the 3D contour lines into elevation lines. The necessary topographical features (building, road) were incorporated. Thereafter by defining the acoustic receptors and aforementioned model input, SoundPLAN

8.2 modelled the traffic noise pollution, in terms of day time (L_d) and night time (L_n) noise level as per Federal Highway Administration Traffic Noise Model (FHWA TNM 2.5). Based on the model input, different noise propagation scenarios have been developed and validated with the observed noise data and different traffic source contribution has been characterised. Model output could be categorised as, output at single receiver point, façade noise map (FNM) and grid noise map (GNM). Outdoor traffic noise model was simulated for single point receiver at outdoor locations (1.4 m from the curb side) and at the façades of the building where the study was conducted. And, at the building indoors receiver assumed at 1.4 m distance from the adjacent walls and furniture and at 1.2 m height from the floor level. Noise level has been modelled using Eq. (5.1) (FHWA, 1998).

$$L_{Aeq\ 1h} = EL_i + A_{traffic_i} + A_d + A_s \tag{5.1}$$

where, 'L_{Aeq1h}' is the hourly equivalent noise level, 'EL_i' is the vehicle noise emission level for the i^{th} vehicle type, '$A_{traffici}$' is the adjustment for traffic flow, volume and speed for the i^{th} vehicle type, 'A_d' is the adjustment for distance between the roadway and receiver and for the length of the roadway, and 'A_s' refers to the adjustment for all shielding and ground effects between the roadway and the receiver.

For indoor noise model, SoundPLAN 8.2 used the building-acoustic module (BA module), which uses the noise input from outdoor façade of any building to estimate the indoor noise level by assessing permissible indoor noise limit.

5.2 TRAFFIC NOISE MODELLING

Figure 5.2 shows that the front façade was most exposed to the traffic noise. Ground floor to higher floors exposed to increasing range of noise level above 60 dB (A) at day time. During night predicted noise level also increased above 56 dB (A) in the front façade. In the right side of the office building façade predicted noise level exceeded above 50 dB (A) from ground floor level to upper floor (Figure 5.3).

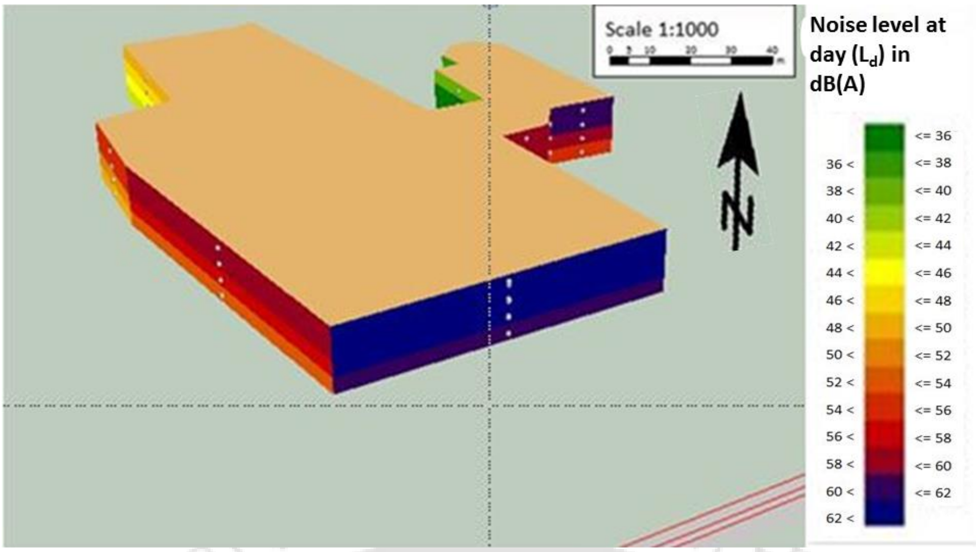


Figure 5.2 Day time FNM of office building (receiver center of each floor)

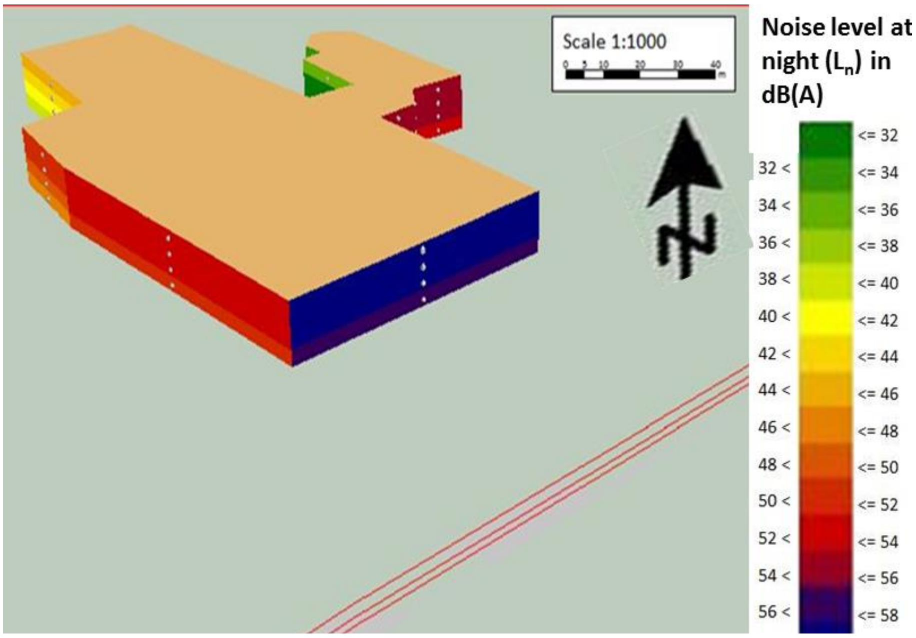


Figure 5.3 Night time FNM of office building (receiver at center of each floor)

In grid noise map with grid spacing 10 m, it shows that at day time predicted noise level (Figure 5.4) exceeded 72 dB (A) near curb side and in the immediate vicinity of the front façade of office building the predicted noise level between 68 - 72 dB(A) at daytime. At night predicted noise level near curb side of G.S. road (Figure 5.5) is lying in the range of > 68 to ≤ 72 dB (A). On the other hand, in front of front façade of office building, predicted noise level is in the range between greater than 64 - 68 dB (A).

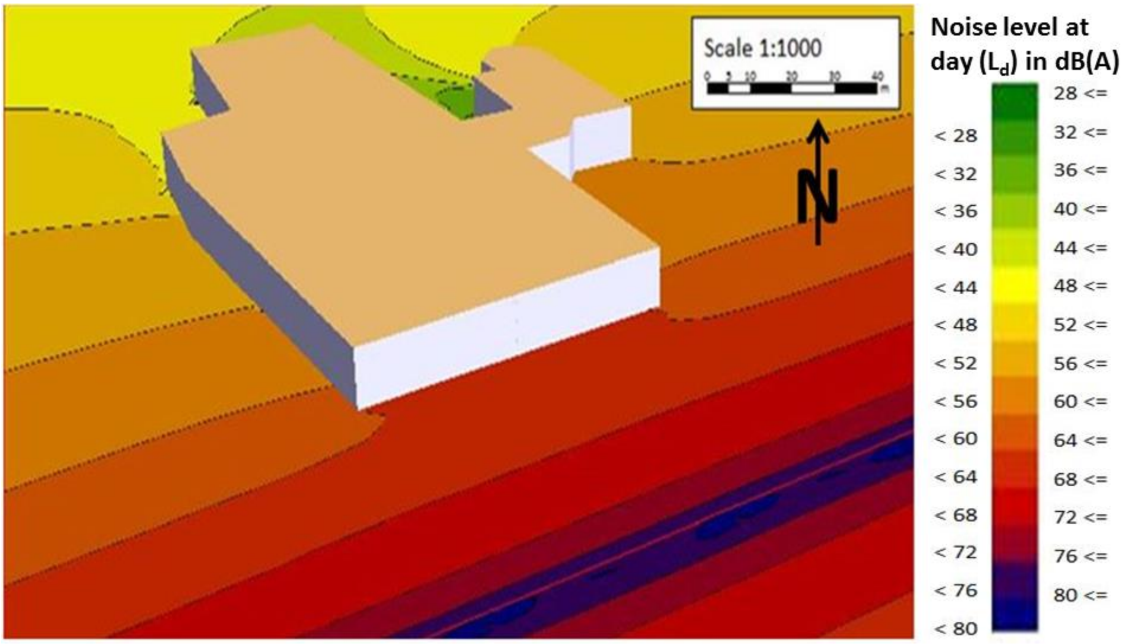


Figure 5.4 Day time GNM near street side

Alam et al. (2021) also modelled the traffic noise for residential area with SoundPLAN software and observed similar violation of noise level in South Delhi city of India.

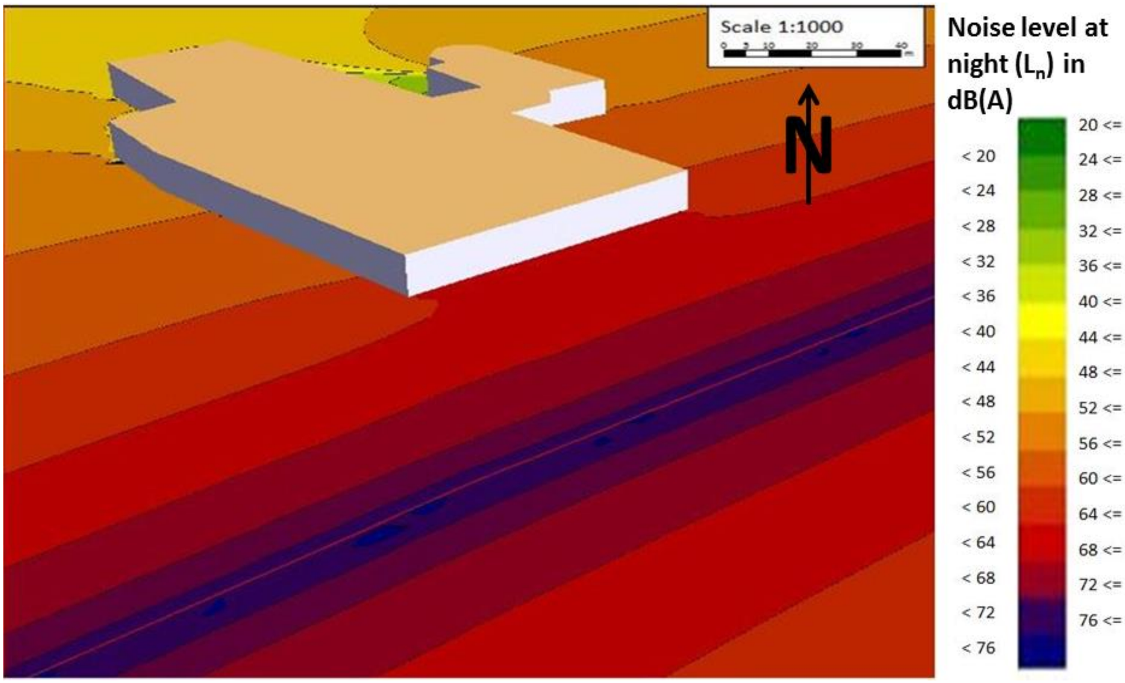


Figure 5.5 Night time GNM near street side area

On the other hand, for indoor traffic noise modeling approach, building façade consisting of brick wall and 30% of glass area for door and window, traffic induced noise was simulated with account of building materials, room geometry and 2 dB (A) flanking transmission.

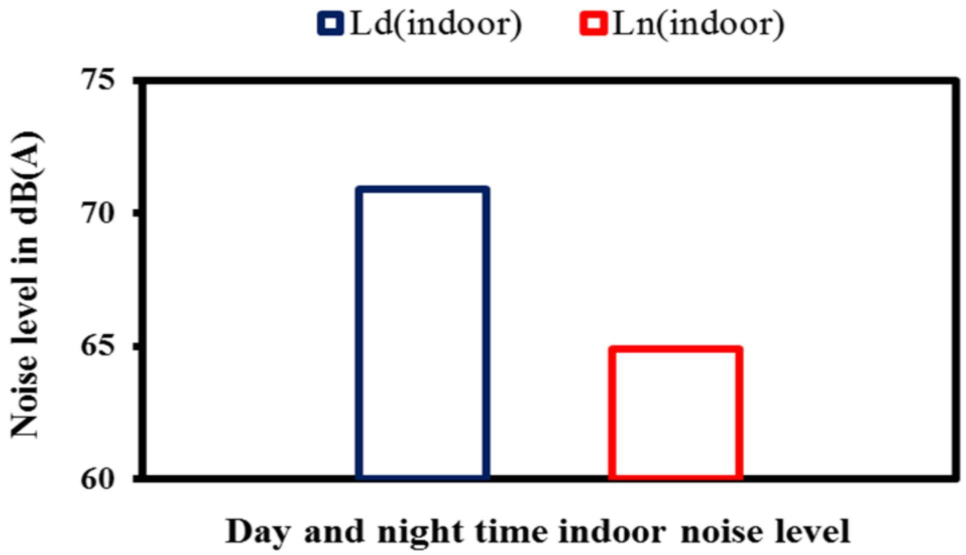


Figure 5.6 Day and night time predicted noise level of office indoor

In consideration of receiver at front façade of the office building the day time simulated indoor noise level was 70.9 dB (A) (Figure 5.6). During day working hour outdoor traffic density was higher than evening and night time that's why predicted indoor noise level was high.

During night simulated indoor noise level was 64.9 dB (A) which basically originated from outdoor traffic activities where bike and car were the most predominant traffic sources in the study area (Figure 5.6). All these study output nearly similar with the study of Jeong et al. (2010) and Ece et al. (2018).

Table 5.1 Modeling output by assuming point receiver at the outdoor of front façade

Building floor	L_d in dB(A)	L_n in dB(A)
Ground Floor	62.8	61
First Floor	66.7	64.2
Second Floor	66.8	64.3
Third Floor	66.9	64.5

In the case of single receiver at different floors of building, simulated traffic noise was increasing with the increase of building floors (Table 5.1). Although predicted noise exceeded the CPCB standard of 65 dB(A) and 55 dB(A) at day and at night respectively.

5.3 COMPARISON OF MEASURED AND MODEL NOISE LEVEL

Figure 7.6 and Figure 7.7 shows measured outdoor and indoor noise level was little higher than predicted noise level as the SoundPLAN only consider the nose originated due to traffic movement . However, in realistic scenario there was many factors including multiple reflections, public activities influenced the measured noise level apart from the vehicular noise.

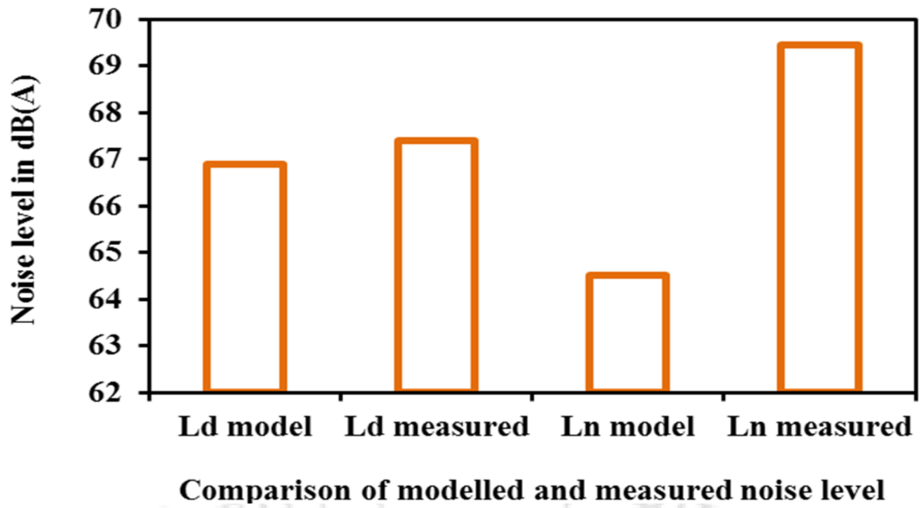


Figure 5.7 Comparison of modelled and measured street side ambient noise level

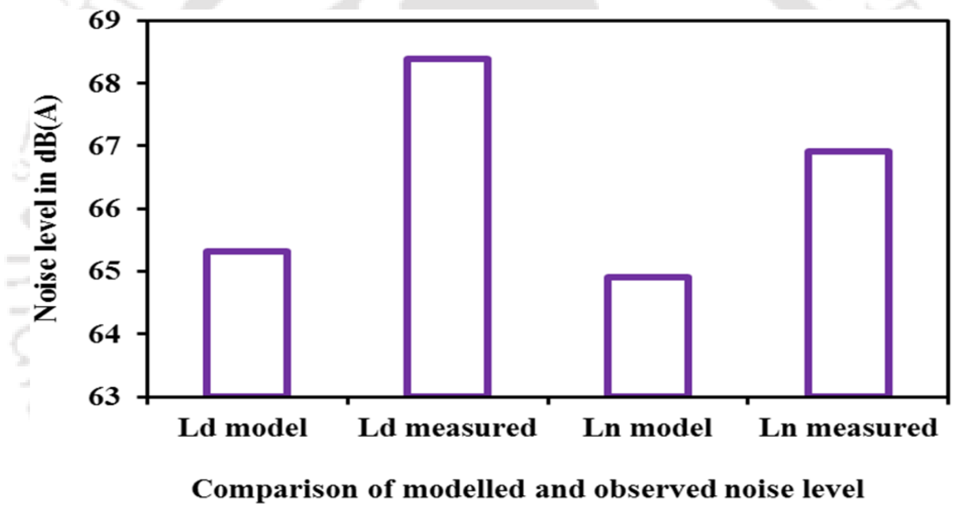


Figure 5.8 Comparison of modelled and measured office indoor noise level

5.4 MODEL VALIDATION

The predicted noise level was validated with the measured noise level by fractional bias (FB) measure (Eq.(5.2)).

$$FB = \frac{2 \cdot \overline{(C_o - C_p)}}{\overline{C_o} + \overline{C_p}} \tag{5.2}$$

where, 'C_o' and 'C_p' are the measured and predicted noise level respectively.

Figure 7.8 shows the FB for outdoor roadside area at day and at night were 0.0072 and 0.073 respectively, and for office indoor the same for day and night were -0.036 and 0.03 respectively.

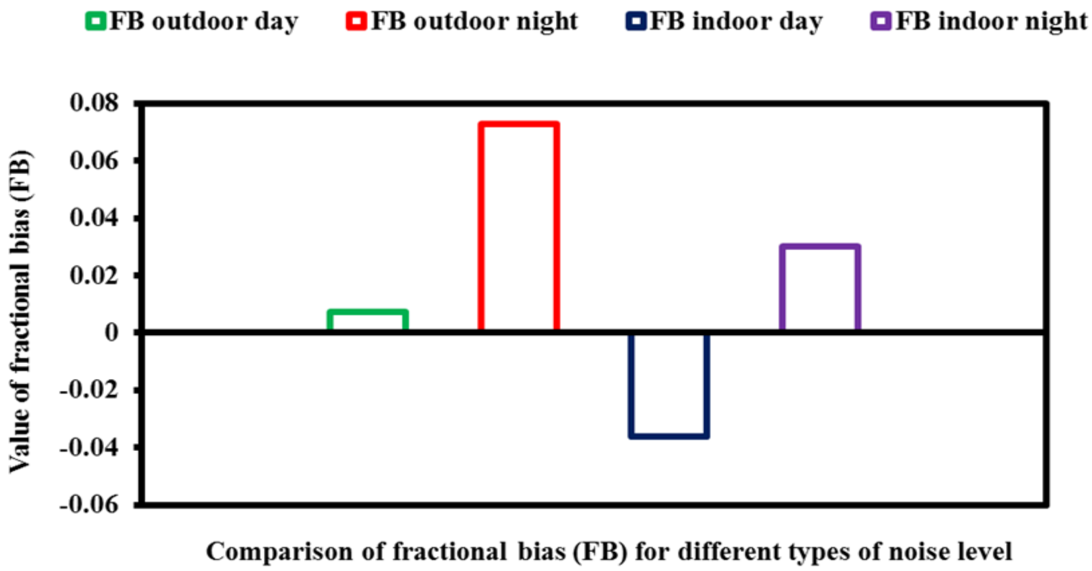


Figure 5.9 Model validation measure by fractional bias (FB)

This finding was in line with the study by Fallah-Shorshani et al.(2022), they observed the FB lies between – 0.80 to 1.92 for CadnaA, GAM, HLTNM, XGB and Harmonoise noise propagation models.

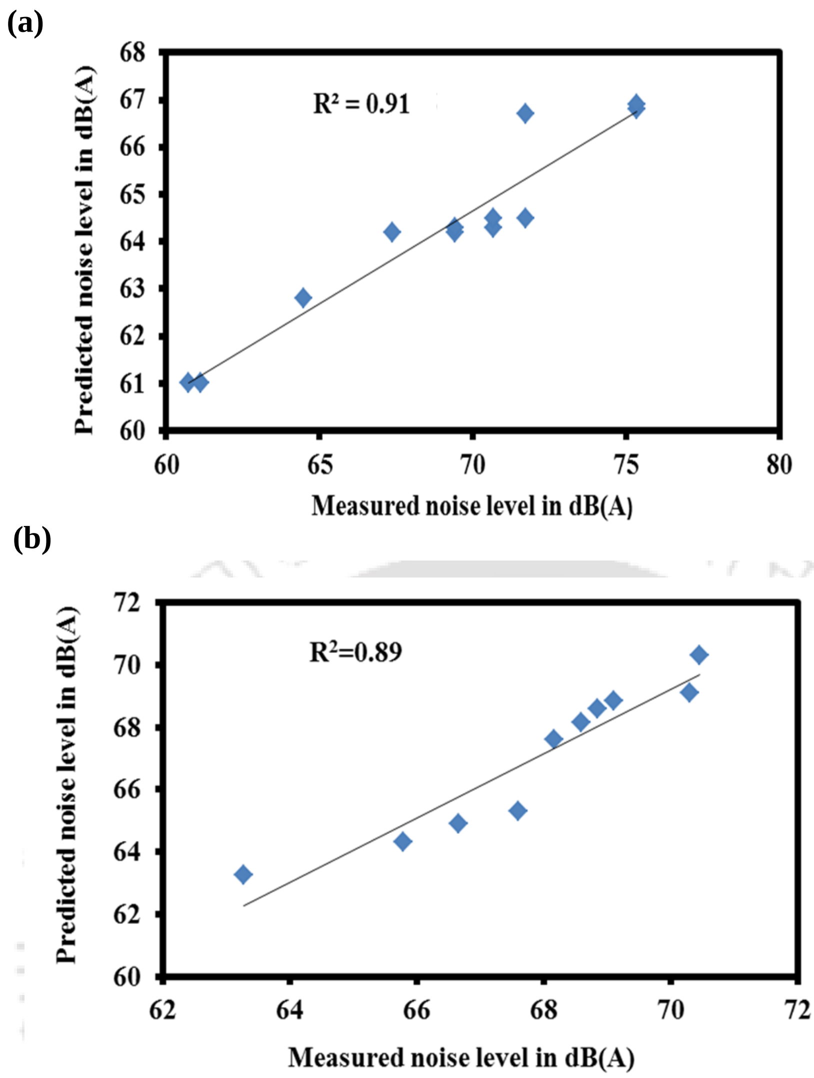


Figure 5.10 Scatter plot between measured and predicted noise level (a) street side ambient and (b) office indoor microenvironments

Figure 5.10 shows the observed coefficient of determination (R^2) was > 0.8 for both outdoor and indoor noise study, which indicate that predicted noise level was well fitted with the measured noise level.

5.5 CONTRIBUTION OF DIFFERENT TRAFFIC ACTIVITIES ON ENVIRONMENTAL NOISE POLLUTION

Figure 5.11 shows that at day time car was observed as the noisiest traffic at that study area followed by bike, MUV, bus and truck and at night truck was the noisiest traffic followed by car, bike and MUV. On the other hand, inside the office, contribution from bike at day time was highest followed by car, MUV, bus and truck (Figure 5.12).

There was no bus observed at night.

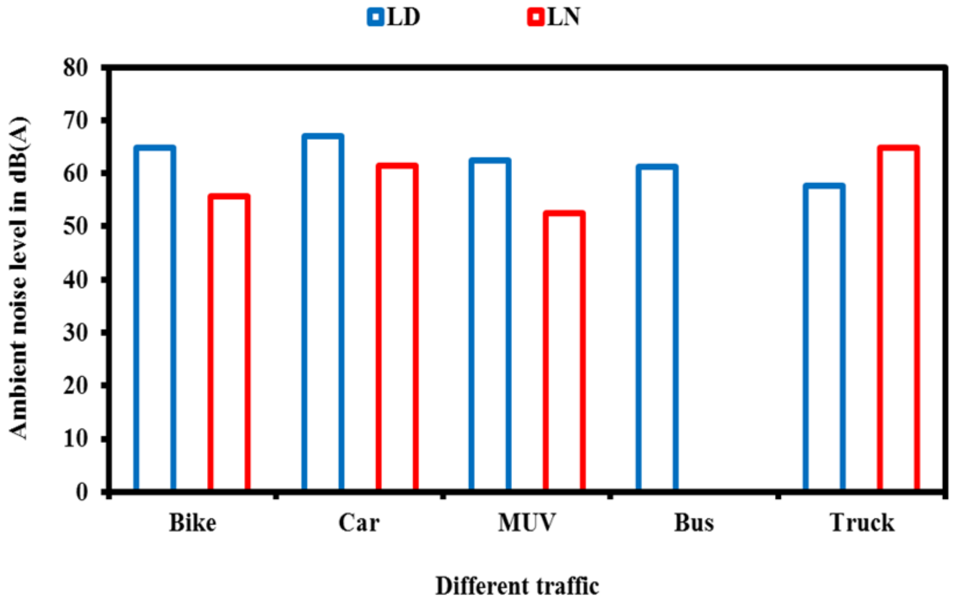


Figure 5.11 Different traffic contributions on street side ambient noise level

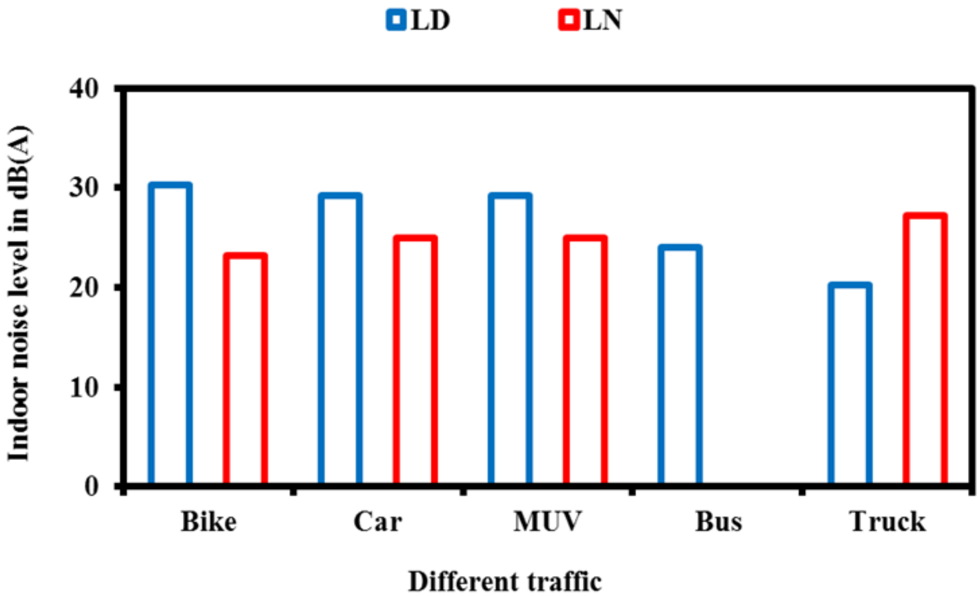


Figure 5.12 Different traffic contributions on office indoor noise level

Figure 5.13 shows that car contributed low frequencies noise while, bike was observed as the leading contributor of 250 Hz noise frequencies. Heavy vehicles including bus and truck contributed higher frequencies of noise at the roadside area.

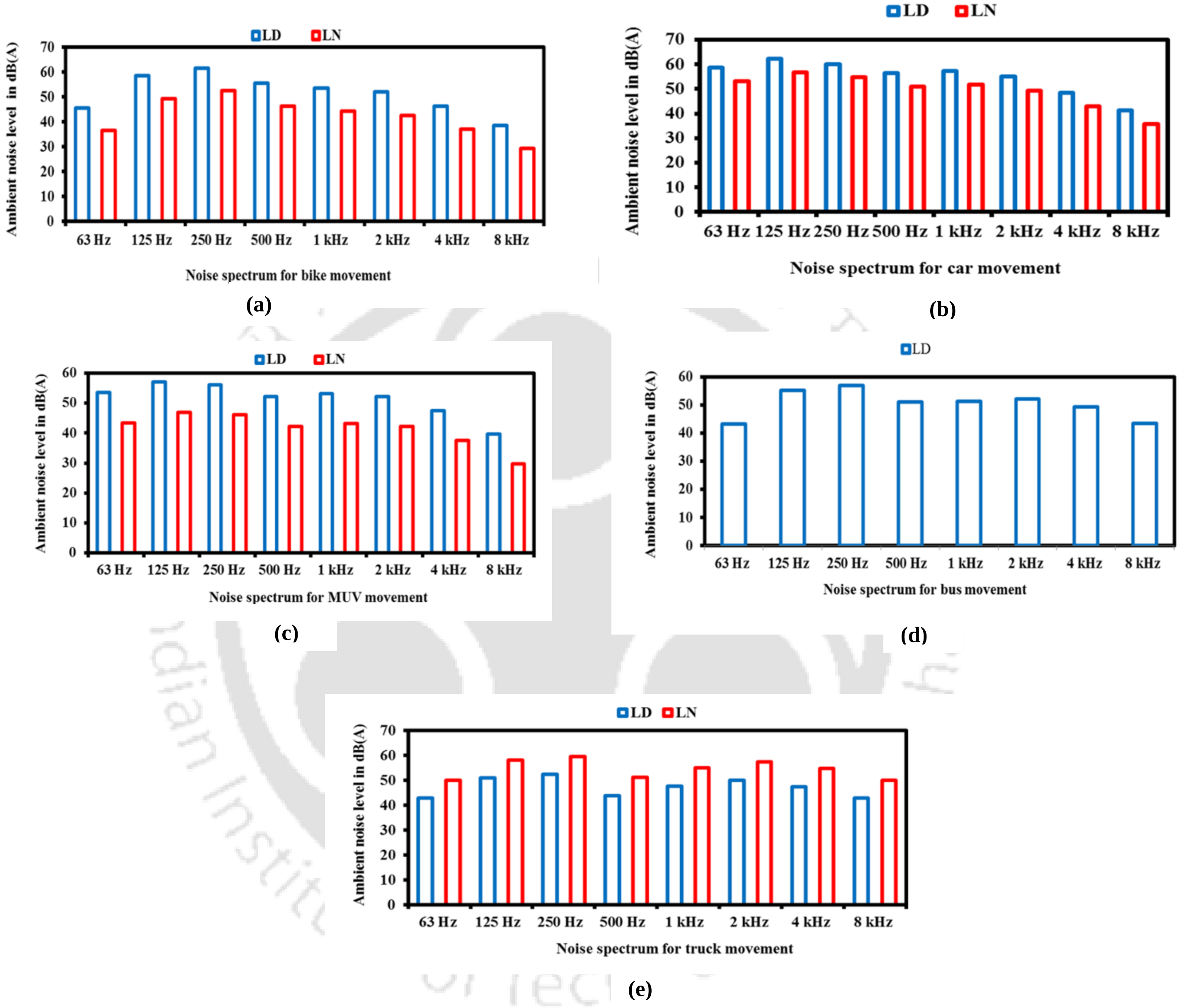


Figure 5.13 Street side ambient noise spectrum for (a) bike, (b) car, (c) MUV, (d) bus and (e) truck

5.6 DISCUSSION

Traffic noise modelling study concludes that day time predicted noise level was higher than 60 dB(A) at building outdoor and at night it was exceeded 56 dB(A) near roadside. Similar results found by Ece et al. (2018). In Indian city, Sonaviya and Tandel (2020) observed 4-11 dB(A) under prediction of traffic noise level by RLS 90 model in SoundPLAN essential 4.0 software. For indoor office building allowing 2 dB (A) of flanking transmission, day time predicted noise was 70.9 dB(A) and at night it was 64.9 dB(A). At day and night time GNM near roadside showed that the predicted noise was exceeded the CPCB prescribed limit mostly due to vehicular activities. Car movement was found as the major noise contributor in that study area. Very few trucks were there which contributed noise at night time. Bike movement generally dominated the 250 Hz noise frequency. The higher noise frequencies generally dominated by bus and truck movement at that study area. This observation could be helpful for developing the different traffic noise mitigation scenarios by identifying the noisiest traffic in that study area.

CHAPTER 6

TRAFFIC-BORNE $PM_{2.5}$ AND NOISE IMPACTS ON URBAN WORKERS' ANNOYANCE

6.1 PREDICTION OF NOISE ANNOYANCE USING QUESTIONNAIRE AND NOISE DESCRIPTORS

The ordinal regression analysis was carried out to predict workplace annoyance as functions of acoustic, $PM_{2.5}$ and non-acoustic descriptors for the two categories of human receptors and showed that all models satisfied the model significance criteria (i.e. $p < 0.05$).

Table 6.1 Comparison of Nagelkarke Pseudo-R^2 of street vendors' and office workers' workplace annoyance model

Predictors	**Participants**	Nagelkerke Pseudo-R^2
Noise	Street vendors	0.23
	Office workers	0.15
$PM_{2.5}$	Street vendors	0.19
	Office workers	0.10
Combined Noise and $PM_{2.5}$	Street vendors	0.38
	Office workers	0.18

6.1.1 Street vendors' workplace annoyance prediction

Table 6.1 shows the Nagelkarke-Pseudo R^2 0.23, 0.19 and 0.38 for noise, $PM_{2.5}$ and combined impact of noise and $PM_{2.5}$ model respectively, indicate 23%, 19% and 38% respective variability of models for predictor variables (Bouzid et al, 2020).

Table 6.2 Model estimate of street vendors' workplace annoyance

Predictors		Model Parameters	Estimate	Wald (χ^2)	Sig.	*Odds ratio* (*OR*)	95% *C.I.*	
							L.B.	*U.B.*
Noise	**Threshold**	No	10.531	3.734	0.053	37441.356	0.860	1.63×10^9
		Slight	10.852	3.946	0.047	51612.943	1.156	2.30×10^9
		Medium	11.288	4.242	0.039	79842.061	1.726	3.69×10^9
	Location	5000 Hz	0.232	4.546	0.033	1.262	1.019	1.562
		Roadside building facing	1.305	1.901	0.168	3.689	0.577	23.589
		Building not faced toward road				0^a		
		No smoking	-1.259	3.616	0.057	0.284	0.078	1.039
		Smoking				0^a		
$PM_{2.5}$	**Threshold**	No	-3.698	6.517	0.011	0.02	0.00	0.42
		Slight	-3.387	5.590	0.018	0.03	0.00	0.56
		Medium	-2.970	4.425	0.035	0.05	0.00	0.82
	Location	$PM_{2.5}$	-0.022	5.263	0.022	0.98	0.96	1.00
		Roadside building facing	2.237	3.676	0.055	9.36	0.95	92.10
		Building not faced toward road				0^a		
Combined Noise and $PM_{2.5}$	**Threshold**	No	7.664	3.043	0.081	2129.65	0.39	1.16×10^7
		Slight	8.041	3.330	0.068	3106.01	0.55	1.75×10^7
		Medium	8.530	3.715	0.054	5065.38	0.87	2.96×10^7
	Location	$PM_{2.5}$	-0.019	3.944	0.047	0.98	0.96	1.00
		50 Hz	0.218	4.518	0.034	1.24	1.02	1.52
		Family income	0.382	.475	0.491	1.47	0.49	4.34
		$PM_{2.5}$	2.441	6.991	0.008	11.49	1.88	70.19
		Roadside door facing	-0.019	3.944	0.047	0.98	0.96	1.00
		Door not faced toward road				0^a		

where, the link was logit and 0^a is the parameter which is set to zero because it is redundant.

6.1.1.1 Impact of noise on street vendors' workplace annoyance

In the noise and workplace annoyance model (Table 6.2), the 5000 Hz (*OR*: 1.262; 95% *C.I.*: 1.019-1.562; Wald (χ^2): 4.546) was the significant predictor of the street vendor's workplace annoyance. The results showed that the unit increase in 5000 Hz leads to 1.262 times workplace annoyance for the street vendors. Eq. (6.1)-(6.3) derived from (Table 6.2) for predicting street vendors' noise annoyance at the workplace in the form of acoustic and non-acoustic descriptors. The Eq. (6.1) - (6.4) indicate the relationship of different annoyance responses with the predictors.

$$logit(NA) = 10.531 - 0.232 \cdot (a) + 1.305 \cdot (b) - 1.259 \cdot (s) \quad (6.1)$$

$$logit(SA) = 10.852 - 0.232 \cdot (a) + 1.305 \cdot (b) - 1.259 \cdot (s) \quad (6.2)$$

$$logit(MA) = 11.288 - 0.232 \cdot (a) + 1.305 \cdot (b) - 1.259 \cdot (s) \quad (6.3)$$

$$logit(HA) = 1 - logit(MA) \quad (6.4)$$

where, '*NA*' is the no annoyance, '*SA*' is the slight annoyance, '*MA*' is the medium annoyance, '*HA*' is the high annoyance , '*a*' is noise level at 5000 Hz frequency, '*b*' is the roadside building facing, '*s*' is the no smoking.

6.1.1.2 Impact of $PM_{2.5}$ pollution on street vendors' workplace annoyance

In $PM_{2.5}$ and workplace annoyance model, Table 5.2 shows $PM_{2.5}$ (*OR*: 0.98; 95% *C.I.*: 0.96-1; Wald (χ^2): 5.263) and roadside building facing (*OR*: 9.36; 95% *C.I.*: 0.95-92.10; Wald (χ^2): 3.676) were the significant factors. The results showed that the unit increase in $PM_{2.5}$ leads to 0.98 times decrease in workplace annoyance and increase in roadside facing of residential building leads to 9.36 times unit increase in workplace annoyance of street vendors. The Eq. (6.5) - (6.8) indicate the relationship of different annoyance responses with the predictors.

$$logit(NA) = -3.698 + 0.022 \cdot (PM_{2.5}) - 2.237 \cdot (b) \quad (6.5)$$

$$logit(SA) = -3.387 + 0.022 \cdot (PM_{2.5}) - 2.237 \cdot (b) \quad (6.6)$$

$$logit(MA) = -2.970 + 0.022 \cdot (PM_{2.5}) - 2.237 \cdot (b) \quad (6.7)$$

$$logit(HA) = 1 - logit(MA) \quad (6.8)$$

where, '*b*' is the roadside building facing.

6.1.1.3 Combined impact of $PM_{2.5}$ and noise pollution on street vendors' workplace annoyance

In this model, Table 6.2 showed $PM_{2.5}$ (*OR*: 0.98; 95% *C.I.*: 0.96-1; Wald (X^2): 3.944), 50 Hz noise frequency (*OR*: 1.24; 95% *C.I.*: 1.02-1.52; Wald (X^2): 4.518) and roadside door location (*OR*: 11.49; 95% *C.I.*: 1.88-70.19; Wald (X^2): 6.991) were the significant predictors. The results showed that 1 μg/m^3 increase in $PM_{2.5}$ leads to 0.98 times decrease in workplace annoyance and 1 dB (A) increase in 50 Hz noise frequency leads to 1.24 times increase in workplace annoyance. However, degree of road facing residential door location increases 11.49 times workplace annoyance perception. The Eq. (6.9) - (6.12) indicate the relationship of different annoyance responses with the predictors.

$$logit(NA) = 7.664 + 0.019 \cdot (PM_{2.5}) - 0.218 \cdot (b) - 0.382 \cdot (f) - 2.441 \cdot (d) \quad (6.9)$$

$$logit(SA) = 8.041 + 0.019 \cdot (PM_{2.5}) - 0.218 \cdot (b) - 0.382 \cdot (f) - 2.441 \cdot (d) \quad (6.10)$$

$$logit(MA) = 8.530 + 0.019 \cdot (PM_{2.5}) - 0.218 \cdot (b) - 0.382 \cdot (f) - 2.441 \cdot (d) \quad (6.11)$$

$$logit(HA) = 1 - logit(MA) \quad (6.12)$$

where, '*b*' is the noise level at 50 Hz frequency, '*f*' is the family income, '*d*' is the roadside door facing.

6.1.2 Office workers' workplace annoyance prediction

Table 6.1 shows the Nagelkarke-Pseudo R^2 as 0.15, 0.10 and 0.18 for noise, $PM_{2.5}$ and combined impact of noise and $PM_{2.5}$ model respectively, indicate 15%, 10% and 18% respective variability of models for predictor variables (Bouzid et al, 2020).

6.1.2.1 Impact of noise on office workers' workplace annoyance

Table 6.3 shows 315 Hz (*OR*: 1.161; 95% *C.I.*: 1.007-1.338; Wald (χ^2): 4.210), 100 Hz (*OR*: 1.202; 95% *C.I.*: 1.009-1.431; Wald (χ^2): 4.254) and family income (*OR*: 0.716; 95% *C.I.*: 0.515-0.997; Wald (χ^2): 3.920) were found to be the significant predictors of the model. This indicates the increase in 315 Hz and 100 Hz of 1 dB (A) leads to 1.161 and 1.202 times respective increase in workplace annoyance. Similarly, with the increase in 1 INR family income leads to 0.716 decreased in workplace annoyance. The Eq. (6.13) - (6.16) refer the relationship of different annoyance responses with the predictors.

$$logit(NA) = 7.984 - 0.149 \cdot (c) + 0.105 \cdot (d) - 0.184 \cdot (e) + 0.333 \cdot (f) + 0.665 \cdot (t) \quad (6.13)$$

$$logit(SA) = 9.842 - 0.149 \cdot (c) + 0.105 \cdot (d) - 0.184 \cdot (e) + 0.333 \cdot (f) + 0.665 \cdot (t) \quad (6.14)$$

$$logit(MA) = 11.399 - 0.149 \cdot (c) + 0.105 \cdot (d) - 0.184 \cdot (e) + 0.333 \cdot (f) + 0.665 \cdot (t) \quad (6.15)$$

$$logit(HA) = 1 - logit(MA) \quad (6.16)$$

where, '*c*', '*d*' and '*e*' are the noise level at 315 Hz, 630 Hz and 100 Hz frequencies respectively, '*f*' is the family income, '*t*' is the no night traffic activities near the residence of office worker's.

Table 6.3 Model estimate of office workers' workplace annoyance

Predictors	Model Parameters		Estimate	Wald (X^2)	Sig.	*Odds ratio (OR)*	95% *C.I.*	
							L.B.	*U.B.*
Noise	**Threshold**	No	7.984	3.278	0.070	2932.178	0.518	1.6×10^7
		Slight	9.842	4.894	0.027	18806.686	3.073	1.1×10^8
		Medium	11.399	6.464	0.011	89207.959	13.622	5.8×10^8
	Location	315 Hz	0.149	4.210	0.040	1.161	1.007	1.338
		630 Hz	-0.105	3.452	0.063	0.900	0.806	1.006
		100 Hz	0.184	4.254	0.039	1.202	1.009	1.431
		Family Income	-0.333	3.920	0.048	0.716	0.515	0.997
		No night traffic	-0.665	2.907	0.088	0.514	0.239	1.105
		Night traffic			0^a			
$PM_{2.5}$	**Threshold**	No	0.193	0.254	0.614	1.213	0.573	2.570
		Slight	1.981	20.855	0.000	7.253	3.099	16.975
		Medium	3.497	38.027	0.000	33.030	10.868	100.384
	Location	$PM_{2.5}$	0.010	6.584	0.010	1.010	1.002	1.018
		No night traffic	-0.879	5.035	0.025	0.415	0.193	0.895
		Night traffic			0^a			
Combined Noise and $PM_{2.5}$	**Threshold**	No	4.632	1.069	0.301	102.709	0.016	6.6×10^5
		Slight	6.527	2.100	0.147	683.488	0.100	4.6×10^6
		Medium	8.081	3.182	0.074	3232.277	0.450	2.3×10^7
	Location	315 Hz	0.145	3.856	0.050	1.156	1.000	1.336
		630 Hz	-0.114	3.961	0.047	0.892	0.798	0.998
		100 Hz	0.101	1.226	0.268	1.106	0.925	1.321
		$PM_{2.5}$	0.008	4.047	0.044	1.008	1.000	1.016
		No night traffic	-0.873	4.772	0.029	0.418	0.191	0.914
		Night traffic			0^a			
		No smoking	-0.609	1.969	0.161	0.544	0.232	1.273
		Smoking			0^a			

where, the link was logit and 0^a is the parameter which is set to zero because it is redundant.

6.1.2.2 Impact of $PM_{2.5}$ on office workers' workplace annoyance

In this model Table 6.3 showed that $PM_{2.5}$ (*OR*: 1.010; 95% *C.I.*: 1.002-1.018; Wald (χ^2): 6.584) and no night traffic (*OR*: 0.415; 95% *C.I.*: 0.193-0.895; Wald (χ^2): 5.035) were the significant predictors. This indicate the unit increase in $PM_{2.5}$ and the degree of no night time traffic movement leads to 1.010 and 0.415 times respective increase and decrease in workplace annoyance. The Eq. (6.17) – (6.20) refers the relationship of different annoyance responses with the predictor variables.

$$logit(NA) = 0.193 - 0.010 \cdot (PM_{2.5}) + 0.879 \cdot (t) \quad (6.17)$$

$$logit\ (SA) = 1.981 - 0.010 \cdot (PM_{2.5}) + 0.879 \cdot (t) \quad (6.18)$$

$$logit(MA) = 3.497 - 0.010 \cdot (PM_{2.5}) + 0.879 \cdot (t) \quad (6.19)$$

$$logit(HA) = 1 - logit(MA) \quad (6.20)$$

where, '*t*' is the no night traffic activities near the residence of office worker's.

6.1.2.3 Combined impact of $PM_{2.5}$ and noise pollution on office workers' workplace annoyance

Table 6.3 shows the 315 Hz (*OR*: 1.156; 95% *C.I.*: 1-1.336; Wald (χ^2): 3.856), 630 Hz (*OR*: 0.892; 95% *C.I.*: 0.798-0.998; Wald (χ^2): 3.961) noise spectrum, $PM_{2.5}$ (*OR*: 1.008; 95% *C.I.*: 1-1.016; Wald (χ^2): 4.047), no night traffic (*OR*: 0.418; 95% *C.I.*: 0.191-0.914; Wald (χ^2): 4.772) are the significant predictors. This indicates that unit increase in these predictors leads to 1.156, 0.892, 1.008, 0.418 times respective increase, decrease, increase and decrease in workplace annoyance. The Eq. (6.21) - (6.24) refer the relationship between different annoyance responses and predictors.

$$logit(NA) = 4.632 - 0.145 \cdot (f) + 0.114 \cdot (g) - 0.101 \cdot (h) - 0.008 \cdot (PM_{2.5}) + 0.873 \cdot (t) + 0.609 \cdot (s) \quad (5.21)$$

$$logit\ (SA) = 6.527 - 0.145 \cdot (f) + 0.114 \cdot (g) - 0.101 \cdot (h) - 0.008 \cdot (PM_{2.5}) + 0.873 \cdot (t) + 0.609 \cdot (s) \quad (5.22)$$

$$logit(MA) = 8.081 - 0.145 \cdot (f) + 0.114 \cdot (g) - 0.101 \cdot (h) - 0.008 \cdot (PM_{2.5}) + 0.873 \cdot (t) + 0.609 \cdot (s) \quad (5.23)$$

$$logit(HA) = 1 - logit(MA) \quad (5.24)$$

where, 'f', 'g' and 'h' represent the noise level at 315 Hz, 630 Hz and 100 Hz frequencies respectively, 't' is the no night traffic activities near office workers' residence and 's' is the no smoking response.

6.2 DOSE-RESPONSE RELATIONSHIP

The dose-response functions were developed in terms of frequencies and $PM_{2.5}$ using Eq. (6.1) - Eq. (6.24) for the different categories of respondents. Figure 6.1 (a)-(d) showed that noise at 50 Hz frequency > 40 dB (A) and $PM_{2.5}$ > 100 µg/m^3 leads to respective increase and decrease in the street vendors' degree of annoyance perception. This reflects the street vendors' noise sensitivity and habitual adjustment with the elevated air pollution levels. Figure 6.2 shows the office workers' annoyance response scenarios for three different noise spectrum (100 Hz, 315 Hz and 630 Hz) and $PM_{2.5}$. For every scenario $PM_{2.5}$ > 50 µg/m^3 leads to the increase in degree of annoyance. Figure 6.2 ((a)-(d)) shows, for 100 Hz noise spectrum, noise level > 35 dB (A) leads to an increase in the degree of annoyance perception. Figure 6.2 ((e)-(h)) indicate that, noise level > 50 dB (A) at 315 Hz noise spectrum, increases the degree of workplace annoyance perception of office workers'. Figure 6.2((i)-(l)) elucidate that noise level > 55 dB(A) of 630 Hz noise frequency leads to decrease in degree of annoyance perception. This indicates the possibility of NIPTS of office workers. Bouzid et al. (2020) observed that L_{den} of 40-60 dB (A), residents of Sfax city was less annoyed. These might result from NIPTS syndrome (Karimi et al., 2010; Alam, 2011). In this present research it was observed that the noise perception varied noticeably for different group of workers' for different noise spectrum, which could be due to the NIPTS and noise sensitivity factors.

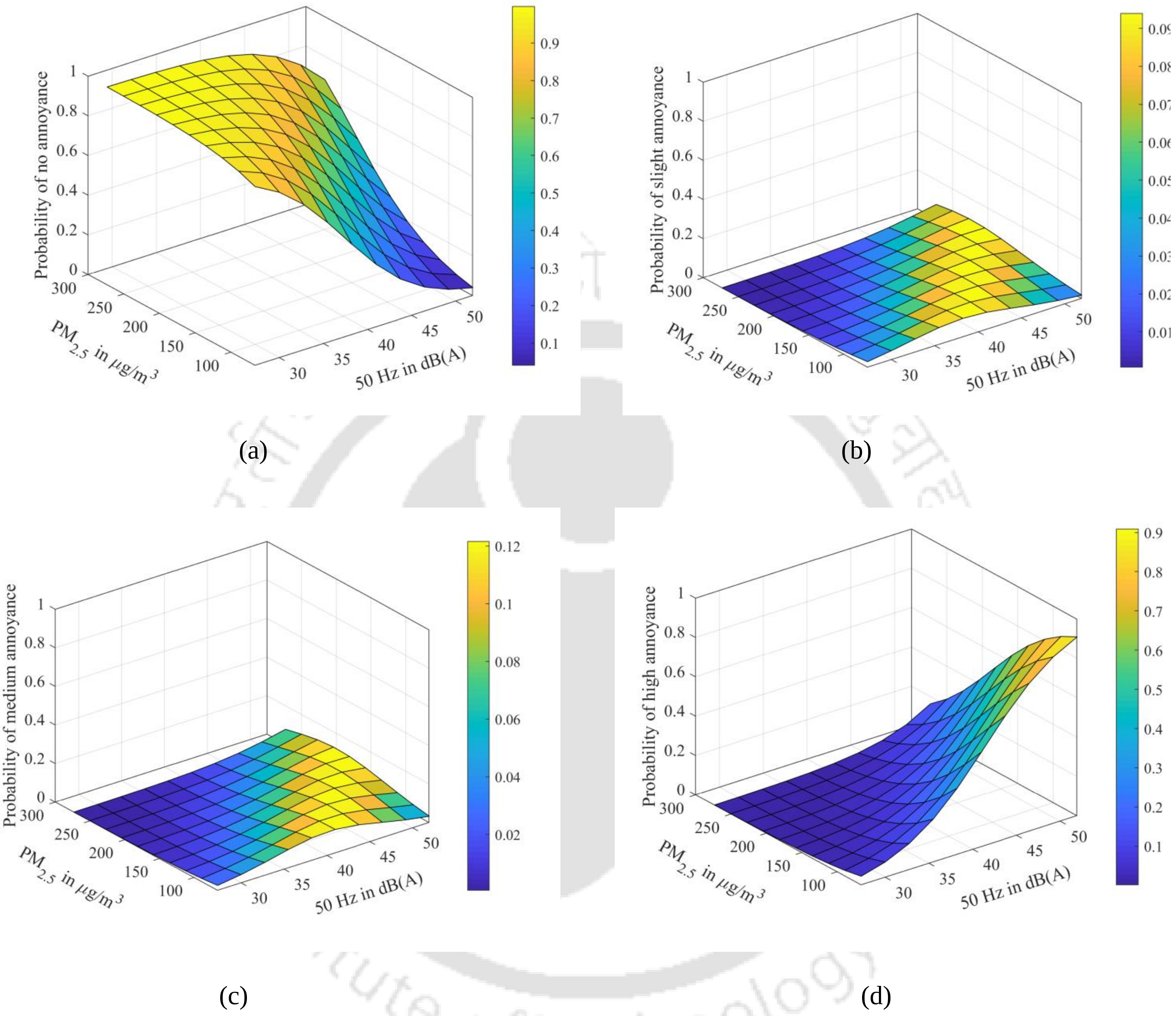


Figure 6.1 Dose response relationship for street vendors' (a) no annoyance, (b) slight annoyance, (c) medium annoyance and (d) high annoyance

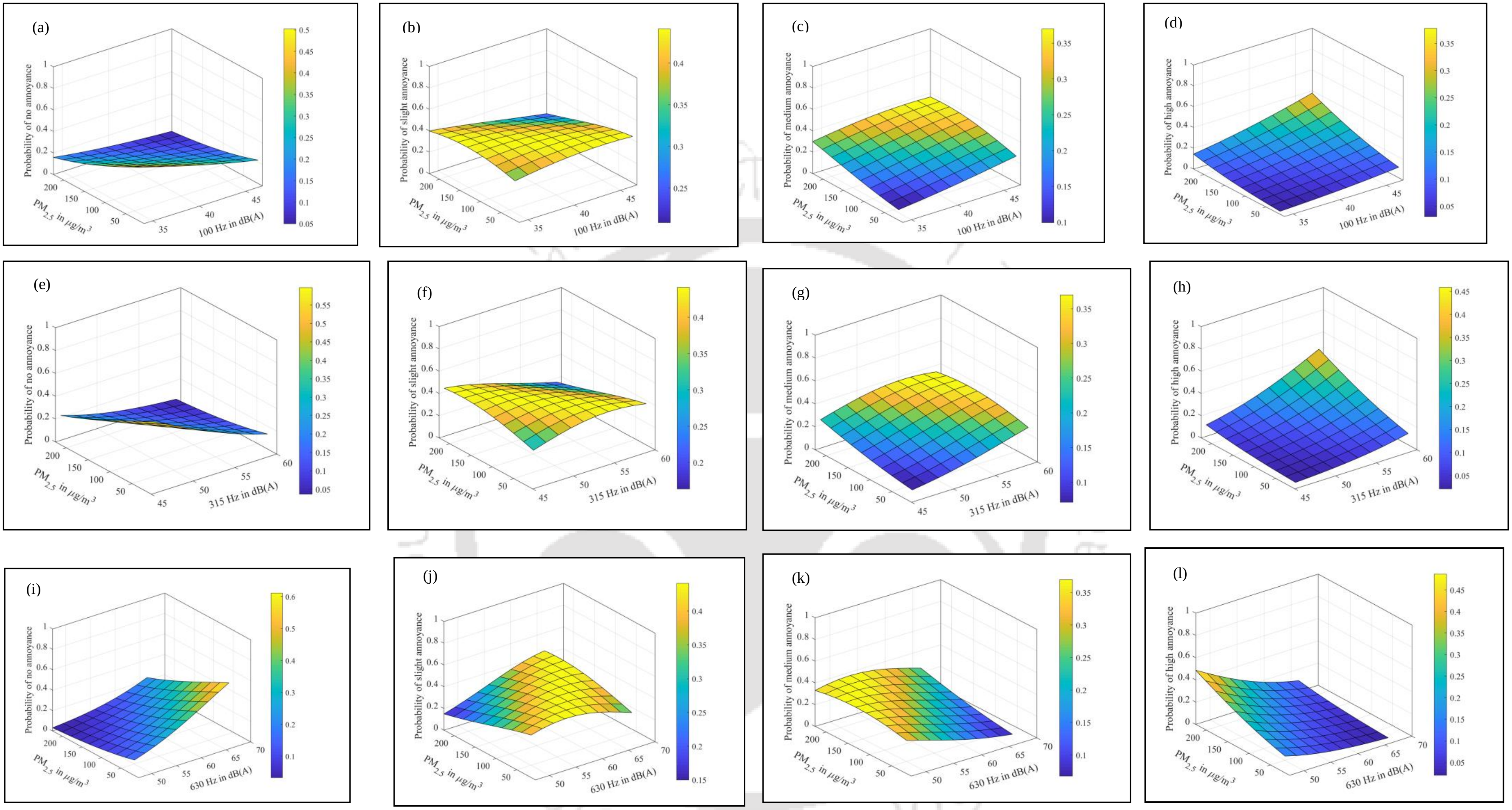


Figure 6.2 Dose response relationship of workplace annoyance of office workers for 100 Hz (a)-(d), 315 Hz (e)-(h) and 630 Hz (i)-(l)

6.3 DISCUSSION

The social questionnaire data and the $PM_{2.5}$ and noise levels collected from the workplaces, and outdoor microenvironments in an urban traffic corridor were analyzed by various statistical tests for interrelationships and perceptive impacts on the humans moving through different microenvironments. The main focus was to determine the relationships of various parameters with the workplace annoyance and express workplace annoyance in terms of traffic borne $PM_{2.5}$ and noise descriptors. The traffic corridor selected for the study represents the typical urban centre in developing countries. The traffic fleet contains a higher share of two-wheelers with mixed traffic of cars, buses, multi-utility vehicles and three-wheelers. Most cities in India have a higher share of two-wheelers, as was also reported by Vijay et al. (2015) in Nagpur, India.

From the ordinal regression modelling of street vendors' scenario, 50 Hz, 5000 Hz noise spectrum, $PM_{2.5}$, door location, building facing, family income have been the significant predictors of street vendor's workplace annoyance. An increase in 50 Hz, 5000 Hz frequency noise level increase the workplace annoyance, but increase in $PM_{2.5}$ surprisingly decrease the workplace annoyance, which could be attributed that street vendors are more sensitive to noise than $PM_{2.5}$. Okokon et al. (2018) observed that people who dwelled with street-side bedroom windows were very prone to use antidepressants due to higher noise exposure. In the case of office workers, noise perception during sleeping has been observed as a significant predictor of workplace annoyance. It was well established that noise events can hamper sleep structure (Ebben et al., 2021; Sanok et al., 2022); therefore, noise event interference with sleep induces workplace annoyance. In the case of office workers' scenario, 100 Hz, 315 Hz and 630 Hz noise spectrum, $PM_{2.5}$, no night traffic and no smoking habits were the significant predictors of workplace annoyance. Unit increase in 100 Hz, 315 Hz noise spectrum and $PM_{2.5}$ leads to increase the workplace annoyance and 630 Hz decreases the workplace annoyance. This scenario indicates the variation in noise sensitivity of street vendors for different noise spectrum. On the other hand, no night traffic condition near their residence and their no smoking habits were the preferable condition for their less workplace annoyance perception. This study first introduced the noise frequency and $PM_{2.5}$ for describing the dose-response relationship between traffic noise and $PM_{2.5}$ pollution and workplace annoyance. From street vendors' analysis this can be elucidated that at 50 Hz noise frequency noise level > 40 dB (A) lead to enhance high annoyance perception. While, at that frequency, noise level between 30-45 dB (A) induced medium annoyance perception. However, $PM_{2.5}$ > 100 μg/m^3 associated with the reduction in annoyance perception, which could be attributed that street vendors were more sensitive on noise than air pollutants. On the other hand, in office workers' scenario, noise level > 35 dB (A) and > 50 dB (A) of 100 Hz and 315 Hz noise spectrum increased the high annoyance perception of office workers, but noise level > 55 dB (A) of 630 Hz noise frequency decrease their high annoyance perception. Therefore, this variation in the response against different noise spectrum indicates the heterogeneity of audibility of office workers, which might be the outcome of NIPTS. However, $PM_{2.5}$ >50 μg/m^3 increased their high annoyance perception. Miedema and Oudshoorn (2001) and Klæboe et al. (2005) observed similar findings for L_{den} and different annoyance ratings. Therefore, this study observed the influence of demographic, socio-contextual factors, smoking status, low and mid noise spectrum and $PM_{2.5}$ for evaluating annoyance. Similar findings were also obtained in different studies (Camusso and Pronello, 2016; Mueller et al., 2020; Das et al., 2021; Hanibuchi et al., 2021; Pinsonnault-Skvarenina et al., 2021).

CHAPTER 7

TRAFFIC-BORNE $PM_{2.5}$ AND NOISE IMPACTS ON URBAN WORKERS' CARDIOVASCULAR HEALTH

7.1 IMPACT OF NOISE SPECTRUM, $PM_{2.5}$ ON STREET VENDORS' AND OFFICE WORKERS' BP AND HR

The Table A-7 corresponds to the details of model fitting criteria and model significance level for both street vendors and office workers. Table 7.1 shows the comparison of Nagelkarke Pseudo-R^2 for different models of street vendors and office workers.

Table 7.1 Comparison of Nagelkarke Pseudo-R^2 for different models of street vendors' and office workers'

		Nagelkerke Pseudo-R^2		
Predictors	**Participants**	**SBP**	**DBP**	**HR**
Noise	Street vendors	0.156	0.337	0.255
	Office workers	0.192	0.174	0.235
$PM_{2.5}$	Street vendors	0.206	0.407	0.736
	Office workers	0.130	0.155	0.160
Combined Noise and $PM_{2.5}$	Street vendors	0.283	0.285	0.232
	Office workers	0.183	0.177	0.269

7.1.1 Street vendors' scenario

Street vendors' SBP, DBP and HR were modelled with the help of noise spectrum, $PM_{2.5}$, annoyance perception and demographic variables.

7.1.1.1 SBP study

The impact of noise spectrum on SBP of street vendors showed that the model explained 15.6% variability (Nagelkerke Pseudo R^2=0.156) (Table 7.1). In this model, 630 Hz frequency was the significant predictor (adjusted *OR*: 0.85; 95% *C.I.*:0.72-1; Wald(χ^2): 4.085), indicating 0.85 time decrease in SBP with one unit increase in 630 Hz frequency considering remaining predictors constant (Table 7.2). The Eq. (7.1)-(7.3) show the relationship of the noise spectrum with the demographic information and SBP of the street vendors.

$$logit\ (SBP_1) = -12.956 + 0.164 \cdot (a) + 1.048 \cdot (b) \tag{7.1}$$

$$logit(SBP_2) = -10.073 + 0.164 \cdot (a) + 1.048 \cdot (b) \tag{7.2}$$

$$logit\ (SBP_3) = -8.625 + 0.164 \cdot (a) + 1.048 \cdot (b) \tag{7.3}$$

where, 'a' is the noise level at 630 Hz frequency and 'b' is the road facing residential dwelling.

Table 7.2 Model parameter estimate of street vendors' SBP

Predictor	Model Parameters		Estimate	Wald (X^2)	Sig.	Odds ratio (*OR*)	95% *C.I.*	
							LB	*UB*
Noise	Threshold	SBP_1 : < 100 mm Hg	-12.956	6.977	0.008	0.00	0.00	0.04
		SBP_2: 100-120 mm Hg	-10.073	4.511	0.034	0.00	0.00	0.46
		SBP_3: 122-140 mm Hg	-8.625	3.384	0.066	0.00	0.00	1.76
	Location	630 Hz	-0.164	4.085	0.043	0.85	0.72	1.00
		Roadside building facing	-1.048	1.761	0.185	0.35	0.07	1.65
		Building not faced towards road				0^a		
$PM_{2.5}$	Threshold	SBP_1 : < 100 mm Hg	-2.639	2.215	0.137	0.07	0.00	2.31
		SBP_2: 100-120 mm Hg	0.345	0.043	0.836	1.41	0.05	37.09
		SBP_3: 122-140 mm Hg	1.840	1.187	0.276	6.30	0.23	172.55
	Location	$PM_{2.5}$	0.007	0.560	0.454	1.01	0.99	1.03
		Roadside Annoyance	-0.464	0.701	0.402	0.63	0.21	1.86
		No free traffic flow	1.969	5.538	0.019	7.16	1.39	36.90
		Free traffic flow				0^a		
		No high night traffic	0.958	1.920	0.166	2.61	0.67	10.12
		High night traffic				0^a		
Combined Noise and $PM_{2.5}$	Threshold	SBP_1 : < 100 mm Hg	-13.175	7.121	0.008	0.00	0.00	0.03
		SBP_2: 100-120 mm Hg	-9.992	4.465	0.035	0.00	0.00	0.48
		SBP_3: 122-140 mm Hg	-8.377	3.225	0.073	0.00	0.00	2.15
	Location	$PM_{2.5}$	0.012	1.777	0.182	1.01	0.99	1.03
		630 Hz	-0.161	4.527	0.033	0.85	0.73	0.99
		Family income	-0.499	1.397	0.237	0.61	0.27	1.39
		Roadside annoyance	-0.951	3.137	0.077	0.39	0.13	1.11
		No congested flow	1.390	2.995	0.084	4.02	0.83	19.39
		Congested flow				0^a		

where, the link was logit and 0^a is the parameter which is set to zero because it is redundant.

The Eq. (7.1)-(7.3) show the relationship of the noise spectrum with the demographic information and SBP of the street vendors.

$$logit\ (SBP_1) = -12.956 + 0.164 \cdot (a) + 1.048 \cdot (b) \quad (7.1)$$

$$logit(SBP_2) = -10.073 + 0.164 \cdot (a) + 1.048 \cdot (b) \quad (7.2)$$

$$logit\ (SBP_3) = -8.625 + 0.164 \cdot (a) + 1.048 \cdot (b) \quad (7.3)$$

where, 'a' is the noise level at 630 Hz frequency and 'b' is the road facing residential dwelling.

Similarly, the impact of $PM_{2.5}$ results showed, Nagelkerke Pseudo R^2=0.206, indicating 20.6% variability of the model. The only non-occurrence of free traffic flow near the residential roadside area was the significant predictor (adjusted *OR*: 7.16; 95% *C.I.*:1.39-36.90; Wald (χ^2): 5.538), indicating with one unit increase in happening this no-free-flow condition led to 7.16 times increase in SBP of street vendors considering remaining predictors constant (Table 7.2). The Eq. (7.4)-(7.6) showed the relationship between the $PM_{2.5}$ and demographic information and SBP of the street vendors.

$$logit\ (SBP_1) = -2.369 - 0.007 \cdot PM_{2.5} + 0.464 \cdot (a) - 1.969 \cdot (b) - 0.958 \cdot (c) \quad (7.4)$$

$$logit\ (SBP_2) = 0.345 - 0.007 \cdot PM_{2.5} + 0.464 \cdot (a) - 1.969 \cdot (b) - 0.958 \cdot (c) \quad (7.5)$$

$$logit\ (SBP_3) = 1.840 - 0.007 \cdot PM_{2.5} + 0.464 \cdot (a) - 1.969 \cdot (b) - 0.958 \cdot (c) \quad (7.6)$$

where, 'a' is the roadside annoyance feeling, 'b' is the non-occurrence of traffic flow and 'c' is the no dense traffic operation at night near residence.

Similarly, in the analysis of combined exposure of noise and $PM_{2.5}$ on the SBP Nagelkerke Pseudo R^2 was 0.283, indicating 28.3% variability in the model. In this case, the noise level at 630 Hz was the significant predictors (adjusted *OR*: 0.85; 95% *C.I.*:0.73-0.99; Wald (χ^2): 4.527), indicating one unit increase in 630 Hz noise frequency decreases the SBP 0.85 times, assuming other predictors constant (Table 7.2). The Eq. (7.7)-(7.9) indicates the interrelationship of SBP with the different predictors.

$$logit\ (SBP_1) = -13.175 - 0.012 \cdot PM_{2.5} + 0.161 \cdot (b) + 0.499 \cdot (d) + 0.951 \cdot (e) - 1.390 \cdot (f) \quad (6.7)$$

$$logit\ (SBP_2) = -9.992 - 0.012 \cdot PM_{2.5} + 0.161 \cdot (b) + 0.499 \cdot (d) + 0.951 \cdot (e) - 1.390 \cdot (f) \quad (6.8)$$

$$logit\ (SBP_3) = -8.377 - 0.012 \cdot PM_{2.5} + 0.161 \cdot (b) + 0.499 \cdot (d) + 0.951 \cdot (e) - 1.390 \cdot (f) \quad (6.9)$$

where, 'b' is the noise level at 630 Hz frequency, 'd' is family income, 'e' is roadside annoyance and 'f' is the non-occurrence of congested traffic near residence.

7.1.1.2 Diastolic blood pressure (DBP) study

The noise impact on DBP study the Nagelkerke Pseudo-R^2 was 0.337, indicating 33.7% model variation with the predictor variables (Table7.1). Here, 31.5 Hz noise frequency (adjusted *OR*: 0.78; 95% *C.I.*:0.63-0.96; Wald (X^2): 5.394) and roadside annoyance perceptions were the significant predictors (adjusted *OR*: 0.19; 95% *C.I.*:0.06-0.61; Wald (X^2): 7.772) (Table 7.3).

Table 7.3 Model parameter estimate of street vendors' DBP

Predictor		Model Parameters	Estimate	Wald (X^2)	Sig.	Odds ratio (*OR*)	95% *C.I.*	
							LB	*UB*
Noise	Threshold	DBP_1: < 80 mm Hg	-11.003	9.954	0.002	0.00	0.00	0.02
		DBP_2: 80-100 mm Hg	-7.305	5.362	0.021	0.00	0.00	0.33
	Location	31.5 Hz	-0.248	5.394	0.020	0.78	0.63	0.96
		Family income	-1.026	2.266	0.132	0.36	0.09	1.36
		Roadside annoyance	-1.669	7.772	0.005	0.19	0.06	0.61
$PM_{2.5}$	Threshold	DBP_1: < 80 mm Hg	-11.000	3.557	0.059	0.00	0.00	1.54
		DBP_2: 80-100 mm Hg	-8.469	2.332	0.127	0.00	0.00	11.04
	Location	$PM_{2.5}$	-0.053	3.984	0.046	0.95	0.90	1.00
		Age	-0.992	0.553	0.457	0.37	0.03	5.06
Combined Noise and $PM_{2.5}$	Threshold	DBP_1: < 80 mm Hg	-8.198	7.184	0.007	0.00	0.00	0.11
		DBP_2: 80-100 mm Hg	-4.613	2.663	0.103	0.01	0.00	2.53
	Location	31.5 Hz	-0.193	4.368	0.037	0.82	0.69	0.99
		Roadside annoyance	-1.658	7.426	0.006	0.19	0.06	0.63
		$PM_{2.5}$	0.007	0.547	0.459	1.01	0.99	1.02

The findings revealed that with one unit increase in 31.5 Hz frequency and roadside annoyance perception could associated with 0.78 and 0.19 times decrease in SBP, respectively. The Eq. (7.10) and Eq. (7.11) refers the relationship of DBP, noise frequency and roadside annoyance of street vendors.

$$logit\ (DBP_1) = 11.003 + 0.248 \cdot (c) + 1.026 \cdot (g) + 1.669 \cdot (h) \quad (7.10)$$

$$logit\ (DBP_2) = -7.305 + 0.248 \cdot (c) + 1.026 \cdot (g) + 1.669 \cdot (h) \quad (7.11)$$

where, 'c' is the noise level at 31.5 Hz frequency, 'g' and 'h' are the family income and roadside annoyance perception, respectively.

In $PM_{2.5}$ and DBP study, Nagelkerke Pseudo-R^2 was 0.407, revealing the 40.7% model variability with the predictor variables (Table 7.1). The results revealed that $PM_{2.5}$ was the significant predictor (adjusted *OR*: 0.95; 95%*C.I.*:0.90-1; Wald (χ^2):3.984) indicates the one unit increase in $PM_{2.5}$ concentration was associated with 0.95 times decrease in DBP, assuming other predictors constant (Table 7.3). The Eq. (7.12)-(7.13) indicate the relationship between DBP, $PM_{2.5}$ and age of the participants.

$$logit\ (DBP_1) = 11 + 0.053 \cdot (PM_{2.5}) + 0.992 \cdot (age) \quad (7.12)$$

$$logit\ (DBP_2) = -8.469 + 0.053 \cdot (PM_{2.5}) + 0.992 \cdot (age) \quad (7.13)$$

In the analysis of the combined impact of noise frequency and $PM_{2.5}$ on DBP, Nagelkerke Pseudo R^2 was 0.285, indicating 28.5% model variability (Table 7.1). In this case, 31.5 Hz (adjusted *OR*: 0.82; 95% *C.I.*:0.69-0.99; Wald (χ^2):4.368) and roadside annoyance perception (adjusted *OR*: 0.19; 95% *C.I.*:0.06-0.63; Wald (χ^2):7.426) were the significant predictors (Table 6.3). The findings indicates that with one unit increase in 31.5 Hz noise frequency and roadside annoyance was associated with 0.82 and 0.19 times decrease in DBP, respectively, considering other constant predictors. The Eq. (7.14) and Eq.(7.15) refer the relationship between combine noise, $PM_{2.5}$ and DBP and other covariates.

$$logit\ (DBP_1) = -8.198 + 0.193 \cdot (b) + 1.658 \cdot (h) - 0.007 \cdot (PM_{2.5}) \quad (7.14)$$

$$logit\ (DBP_2) = -4.613 + 0.193 \cdot (b) + 1.658 \cdot (h) - 0.007 \cdot (PM_{2.5}) \quad (7.15)$$

where, 'b' is the noise level at 31.5 Hz frequency and 'h' indicates the roadside annoyance perception

7.1.1.3 Heart rate (HR) study

The noise impact on HR model, the Nagelkerke Pseudo-R^2=0.255 referring the 25.5% model variation with the predictors (Table 7.1). In this findings, 25 Hz (adjusted *OR*: 1.32; 95% *C.I.*:1.02-1.71; Wald (χ^2):4.337) was the significant predictor, indicating with the one unit increase in this frequency leads to 1.32 time increase in HR, assuming other predictors constant (Table 7.4). The Eq. (7.16) and Eq. (7.17) were the relationship equations of HR, noise and questionnaire outcome.

$$logit\ (HR_1) = -17.225 + 0.351 \cdot (c) - 0.276 \cdot (d) + 0.633 \cdot (h) + 0.852 \cdot (b) \quad (7.16)$$

$$logit\ (HR_2) = -15.862 + 0.351 \cdot (c) - 0.276 \cdot (d) + 0.633 \cdot (h) + 0.852 \cdot (b) \quad (7.17)$$

where, 'c' and 'd' are the noise at 315 Hz and 25 Hz frequency respectively, 'h' denotes roadside annoyance and 'b' denotes building age

Table 7.4 Model parameter estimate of street vendors' HR study

Predictor		Model Parameters	Estimate	Wald (X^2)	Sig.	Odds ratio (*OR*)	95% *C.I.*	
							LB	*UB*
Noise	Threshold	HR_1: <72 beats/min	-17.225	3.460	0.063	0.00	0.00	2.52
		HR_2 : 72-80 beats/min	-15.862	2.971	0.085	0.00	0.00	8.80
	Location	315 Hz	-0.351	3.537	0.060	0.70	0.49	1.01
		25 Hz	0.276	4.337	0.037	1.32	1.02	1.71
		Roadside annoyance	-0.633	1.065	0.302	0.53	0.16	1.77
		Building age	-0.852	3.697	0.055	0.43	0.18	1.02
$PM_{2.5}$	Threshold	HR_1: <72 beats/min	-21.356	7.229	0.007	0.00	0.00	0.00
		HR_2 : 72-80 beats/min	-17.538	4.824	0.028	0.00	0.00	0.15
	Location	$PM_{2.5}$	0.006	0.030	0.862	1.01	0.94	1.07
		Age	0.723	0.132	0.716	2.06	0.04	101.34
		Mask used : no	-21.469			0.00	0.00	0.00
		Mask used: yes				0[a]		
		Smoker at home: none	4.213	4.026	0.045	67.53	1.10	4137.05
		Smoker at home: many				0[a]		
		Time of experiencing health effect				0[a]		
		Building facing : roadside	-3.637	1.144	0.285	0.03	0.00	20.67
		Building facing : not roadside				0[a]		
		Roadside annoyance : no	21.155			1.5×10^9	1.5×10^9	1.5×10^9
		Roadside annoyance : medium	-1.127	0.432	0.511	0.32	0.01	9.32
		Roadside annoyance: high				0[a]		
Combined noise and $PM_{2.5}$	Threshold	HR_1: <72 beats/min	-15.665	2.949	0.086	0.00	0.00	9.14
		HR_2 : 72-80 beats/min	-14.329	2.497	0.114	0.00	0.00	31.27
	Location	315 Hz	-0.338	3.013	0.083	0.71	0.49	1.04
		25 Hz	0.266	3.960	0.047	1.30	1.00	1.69
		Building age	-0.918	4.347	0.037	0.40	0.17	0.95
		$PM_{2.5}$	-0.002	0.054	0.816	1.00	0.98	1.02

where, the link was logit and 0[a] was the parameter which set to zero because it is redundant.

In $PM_{2.5}$ and HR study, Nagelkerke Pseudo-R^2 was 0.736, indicates the 73.6% model variation (Table 7.1). Absence of smoker at home was the significant predictor (adjusted *OR*: 67.53; 95% *C.I.*:1.10-4137.05; Wald (χ^2): 4.026), indicating 67.53 times increase in HR was associated with the unit increase in residential smoker (Table 7.4). The Eq. (7.18)-(7.19) refers the linkage between the HR, $PM_{2.5}$ and questionnaire outcomes.

$$logit\ (HR_1) = -21.356 - 0.006 \cdot (PM_{2.5}) - 0.723 \cdot (Age) + 21.469 \cdot (i) - 4.213 \cdot (j) + 3.637 \cdot (k) - 21.15 \cdot (l) + 1.127 \cdot (m) \tag{7.18}$$

$$logit\ (HR_2) = -17.538 - 0.006 \cdot (PM_{2.5}) - 0.723 \cdot (Age) + 21.469 \cdot (i) - 4.213 \cdot (j) + 3.637 \cdot (k) - 21.15 \cdot (l) + 1.127 \cdot (m) \tag{7.19}$$

where, 'i' is no mask usage, 'j' is no residential smoker, 'k' is road facing residential dwelling, 'l' is no roadside annoyance perception and 'm' is medium roadside annoyance.

In the analysis of combined impact of noise spectrum and $PM_{2.5}$ on the HR, Nagelkerke Pseudo-R^2 was 0.232, revealing 23.2% model variation (Table 7.1). It was observed that 25 Hz noise frequency (adjusted *OR*: 1.30; 95% *C.I.*:1-1.69; Wald (χ^2): 3.960) and residential building age (adjusted *OR*: 0.40; 95% *C.I.*:0.17-0.95; Wald (χ^2): 4.347) were the significant predictors. The findings revealed that with unit increase in noise of 25 Hz frequency and residential building aging was corresponds to 1.30 times increase and 0.40 times decrease in HR, respectively (Table 7.4). The Eq. (7.20)-(7.21) show the relationship between HR, noise frequency, $PM_{2.5}$ and questionnaire variables.

$$logit\ (HR_1) = -15.665 + 0.338 \cdot (e) - 0.266 \cdot (f) + 0.918 \cdot (n) + 0.002 \cdot (PM_{2.5}) \tag{7.20}$$

$$logit\ (HR_2) = -14.329 + 0.338 \cdot (e) - 0.266 \cdot (f) + 0.918 \cdot (n) + 0.002 \cdot (PM_{2.5}) \tag{7.21}$$

where, '*e*' and '*f*' are the noise level at 315 Hz and 25 Hz frequency respectively, '*n*' is residential building age of the street vendors.

7.1.2 Office workers' scenario

7.1.2.1 Systolic blood pressure (SBP) study

The noise and SBP model explained 19.2% variability (Nagelkerke Pseudo-R^2 = 0.192) (Table 7.1). Table 7.5 shows 50 Hz noise frequency (adjusted *OR*: 0.88; 95% *C.I.*:0.78-0.99; Wald (χ^2): 4.430) and LPG and kerosene cooking fuel usage (adjusted *OR*: 0.08; 95% *C.I.*:0.01-0.96; Wald (χ^2): 3.975) were the significant predictors. This finding reveals that with unit increase in both predictors were responsible for 0.88 and 0.08 time respective decrease in SBP for officials. The Eq. (7.22)-(7.24) show the relationship between SBP and noise.

Table 7.5 Model parameter estimate of office workers' SBP model

Predictor		Model Parameters	Estimate	Wald (X^2)	Sig.	Odds ratio (*OR*)	95% *C.I.* *LB*	95% *C.I.* *UB*
Noise	Threshold	SBP_1 : < 100 mm Hg	-5.609	5.374	0.020	0.00	0.00	0.42
		SBP_2: 100-120 mm Hg	-2.862	1.452	0.228	0.06	0.00	6.01
		SBP_3: 122-140 mm Hg	-0.696	0.087	0.767	0.50	0.00	50.30
	Location	50 Hz	-0.127	4.430	0.035	0.88	0.78	0.99
		Age	0.713	2.528	0.112	2.04	0.85	4.92
		LPG fuel	-0.820	1.116	0.291	0.44	0.10	2.02
		LPG and electric cook stove	0.109	0.013	0.909	1.12	0.17	7.28
		LPG and kerosene stove	-2.537	3.975	0.046	0.08	0.01	0.96
		Other pollute fuel			0[a]			
		Hearing aid used : never	-1.068	1.158	0.282	0.34	0.05	2.41
		Hearing aid used : since few days	-0.833	0.239	0.625	0.43	0.02	12.30
		Hearing aid used : since some months	0.491	0.048	0.826	1.63	0.02	132.05
		Hearing aid used : since some years			0[a]			
		Masks used : never	1.833	3.800	0.051	6.25	0.99	39.47
		Masks used : sometimes	1.733	2.979	0.084	5.66	0.79	40.50
		Masks used : always			0[a]			
$PM_{2.5}$	Threshold	SBP_1 : < 100 mm Hg	-2.921	6.125	0.013	0.05	0.01	0.54
		SBP_2: 100-120 mm Hg	-0.372	0.109	0.741	0.69	0.08	6.26
		SBP_3: 122-140 mm Hg	1.711	2.283	0.131	5.54	0.60	50.98
	Location	Age	0.712	2.544	0.111	2.04	0.85	4.88
		$PM_{2.5}$	0.003	0.660	0.417	1.00	1.00	1.01
		Home annoyance	-0.446	3.696	0.055	0.64	0.41	1.01
		No traffic flow	-1.157	0.622	0.430	0.31	0.02	5.57
		Free traffic flow	-1.446	5.408	0.020	0.24	0.07	0.80
		Moderate traffic flow	-0.900	2.479	0.115	0.41	0.13	1.25
		Congested traffic flow			0[a]			
Combined	Threshold	SBP_1 : < 100 mm Hg	-5.203	1.224	0.269	0.01	0.00	55.34
		SBP_2: 100-120 mm Hg	-2.552	0.296	0.586	0.08	0.00	766.20
		SBP_3: 122-140 mm Hg	-0.368	0.006	0.937	0.69	0.00	6668.17
	Location	Age	0.455	1.083	0.298	1.58	0.67	3.72
		$PM_{2.5}$	0.004	1.012	0.315	1.00	1.00	1.01
		50 Hz	-0.149	5.064	0.024	0.86	0.76	0.98
		63 Hz	0.149	3.317	0.069	1.16	0.99	1.36
		80 Hz	-0.013	0.015	0.901	0.99	0.81	1.20
		100 Hz	-0.099	1.063	0.302	0.91	0.75	1.09
		Family income	0.337	3.712	0.054	1.40	0.99	1.97
		Roadside breathing trouble : No	-0.882	4.951	0.026	0.41	0.19	0.90
		Roadside breathing trouble : Yes			0[a]			

where, the link was logit and 0[a] is the parameter which is set to zero because it is redundant.

$$logit\ (SBP_1) = -5.609 + 0.127 \cdot (g) - 0.713 \cdot (Age) + 0.820 \cdot (p) - 0.109 \cdot (q) + 2.537 \cdot (r) + 1.068 \cdot (s) + 0.833 \cdot (t) - 0.491 \cdot (u) \quad (7.22)$$

$$logit\ (SBP_2) = -2.862 + 0.127 \cdot (g) - 0.713 \cdot (Age) + 0.820 \cdot (p) - 0.109 \cdot (q) + 2.537 \cdot (r) + 1.068 \cdot (s) + 0.833 \cdot (t) - 0.491 \cdot (u) \quad (7.23)$$

$$logit\ (SBP_3) = -8.377 + 0.127 \cdot (g) - 0.713 \cdot (Age) + 0.820 \cdot (p) - 0.109 \cdot (q) + 2.537 \cdot (r) + 1.068 \cdot (s) + 0.833 \cdot (t) - 0.491 \cdot (u) \quad (7.24)$$

where, 'g' is the noise level at 50 Hz frequency, 'p', 'q' and 'r' are LPG fuel, LPG and electric stove, and LPG and kerosene fuel, respectively, 's' , 't' and 'u' are usage of hearing aid never, since few days and since years, respectively.

The $PM_{2.5}$ and SBP model explained 13% variability (Nagelkerke Pseudo-R^2=0.130) (Table 7.1). In this model free traffic flow was the significant predictor (adjusted *OR*: 0.24; 95% *C.I.*:0.07-0.80; Wald (χ^2): 5.408) (Table 7.5). This finding revealed that with increase in free traffic flow near the residential vicinity, the SBP has been found to be decreased by 0.24 time (Table 7.5). The Eq. (7.25)-(7.27) show the relationship between $PM_{2.5}$ and SBP.

$$logit\ (SBP_1) = -2.921 - 0.712 \cdot (Age) - 0.003 \cdot (PM_{2.5}) + 0.446 \cdot (HA) + 1.157 \cdot (v) + 1.446 \cdot (w) + 0.9 \cdot (x) \quad (7.25)$$

$$logit\ (SBP_2) = -0.372 - 0.712 \cdot (Age) - 0.003 \cdot (PM_{2.5}) + 0.446 \cdot (HA) + 1.157 \cdot (v) + 1.446 \cdot (w) + 0.9 \cdot (x) \quad (7.26)$$

$$logit\ (SBP_3) = -1.711 - 0.712 \cdot (Age) - 0.003 \cdot (PM_{2.5}) + 0.446 \cdot (HA) + 1.157 \cdot (v) + 1.446 \cdot (w) + 0.9 \cdot (x) \quad (7.27)$$

where, '*HA*' is home annoyance, '*v*', '*w*' and '*x*' are no flow, free flow and moderate flow, respectively.

The model related to combined exposure of noise and $PM_{2.5}$ on SBP explained 18.3% variability (Nagelkerke Pseudo-R^2=0.183) (Table 7.1). Here, 50 Hz noise frequency (adjusted *OR*: 0.86; 95% *C.I.*:0.76-0.98; Wald (X^2): 5.064) and no roadside breathing trouble (adjusted *OR*: 0.41; 95% *C.I.*:0.19-0.90; Wald (X^2): 4.951) were found as the significant predictors of SBP (Table 7.5). This can be interpreted that with unit increase in noise at 50 Hz frequency and not feeling breathing issues near road associated with 0.86 and 0.41 respective decrease in SBP. The Eq.(7.28)-(7.30) show relationship between $PM_{2.5}$, noise spectral components and questionnaire outcome and the SBP.

$$logit\ (SBP_1) = -5.203 - 0.455 \cdot (Age) - 0.004 \cdot (PM_{2.5}) + 0.149 \cdot (h) - 0.149 \cdot (i) + 0.013 \cdot (j) + 0.099 \cdot (k) - 0.337 \cdot (y) + 0.882 \cdot (z) \quad (7.28)$$

$$logit\ (SBP_2) = -2.552 - 0.455 \cdot (Age) - 0.004 \cdot (PM_{2.5}) + 0.149 \cdot (h) - 0.149 \cdot (i) + 0.013 \cdot (j) + 0.099 \cdot (k) - 0.337 \cdot (y) + 0.882 \cdot (z) \quad (7.29)$$

$$logit\ (SBP_3) = -0.368 - 0.455 \cdot (Age) - 0.004 \cdot (PM_{2.5}) + 0.149 \cdot (h) - 0.149 \cdot (i) + 0.013 \cdot (j) + 0.099 \cdot (k) - 0.337 \cdot (y) + 0.882 \cdot (z) \quad (7.30)$$

where, '*h*', '*i*' , '*j*' and '*k*' are the noise level at 50 Hz, 63 Hz, 80Hz and 100 Hz frequencies respectively, '*y'* is family income and '*z*' is not feeling breathing issues near roadside, respectively.

7.1.2.2 Diastolic blood pressure (DBP) study

The noise and DBP, $PM_{2.5}$ and DBP and the combined impact model explained 17.4% (Nagelkerke Pseudo-R^2=0.174), 15.5% (Nagelkerke Pseudo R^2=0.155) and 17.7% variability (Nagelkerke Pseudo R^2=0.177), respectively (Table 7.1). In these models, only hearing aid usage since few days was the significant predictor (Table 7.6). For noise and DBP model hearing aid usage predictor was observed with adjusted *OR*: 0.13(95% *C.I.*:0.03-0.56; Wald (χ^2): 7.419), for $PM_{2.5}$ and DBP model the adjusted *OR*: 0.14(95% *C.I.*:0.03-0.56; Wald (χ^2): 6.557) and the combined impact scenario the adjusted *OR*: 0.14(95% *C.I.*:0.03-0.62;Wald (χ^2): 6.670) (Table 7.6). The above results show 0.13 and 0.14 times respective decrease of DBP with the unit increase in hearing aid usage.

Table 7.6 Model parameter estimate of DBP model of office workers'

Predictor		Model Parameters	Estimate	Wald (X^2)	Sig.	Odds Ratio (*OR*)	95% *C.I.* *LB*	*UB*
Noise	Threshold	DBP_1: < 80 mm Hg	-6.827	3.148	0.076	0.00	0.00	2.04
		DBP_2: 80-100 mm Hg	-3.677	0.932	0.334	0.03	0.00	44.17
	Location	AAS	-0.377	1.390	0.238	0.69	0.37	1.28
		250 Hz	-0.116	2.254	0.133	0.89	0.77	1.04
		Smoking: No	0.616	1.653	0.199	1.85	0.72	4.73
		Smoking: Yes			0^a			
		Hearing aid: Since few days	-2.058	7.419	0.006	0.13	0.03	0.56
		Hearing aid: Since long used			0^a			
		Mask used : Never	0.693	2.039	0.153	2.00	0.77	5.18
		Mask used: Using sometimes			0^a			
$PM_{2.5}$	Threshol	DBP_1: < 80 mm Hg	-0.900	0.640	0.424	0.41	0.04	3.69
		DBP_2: 80-100 mm Hg	2.216	3.924	0.048	9.17	1.02	82.23
	Location	AAS	-0.440	1.919	0.166	0.64	0.35	1.20
		$PM_{2.5}$	0.003	0.354	0.552	1.00	0.99	1.01
		Smoking: No	0.640	1.761	0.184	1.90	0.74	4.88
		Smoking: Yes			0^a			
		Hearing aid: Since few days	-1.960	6.557	0.010	0.14	0.03	0.63
		Hearing aid: Since long used			0^a			
		Mask used : Never	0.687	1.980	0.159	1.99	0.76	5.17
		Mask used: Using sometimes			0^a			
Combined noise and $PM_{2.5}$	Threshold	DBP_1: < 80 mm Hg	-6.456	2.690	0.101	0.00	0.00	3.52
		DBP_2: 80-100 mm Hg	-3.307	0.719	0.396	0.04	0.00	76.43
	Location	AAS	-0.394	1.492	0.222	0.67	0.36	1.27
		250 Hz	-0.115	2.180	0.140	0.89	0.77	1.04
		$PM_{2.5}$	0.002	0.285	0.593	1.00	0.99	1.01
		Smoking: No	0.648	1.782	0.182	1.91	0.74	4.96
		Smoking: Yes			0^a			
		Hearing aid: Since few days	-1.984	6.670	0.010	0.14	0.03	0.62
		Hearing aid: Since long used			0^a			
		Mask used : Never	0.735	2.219	0.136	2.09	0.79	5.49
		Mask used: Using sometimes			0^a			

where, the link is logit and 0^a is the parameter which is set to zero because it is redundant.

From Table 7.6, for noise and DBP relationship adjusted with questionnaire outcomes could be written by Eq. (7.31)-(7.32).

$$logit\ (DBP_1) = -5.203 + 0.377 \cdot (AAS) + 0.116 \cdot (l) - 0.616 \cdot (a_1) + 2.058 \cdot (b_1) - 0.693 \cdot (c_1) \tag{7.31}$$

$$logit\ (DBP_2) = -2.552 + 0.377 \cdot (AAS) + 0.116 \cdot (l) - 0.616 \cdot (a_1) + 2.058 \cdot (b_1) - 0.693 \cdot (c_1) \tag{7.32}$$

where, 'l' is the noise level at 250 Hz frequency, a_1 is no smoking habit, b_1 is since few days hearing aid usage and c_1 is the never mask used reaction in the questionnaire.

From Table 7.6, for PM $_{2.5}$ and DBP relationship adjusted with questionnaire outcomes could be written by Eq. (7.33)-(7.34).

$$logit\ (DBP_1) = -0.900 + 0.440 \cdot (AAS) - 0.003 \cdot (PM_{2.5}) - 0.643 \cdot (d_1) + 1.960 \cdot (e_1) - 0.687 \cdot (f_1) \tag{7.33}$$

$$logit\ (DBP_2) = 2.216 + 0.440 \cdot (AAS) - 0.003 \cdot (PM_{2.5}) - 0.643 \cdot (d_1) + 1.960 \cdot (e_1) - 0.687 \cdot (f_1) \tag{7.34}$$

where, d_1 is no smoking habit, e_1 is since few days hearing aid usage and f_1 is never mask used reaction of the respondents.

From Table 7.6, for combined impact of noise and PM $_{2.5}$ on DBP adjusted with questionnaire outcomes could be expressed by Eq. (7.35)-(7.36).

$$logit\ (DBP_1) = -6.456 + 0.394 \cdot (AAS) + 0.116 \cdot (m) - 0.002(PM_{2.5}) - 0.648 \cdot (g_1) + 1.984 \cdot (h_1)\ - 0.735 \cdot (i_1) \tag{7.35}$$

$$logit\ (DBP_2) = -3.307 + 0.394 \cdot (AAS) + 0.116 \cdot (m) - 0.002(PM_{2.5}) - 0.648 \cdot (g_1) + 1.984 \cdot (h_1)\ - 0.735 \cdot (i_1) \tag{7.36}$$

where, 'm' is the noise level at 250 Hz frequency, 'g_1' is no smoking habit, 'h_1' is since few days hearing aid usage and 'i_1' is never mask used reaction in the questionnaire.

7.1.2.3 Hearth rate (HR) study

The noise and HR model explained 23.5% variability (Nagelkerke Pseudo-R^2= 0.235) (Table 7.1). In this model 63 Hz (adjusted *OR*: 1.16; 95% *C.I.*:1.00-1.34; Wald (χ^2): 4.062), 100 Hz (adjusted *OR*: 0.81; 95% *C.I.*:0.67-0.99; Wald (χ^2): 4.403) and 125 Hz (adjusted *OR*: 1.23; 95% *C.I.*:1.02-1.50; Wald (χ^2): 4.474) frequencies were the significant predictors of HR (Table 7.7).

Table 7.7 Model parameter estimate of HR model of office workers'

Predictor		Model Parameters	Estimate	Wald (X^2)	Sig.	Odds Ratio (*OR*)	95% *C.I.*	
							LB	*UB*
Noise	Threshold	HR_1: < 72 beats/min	5.383	1.371	0.242	217.70	0.03	1.7×10^6
		HR_2 : 72-80 beats/min	6.563	2.025	0.155	708.51	0.08	5.9×10^6
	Location	100 Hz	-0.208	4.403	0.036	0.81	0.67	0.99
		125 Hz	0.209	4.474	0.034	1.23	1.02	1.50
		63 Hz	0.150	4.062	0.044	1.16	1.00	1.34
$PM_{2.5}$	Threshold	HR_1: < 72 beats/min	0.314	0.095	0.758	1.37	0.19	10.09
		HR_2 : 72-80 beats/min	1.534	2.226	0.136	4.64	0.62	34.79
	Location	Age	0.490	7.098	0.008	1.63	1.14	2.34
		Family income	0.004	0.946	0.331	1.00	1.00	1.01
		$PM_{2.5}$	-0.011	0.001	0.980	0.99	0.42	2.32
		Road to building vicinity < 2 m	1.398	10.312	0.001	4.05	1.72	9.49
		Road to building vicinity > 2 m			0^a			
Combined noise and $PM_{2.5}$	Threshold	HR_1: < 72 beats/min	4.579	0.924	0.336	97.44	0.01	1.1×10^6
		HR_2 : 72-80 beats/min	5.929	1.539	0.215	375.96	0.03	4.4×10^6
	Location	63 Hz	0.217	6.889	0.009	1.24	1.06	1.46
		100 Hz	-0.273	6.411	0.011	0.76	0.62	0.94
		125 Hz	0.151	2.180	0.140	1.16	0.95	1.42
		Family income	0.637	9.477	0.002	1.89	1.26	2.84
		$PM_{2.5}$	0.009	3.949	0.047	1.01	1.00	1.02
		Road to building vicinity < 2 m	1.367	9.233	0.002	3.92	1.62	9.47
		Road to building vicinity > 2 m			0^a			

where, the link is logit and 0^a is the parameter which is set to zero because it is redundant.

This can be interpreted from the findings that with unit increase in these above frequencies led to 1.16, 0.81 and 1.23 times respective increase, decrease and increase in HR. From, Table 7.7 the relationship expression of HR and noise can be written as,

$$logit\ (HR_1) = 5.383 + 0.208 \cdot (n) - 0.209 \cdot (o) - 0.150(p) \quad (7.37)$$

$$logit\ (HR_2) = 6.563 + 0.208 \cdot (n) - 0.209 \cdot (o) - 0.150(p) \quad (7.38)$$

where, 'n', 'o' and 'p' represents the noise at frequencies of 100 Hz, 125 Hz and 63 Hz, respectively.

The Eq.(7.37)-(7.38) show the relationship between noise and HR of office workers.

The $PM_{2.5}$ and HR model explained 16% variability (Nagelkerke Pseudo-R^2=0.160) (Table 7.1). Table 7.7 shows that age (adjusted *OR*: 1.63; 95% *C.I.*:1.14-2.34; Wald (χ^2): 7.098) and < 2 m residential building vicinity from the nearest road (adjusted *OR*: 4.05; 95% *C.I.*:1.72-9.49; Wald (χ^2): 10.312) were the significant predictors of HR. With unit increase in age and < 2 m building vicinity lead to 1.63 and 4.05 times increase in HR, holding rest of the constant predictors. From, Table 7.7 the relationship expression of HR and $PM_{2.5}$ can be written as,

$$logit\ (HR_1) = 0.314 - 0.490 \cdot (Age) - 0.004 \cdot (j_1) + 0.011(PM_{2.5}) - 1.398 \cdot (k_1) \quad (7.39)$$

$$logit\ (HR_2) = 1.534 - 0.490 \cdot (Age) - 0.004 \cdot (j_1) + 0.011(PM_{2.5}) - 1.398 \cdot (k_1) \quad (7.40)$$

where, 'j_1' is family income and 'k_1' is residential building vicinity from the nearest road was < 2 m.

The Eq. (7.39)-(7.40) show the relationship between HR and $PM_{2.5}$.

The model related to combined exposure of noise and $PM_{2.5}$ on HR explained 26.9% variability (Nagelkerke Pseudo-R^2=0.269) (Table 7.1). In this model, 63 Hz (adjusted *OR*: 1.24; 95% *C.I.*:1.06-1.46; Wald (χ^2): 6.889), 100 Hz (adjusted *OR*: 0.76; 95% *C.I.*:0.62-0.94; Wald (χ^2): 6.411), family income (adjusted *OR*: 1.89; 95% *C.I.*:1.26-2.84; Wald (χ^2): 9.477), $PM_{2.5}$(adjusted *OR*: 1.01; 95% *C.I.*:1.00-1.02; Wald (χ^2): 3.949) and < 2 m residential building vicinity (adjusted *OR*: 3.92; 95% *C.I.*:1.62-9.47; Wald (χ^2): 9.233) were found as the significant predictors of HR (Table 7.7). These results indicated that considering other predictors as constant, with unit increase in the above predictors lead to 1.24, 0.76, 1.89, 1.01 and 3.92 times respective increase, decrease and increase in HR. From, Table 7.7 the relationship expression (Eq. (7.41) – (7.42)) of HR, noise and $PM_{2.5}$ adjusted with the questionnaire outcome can be written as,

$$logit\ (HR_1) = 4.579 - 0.217 \cdot (q) + 0.273 \cdot (r) + 0.151 \cdot (s) - 0.637 \cdot (n_1) - 0.009 \cdot\ (PM_{2.5}) -1.367 \cdot (p_1) \quad (7.41)$$

$$logit\ (HR_2) = 5.929 - 0.217 \cdot (q) + 0.273 \cdot (r) + 0.151 \cdot (s) - 0.637 \cdot (n_1) - 0.009 \cdot (PM_{2.5}) -1.367 \cdot (p_1) \quad (7.42)$$

where, ‘q’, ‘r’ and ‘s’ indicate the noise level at 63 Hz, 100 Hz and 125 Hz frequencies respectively, ‘n_1’ is family income and ‘p_1’ is residential building vicinity from the nearest road was < 2 m.

The Eq.(7.41)-(7.42) show the relationship between HR, noise and $PM_{2.5}$.

7.2 DOSE-RESPONSE RELATIONSHIP

From above discussion in 7.1.2.3 it has observed that only office workers' HR was significantly influenced by $PM_{2.5}$ and noise spectrum (63 Hz and 100 Hz). Therefore, dose-response function was developed for co-exposure of $PM_{2.5}$ and noise spectrum (Figure 7.1).

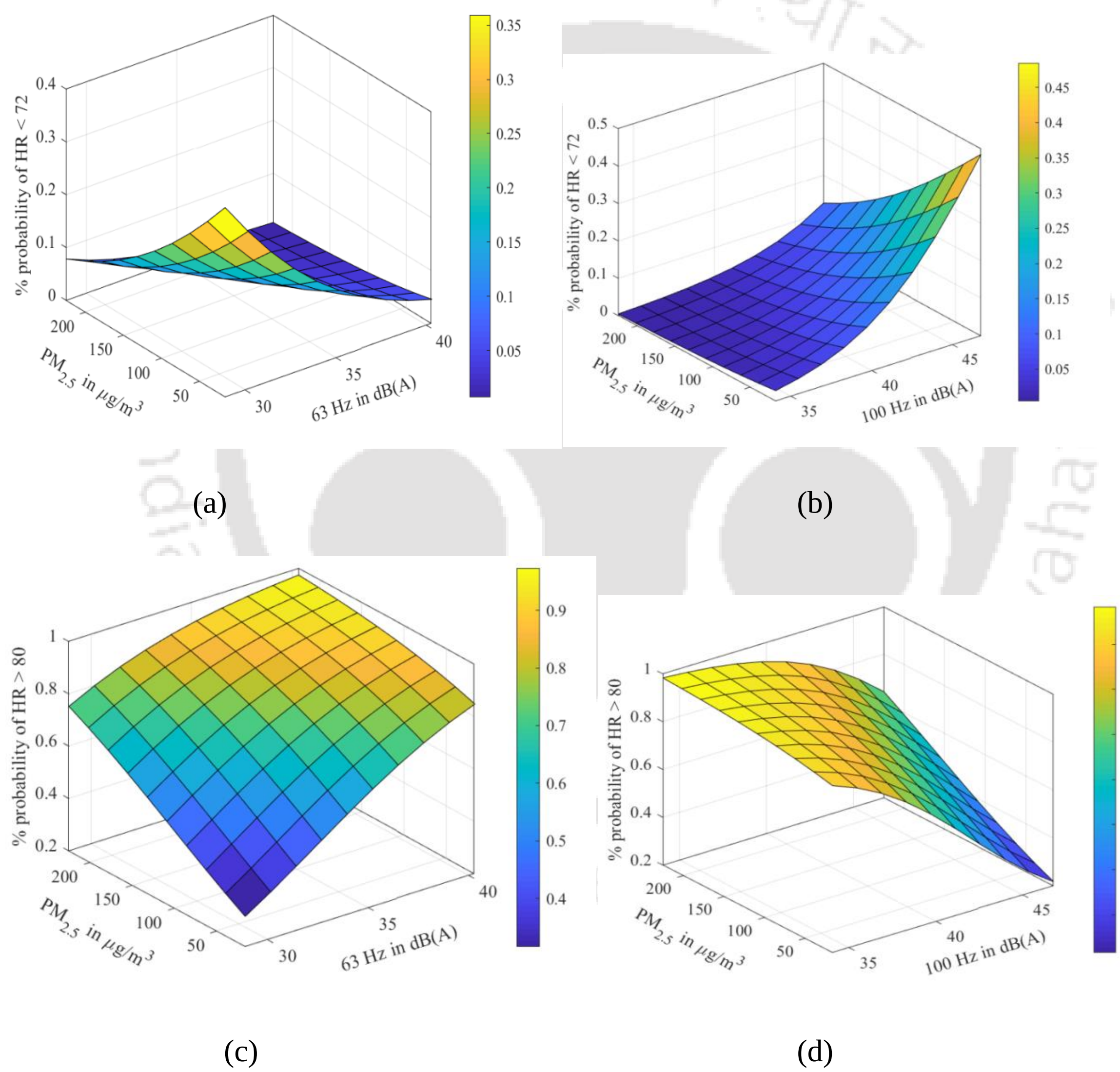


Figure 7.1 Dose response relationship of office workers' HR study

Figure 7.1 (a)-(b) showed the % probability of HR < 72 beats/min, indicate with increasing 63 Hz and 100 Hz noise spectrum of 30 dB (A) and 35 dB (A) led to respective decrease and increase in % probability of HR < 72 beats/min of officials. Similarly, for $PM_{2.5}$ > 50 μg/m^3 led to decease in % probability of HR < 72 beats/min.

Figure 7.1 (c)-(d) shows the probability of HR > 80 beats / min. These indicate with exceeding 63 Hz and 100 Hz frequencies > 30 dB (A) and 35 dB (A) % probability of HR > 80 were respectively increased and decreased. Similarly, for $PM_{2.5}$ both were shown increasing trend > 50 μg/ m^3.

7.3 DISCUSSION

The data collected through social questionnaire, health monitoring and the measurements of $PM_{2.5}$ and noise levels in the office indoor and outdoor microenvironments in an urban traffic corridor have been analysed using statistical tests for interrelationships and impacts on the BP and HR of street vendors and office workers while they move through the different microenvironments. The main goal was to determine the relationships of various parameters with the SBP, DBP and HR due to exposure to traffic noise and $PM_{2.5}$. The traffic corridor selected in the study is similar to a typical urban centre in developing countries. The traffic fleet contains a higher share of two-wheelers with mixed traffic of cars, buses, multi-utility vehicles and three-wheelers. Most cities in developing countries have a higher share of two-wheelers (Vijay et al., 2015).

The ordinal regression results highlighted that SBP, DBP and HR of street vendors are influenced by the 630 Hz, 31.5 Hz and 25 Hz frequency spectrum. Liu et al. (2016) observed the significant influence of 250 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz noise frequencies on industrial workers' BP. $PM_{2.5}$ influenced the DBP of street vendors. Apart from the workplace pollution, street vendors' BP and HR were influenced by their roadside annoyance perception, residential building age, traffic flow near residences and environmental tobacco smoke at home. The SBP of office workers was influenced by the 50 Hz noise frequency, types of cooking fuel, their breathing problems during roadside travel and the traffic flow near residences. Their DBP was reduced due to the use of a hearing aid; this shows the hearing aid could protect them from extensive noise hazards. The HR of office workers was influenced by the 63 Hz-125 Hz frequencies, where, 63 Hz and 125 Hz could elevate the HR, and 100 Hz could decrease the HR. In the combined impact analysis, $PM_{2.5}$ was revealed as the significant predictor of HR, along with the family income and residential proximity to the adjacent road. The dose-response function shows that office workers' combined exposure of $PM_{2.5}$ > 50 µg/m^3 and 63 Hz and 100 Hz noise frequencies > 30 and 35 dB (A) were the crucial cut-offs of HR< 72 beats/min and > 80 beats/ min. The fluctuations of HR with $PM_{2.5}$ indicates that with increasing $PM_{2.5}$ level (> 50 µg/m^3) and exposure to it people may experience faster heart rate which may also be detrimental for cardiovascular health. Xie et al. (2018) observed similar elevation of HR with increase in $PM_{2.5}$ pollution.

This study has focused on traffic noise and $PM_{2.5}$ pollution with impacts on workers' cardiovascular indices (blood pressure and heart rate) near the urban roadway of developing Indian city. The findings of this research could be helpful for designing the traffic noise and $PM_{2.5}$ abatement strategies of developing and to be developed cities by identifying the cut-off level of pollution from cardiac health prevention perspective of urban workers. However, this study was limited to two groups of urban workers. More researches considering different types of public buildings and longer measurements of $PM_{2.5}$ and noise simultaneously are needed. Further the combine impacts on different physiological and psychological health issues of different age and gender groups of people may strengthen the literature in this field of research.

CHAPTER 8

FINDINGS AND CONCLUSION

8.1 KEY FINDINGS

The findings of this research could be useful for framing future policy making and practical implementation of stringent regulations for improving environmental air and noise quality in developing Indian city of Guwahati. The salient findings of this research are as follows:

- ✓ The median noise descriptors exceeded the WHO standard (53 dB (A)) by 8% - 30% and dominance of low to mid frequency noise spectrum (25-5000 Hz) was observed in both microenvironments which exceeded the > 40 dB (A) and higher frequencies (> 5000 Hz) lies within 40 dB (A).
- ✓ The observed noise climates at street-side and inside the office was found to be > 3 dB(A) and > 4 dB(A),respectively.
- ✓ The $PM_{2.5}$ concentrations were exceeded 78% of CPCB 24-h standard and 611% of WHO 24-h standard.
- ✓ In winter, noise level was comparatively higher 78.28±3.91 dB(A), followed by post-monsoon (73.32±6.52 dB(A)), pre-monsoon (73.26±2.81 dB(A)) and monsoon (73.17±3.09 dB(A)).
- ✓ In winter $PM_{2.5}$ was relatively higher 131 ± 39 µg/m^3, followed by pre-monsoon (91.67± 21.6 µg/m^3), post-monsoon (64.97± 29.68 µg/m^3) and monsoon (38.49±7.98 µg/m^3).
- ✓ Street-side ambient noise and $PM_{2.5}$ show a slight significant correlation (ρ=0.299-0.344).
- ✓ Meteorological variables (temperature, atmospheric pressure and solar radiation) show a slight correlation with street-side ambient $PM_{2.5}$ (ρ=0.345; p=0.019), (ρ=0.395; p=0.007) and (ρ=0.441; p=0.002), respectively.

- ✓ Similarly the atmospheric pressure (ρ=0.377; p=0.010) and solar radiation (ρ=0.356; p=0.015) were slightly correlated with street side noise level.
- ✓ The noise-PM2.5 indices have been developed for both roadside and office indoor microenvironments, which have found to be around zero.
- ✓ Street vendors (50%) were highly annoyed at workplace than office workers' (4.90%) due to their high exposure of $PM_{2.5}$ (median $PM_{2.5}$ of 106.67 µg/m^3 at street-side and and of 33.33 µg/m^3 inside the office)and noise (median L_{eq} of 71.35 dB (A) at street-side and of 65.78 dB (A) inside the office).
- ✓ The workplace annoyance was correlated with questionnaire variables (ρ: 0.364-1.000) and $PM_{2.5}$ (ρ:-0.326-0.235). The results showed that > 40 dB (A) of 50 Hz, > 35 dB (A) of 100 Hz, > 50 dB (A) of 315 Hz noise spectrum and > 50µg/m^3 of $PM_{2.5}$ led to significant increase high annoyance perception of the respondents (the probability of high annoyance perception > 30%, >5%,and >10%, respectively).While, noise level > 55 dB (A) 630 Hz led to decrease annoyance of > 5% of office workers' and > 100 µg/m^3 of $PM_{2.5}$ leads to decrease annoyance of < 3% of street vendors.
- ✓ The systolic (≈129 mm Hg) and diastolic blood pressure (≈81 mm Hg) and heart rate (≈82 beats/min) were little bit higher than normal (SBP: 120 mm Hg; DBP: 80 mm Hg; and HR: 72-80 beats/min) in male workers than female workers (SBP≈ 119 mm Hg; DBP ≈ 76 mm Hg; and HR≈ 75 beats/min). The influence of low noise spectrum (50-630 Hz) was mostly observed.

- ✓ The combined effect of $PM_{2.5}$ > 50 μg/m^3 and noise spectrum (63 and 100 Hz) > 30 dB (A) significantly impact the office workers' health in traffic corridors.

8.2 GENERAL CONCLUSION

This research was conducted in the microenvironments roadside and office indoor of Guwahati, North-eastern Indian city to determine the impacts of $PM_{2.5}$ and noise to assess the psychological and physiological health burden (in the form of blood pressure and heart rate) of urban workers. Observed noise and $PM_{2.5}$ level was severely violated the WHO and CPCB standards and exposed workers was expressed their varying degree of psychological disturbance in the form of annoyance and physiological damage in the form of abnormal blood pressure and heart rate due to these pollutants and other demographic, socio-contextual factors. The key conclusions of this research are as follows:

- ✓ The dominance of low-mid frequency noise has been noticed. However, the observed high noise and $PM_{2.5}$ level in that study area is sincerely alarming from human health perspective.
- ✓ The winter times the noise level and $PM_{2.5}$ concentration are relatively higher than other seasons, which conclude some possible influence of stable atmospheric conditions and the intense tourist activities during that period. However, overall poor meteorological influence on noise and $PM_{2.5}$ pollution, elucidate that the distance between the pollution source and the location of the sampling point was less than 100 m, which hinder to assess the meteorological influence on noise and $PM_{2.5}$.
- ✓ The traffic noise modelling was carried out to identify the noisiest traffic in the study area which could be helpful for traffic noise mitigation purpose.
- ✓ It was observed by SoundPLAN traffic noise modelling that car movement significantly

contributes noise at low frequencies while, bus and truck contributes the higher frequencies noise in the study area.

- ✓ As observed street-side ambient noise and $PM_{2.5}$ pollution is relatively higher than office indoor, therefore street vendors were highly annoyed than office workers. Although, influence of demographic, socio-contextual and habitual factors on degree of annoyance and cardiovascular health (blood pressure and heart rate) have been observed. Policy makers could focus on the low noise spectrum, $PM_{2.5}$, demographic, socio-contextual factors for framing policy guidelines to reduce global health burden.

8.3 LIMITATIONS AND FUTURE SCOPE

Survey in different types of public buildings may improve the outcome of this research. Further, the combine impacts on different physiological and psychological health issues of different age and gender groups of people may strengthen the literature in this field of research. More number of respondents could improve the results. The detailed $PM_{2.5}$ concentration modelling could also be done and integrated with the noise propagation modelling. The different mitigation strategies e.g. limiting the noisiest source in the study environment, and development of different air-noise barrier may further contribute to the relevant literature. The resulting reduction due to air-noise barriers could be studied in relationship with the health of the workers.

REFERENCES

Agarwal, S. and Swami, B. L. (2009) 'Road traffic noise annoyance in Jaipur city', *International Journal of Engineering Studies*, 1(1), pp. 39–46.

Akyüz, M. and Çabuk, H. (2009) 'Meteorological variations of PM2. 5/PM10 concentrations and particle-associated polycyclic aromatic hydrocarbons in the atmospheric environment of Zonguldak, Turkey', *Journal of hazardous materials*. Elsevier, 170(1), pp. 13–21.

Alam, P. et al. (2021) '2D and 3D mapping of traffic induced noise near major roads passing through densely populated residential area of South Delhi, India', *PLoS ONE*, 16(3 March). doi: 10.1371/journal.pone.0248939.

Alam, P. and Ahmad, K. (2020) 'Validation of the Road Traffic Noise Prediction Model RLS-90 in an Urban Area', (February), pp. 7–8.

Aldrin, M. and Haff, I. H. (2005) 'Generalised additive modelling of air pollution, traffic volume and meteorology', *Atmospheric Environment*. Elsevier, 39(11), pp. 2145–2155.

Allen Hugh W.; Cohen, Martin A.; Mallach, Gary; Kaufman, Joel D.; Adar, Sara D., R. W. . D. (2009) 'The spatial relationship between traffic-generated air pollution and noise in 2 US cities', *Environmental research*, 109(3), pp. 334–342. doi: 10.1016/j.envres.2008.12.006.

Apparicio, P. et al. (2016) 'Cyclists ' exposure to air pollution and road traf fi c noise in central city neighbourhoods of Montreal', *JTRG*. The Authors, 57, pp. 63–69. doi: 10.1016/j.jtrangeo.2016.09.014.

Apte, J. S. et al. (2015) 'Addressing global mortality from ambient PM2. 5', *Environmental science & technology*. ACS Publications, 49(13), pp. 8057–8066.

Babisch Kathrin; Petz, Markus; Heinrich, Joachim; Cyrys, Josef; Peters, Annette, W. W. (2014) 'Associations between Traffic Noise, Particulate Air Pollution, Hypertension, and Isolated Systolic Hypertension in Adults: The KORA Study', *Environmental health perspectives*, 122(5), pp. 492–498. doi: 10.1289/ehp.1306981.

Babisch, W. (2008) 'Road traffic noise and cardiovascular risk YR', *Noise and Health*, 10(38 UL-https://www.noiseandhealth.org/article.asp?issn=1463-

1741;year=2008;volume=10;issue=38;spage=27;epage=33;aulast=Babisch;t=5), pp. 27–33. doi: 10.4103/1463-1741.39005.

Babisch, W. et al. (2013) 'Noise annoyance—A modifier of the association between noise level and cardiovascular health?', *Science of the total environment*. Elsevier, 452, pp. 50–57.

Babisch, W., Ising, H. and Gallacher, J. E. J. (2003) 'Health status as a potential effect modifier of the relation between noise annoyance and incidence of ischaemic heart disease', *Occupational and Environmental Medicine*, 60(10), pp. 739 LP – 745. doi: 10.1136/oem.60.10.739.

Balasubramanian, V. and Jagannath, M. (2014) 'Detecting motorcycle rider local physical fatigue and discomfort using surface electromyography and seat interface pressure', *Transportation Research Part F: Traffic Psychology and Behaviour*, 22, pp. 150–158. doi: 10.1016/j.trf.2013.12.010.

Banerjee, D., Das, P. P. and Fouzdar, A. (2014) 'Urban Residential Road Traf fi c Noise and Hypertension : a Cross-Sectional Study of Adult Population', 91(6), pp. 1144–1157. doi: 10.1007/s11524-014-9916-1.

Bao, W.-W. et al. (2022) 'Exposure to road traffic noise and behavioral problems in Chinese schoolchildren: A cross-sectional study', *Science of the total environment*. Elsevier, 837, p. 155806.

Barman, N. and Gokhale, S. (2019) 'Urban black carbon - source apportionment, emissions and long-range transport over the Brahmaputra River Valley', *Science of the Total Environment*. Elsevier B.V., 693, p. 133577. doi: 10.1016/j.scitotenv.2019.07.383.

Barrigón Morillas, J. M., Montes González, D. and Rey Gozalo, G. (2016) 'A review of the measurement procedure of the ISO 1996 standard. Relationship with the European Noise Directive', *Science of the Total Environment*. The Authors, 565, pp. 595–606. doi: 10.1016/j.scitotenv.2016.04.207.

Basu, B. et al. (2021) 'Investigating changes in noise pollution due to the COVID-19 lockdown: The case of Dublin, Ireland', *Sustainable Cities and Society*. Elsevier Ltd, 65(November 2020), p. 102597. doi: 10.1016/j.scs.2020.102597.

Beelen, R. et al. (2008) 'Long-term effects of traffic-related air pollution on mortality in a Dutch cohort (NLCS-AIR study).', *Environmental health perspectives*, 116(2), pp. 196–202. doi: 10.1289/ehp.10767.

Beelen, R. et al. (2009) ‘The joint association of air pollution and noise from road traffic with cardiovascular mortality in a cohort study’, *Occupational and Environmental Medicine*, 66(4), pp. 243 LP – 250. doi: 10.1136/oem.2008.042358.

Begou, P. and Kassomenos, P. (2021) ‘Exposure to the road traffic noise in an urban complex in Greece : the quantification of healthy life years lost due to noise-induced annoyance and noise-induced sleep disturbances’. Environmental Science and Pollution Research, pp. 12932–12943.

Beutel, M. E. et al. (2016) ‘Noise annoyance is associated with depression and anxiety in the general population-the contribution of aircraft noise’, *Plos one*. Public Library of Science San Francisco, CA USA, 11(5), p. e0155357.

Bhandari, K., K, N. and Batra, M. (2015) ‘Air pollution, noise, meteorology and traffic: monitoring and correlation at a site selected in Delhi’, *Int. J. Environ. Nat. Sci.*, 4, pp. 1–7. Available at:https://www.scopus.com/inward/record.uri?eid=2-s2.0-85045042357&partnerID=40&md5=24391eb8c98d59a9b6265a927d7f22cc.

Bistafa, S. R. (2006) ‘Acústica Aplicada ao Controle de Ruído, 1º Ed., 368 p’, *Ed. Edgard Blucher, São Paulo*.

Bond, T. C. and Bergstrom, R. W. (2006) ‘Light Absorption by Carbonaceous Particles: An Investigative Review’, *Aerosol Science and Technology*. Taylor & Francis, 40(1), pp. 27–67. doi: 10.1080/02786820500421521.

Boogaard, H. et al. (2009) ‘Exposure to ultrafine and fine particles and noise during cycling and driving in 11 Dutch cities’, *Atmospheric Environment*. Elsevier Ltd, 43(27), pp. 4234–4242. doi: 10.1016/j.atmosenv.2009.05.035.

Bouzid, I., Derbel, A. and Elleuch, B. (2020) ‘Factors responsible for road traffic noise annoyance in the city of Sfax, Tunisia’, *Applied Acoustics*. Elsevier Ltd, 168, p. 107412. doi: 10.1016/j.apacoust.2020.107412.

Brink, M. et al. (2019) ‘A survey on exposure-response relationships for road, rail, and aircraft noise annoyance: Differences between continuous and intermittent noise’, *Environment International*. Elsevier, 125(August 2018), pp. 277–290. doi: 10.1016/j.envint.2019.01.043.

Caciari, T. et al. (2013) ‘Noise-induced hearing loss in workers exposed to urban stressors’, *Science of the Total Environment*. Elsevier B.V., 463–464, pp. 302–308. doi:

10.1016/j.scitotenv.2013.06.009.

Calixto, A., Diniz, F. B. and Zannin, P. H. T. (2003) 'The statistical modeling of road traffic noise in an urban setting', 20(1), pp. 23–29. doi: 10.1016/S0264-2751(02)00093-8.

Camusso, C. and Pronello, C. (2016) 'A study of relationships between traffic noise and annoyance for different urban site typologies', *Transportation Research Part D: Transport and Environment*. Elsevier Ltd, 44, pp. 122–133. doi: 10.1016/j.trd.2016.02.007.

Can, A. et al. (2010) 'Traffic noise spectrum analysis: Dynamic modeling vs. experimental observations', *Applied Acoustics*. Elsevier Ltd, 71(8), pp. 764–770. doi: 10.1016/j.apacoust.2010.04.002.

Chang, T. et al. (2019) 'Application of land-use regression models to estimate sound pressure levels and frequency components of road tra ffi c noise in Taichung , Taiwan', *Environment International*. Elsevier, 131(March), p. 104959. doi: 10.1016/j.envint.2019.104959.

Charron, A. and Harrison, R. M. (2005) 'Fine (PM2.5) and Coarse (PM2.5-10) Particulate Matter on A Heavily Trafficked London Highway: Sources and Processes', *Environmental Science & Technology*. American Chemical Society, 39(20), pp. 7768–7776. doi: 10.1021/es050462i.

Chauhan, R., Shrestha, A. and Khanal, D. (2021) 'Noise pollution and effectiveness of policy interventions for its control in Kathmandu, Nepal', *Environmental Science and Pollution Research*. Environmental Science and Pollution Research, 28(27), pp. 35678–35689. doi: 10.1007/s11356-021-13236-7.

Chauhan, B.S. et al.(2023) Evaluation and Analysis of Environmental Noise Levels in NCT of Delhi, India. *MAPAN*, pp.1-21.

Chen, L. C. and Lippmann, M. (2009) 'Effects of metals within ambient air particulate matter (PM) on human health', *Inhalation toxicology*. Taylor & Francis, 21(1), pp. 1–31.

Chithra, V. S. and Nagendra, S. M. S. (2012) 'Indoor air quality investigations in a naturally ventilated school building located close to an urban roadway in Chennai , India', *Building and Environment*. Elsevier Ltd, 54, pp. 159–167. doi: 10.1016/j.buildenv.2012.01.016.

Choi, W. et al. (2012) 'Prevalence of wide area impacts downwind of freeways under pre-sunrise stable atmospheric conditions', *Atmospheric Environment*. Elsevier, 62, pp. 318–327.

Chowdhury, A. K., Debsarkar, A. and Chakrabarty, S. (2015) 'Critical assessment of day time traffic noise level at curbside open-air microenvironment of Kolkata City, India', *Journal of Environmental Health Science and Engineering*. Journal of Environmental Health Science and Engineering, 13(1), pp. 1–6. doi: 10.1186/s40201-015-0219-6.

Chung, W. K. et al. (2020) 'Comparing the effects of visibility of different neighborhood greenery settings on the preference ratings and noise annoyance responses to road traffic noises', *Applied Acoustics*. Elsevier Ltd, 169, p. 107474. doi: 10.1016/j.apacoust.2020.107474.

Cohn, L. F. and Harris, R. A. (2001) 'Comparing traffic-noise model accuracy using state-specific emission data', *Journal of urban planning and development*. American Society of Civil Engineers, 127(2), pp. 79–93.

Cole-Hunter, T. et al. (2022) 'Long-term exposure to road traffic noise and all-cause and cause-specific mortality: a Danish Nurse Cohort study', *Science of the Total Environment*. Elsevier, 820, p. 153057.

Colvile, R. N. et al. (2001) 'The transport sector as a source of air pollution', *Atmospheric environment*. Elsevier, 35(9), pp. 1537–1565.

CPCB (2000) 'The noise pollution (regulation and control) rules, 2000'. *Central Pollution Control Board, Ministry of Environment and Forests.*

Das, C. P. et al. (2021) 'Prediction of traffic noise induced annoyance: A two-staged SEM-Artificial Neural Network approach', *Transportation Research Part D: Transport and Environment*. Elsevier, 100, p. 103055.

Datta, A. et al. (2017) 'Indoor air quality of non-residential urban buildings in Delhi , India', *International Journal of Sustainable Built Environment*. The Gulf Organisation for Research and Development, 6(2), pp. 412–420. doi: 10.1016/j.ijsbe.2017.07.005.

Deka, R. L., Mahanta, C. and Sarmah, K. (2012) 'Recent variability of solar radiation in the upper Brahmaputra valley of Assam', *Journal of Agrometeorology*, 14(January), pp. 145–150.

Desvina, A. P. et al. (2019) 'Statistical Modelling of Extreme Data of Air Pollution in Pekanbaru City'. doi: 10.15408/inprime.v1i1.12839.

Dey, S. et al. (2012) ‘Variability of outdoor fine particulate (PM2.5) concentration in the Indian Subcontinent: A remote sensing approach’, *Remote sensing of environment*. Elsevier, 127, pp. 153–161.

Dons, E. et al. (2011) ‘Using an activity-based framework to determine effects of a policy measure on population exposure to nitrogen dioxide’, *Transportation research record*. SAGE Publications Sage CA: Los Angeles, CA, 2233(1), pp. 72–79.

Dratva, J. et al. (2010) ‘Impact of road traffic noise annoyance on health-related quality of life: Results from a population-based study’, *Quality of life research*. Springer, 19, pp. 37–46.

Ducret-stich, R. E. et al. (2013) ‘Science of the Total Environment Role of highway traf fi c on spatial and temporal distributions of air pollutants in a Swiss Alpine valley’, *Science of the Total Environment, The*. Elsevier B.V., 456–457, pp. 50–60. doi: 10.1016/j.scitotenv.2013.03.065.

Dzhambov, A. et al. (2017) ‘Residential road traffic noise and general mental health in youth: The role of noise annoyance, neighborhood restorative quality, physical activity, and social cohesion as potential mediators’, *Environment international*. Elsevier, 109, pp. 1–9.

Dzhambov, A. M. and Dimitrova, D. D. (2016) ‘Exposures to road traffic, noise, and air pollution as risk factors for type 2 diabetes: A feasibility study in Bulgaria’, *Noise & health*. Wolters Kluwer--Medknow Publications, 18(82), pp. 133.

Ebben, M. R., Yan, P. and Krieger, A. C. (2021) ‘The effects of white noise on sleep and duration in individuals living in a high noise environment in New York City’, *Sleep Medicine*. Elsevier, 83, pp. 256–259.

Fallah-shorshani, M. et al. (2022) ‘Estimating traffic noise over a large urban area : An evaluation of methods’, *Environment International*. Elsevier Ltd, 170(July), pp. 107583. doi: 10.1016/j.envint.2022.107583.

Fallah-Shorshani, M. et al. (2022) ‘Estimating traffic noise over a large urban area: An evaluation of methods’, *Environment International*. Elsevier Ltd, 170(October), pp. 107583. doi: 10.1016/j.envint.2022.107583.

Fecht, D. et al. (2016a) ‘Spatial and temporal associations of road traf fi c noise and air pollution in London : Implications for epidemiological studies’, *Environment*

International. The Authors, 88, pp. 235–242. doi: 10.1016/j.envint.2015.12.001.

Fecht, D. et al. (2016b) ‘Spatial and temporal associations of road traffic noise and air pollution in London: Implications for epidemiological studies’, *Environment international*. Elsevier, 88, pp. 235–242.

FHWA (1998) ‘FHWA TRAFFIC NOISE MODEL (FHWA TNM)’.Federal Highway Administration.

FHWA (2018) ‘Noise Measurement Handbook’, pp. 205. Federal Highway Administration.

Foraster, M. et al. (2014) ‘High blood pressure and long-term exposure to indoor noise and air pollution from road traffic’, *Environmental Health Perspectives*, 122(11), pp. 1193–1200. doi: 10.1289/ehp.1307156.

Forehead, H. and Huynh, N. (2018) ‘Review of modelling air pollution from traffic at street-level - The state of the science’, *Environmental Pollution*. Elsevier Ltd, 241, pp. 775–786. doi: 10.1016/j.envpol.2018.06.019.

Frei, P., Mohler, E. and Röösli, M. (2014) ‘Effect of nocturnal road traffic noise exposure and annoyance on objective and subjective sleep quality’, *International Journal of Hygiene and Environmental Health*, 217(2), pp. 188–195. doi: https://doi.org/10.1016/j.ijheh.2013.04.003.

Fuks, K. B. et al. (2017) ‘Long-term exposure to ambient air pollution and traffic noise and incident hypertension in seven cohorts of the European study of cohorts for air pollution effects (ESCAPE)’, *European heart journal*. Oxford University Press, 38(13), pp. 983–990.

Gan, W. Q. et al. (2012) ‘Modeling population exposure to community noise and air pollution in a large metropolitan area’, *Environmental research*. Elsevier, 116, pp. 11–16.

Garg, N. and Maji, S. (2014) ‘A critical review of principal traf fi c noise models : Strategies and implications’, *Environmental Impact Assessment Review*. Elsevier Inc., 46, pp. 68–81. doi: 10.1016/j.eiar.2014.02.001.

Gilani, T. A. and Mir, M. S. (2022) ‘A study on road traffic noise exposure and prevalence of insomnia’, *Environmental Science and Pollution Research*, 29(27), pp. 41065–41080. doi: 10.1007/s11356-021-18291-8.

Gokhale, S. (2018) ‘Environmental Noise Pollution’, *Handbook of Environmental Engineering*. Wiley Online Library, pp. 565–582.

Gozalo, G. R. et al. (2022) 'Analysis and Management of Current Road Traffic Noise', *Current Pollution Reports*. Springer International Publishing, pp. 315–327. doi: 10.1007/s40726-022-00234-7.

Gozalo, G. R. and Montes, D. (2021) 'Relationship between temperature and road traffic noise under actual conditions of continuous vehicle flow', 100(September). doi: 10.1016/j.trd.2021.103056.

Guarnaccia, C., Bandeira, J. and Coelho, M. C. (2019) 'Statistical and semi-dynamical road traffic noise models comparison with field measurements Statistical and Semi-Dynamical Road Traffic Noise Models Comparison with Field Measurements', 020039(July 2018).

Guedes, I. C. and Bertoli, S. R. (2005) 'Urban form: An indication of its influence on sound environment in Jardins-Aracaju (SE)', in *Proceedings VIII national and IV Latin–American meeting about comfort in the built environment, ANTAC, Maceió, Brazil*.

Guttikunda, S. K. and Mohan, D. (2014) 'Re-fueling road transport for better air quality in India', *Energy Policy*. Elsevier, 68, pp. 556–561.

Hall, J. W., Haggard, M. P. and Fernandes, M. A. (1984) 'Detection in noise by spectro-temporal pattern analysis', *The Journal of the Acoustical Society of America*. Acoustical Society of America, 76(1), pp. 50–56.

Han, X. et al. (2005) 'Traffic-related Occupational Exposures to PM2.5, CO, and VOCs in Trujillo, Peru', *International Journal of Occupational and Environmental Health*. Taylor & Francis, 11(3), pp. 276–288. doi: 10.1179/107735205800246073.

Hanibuchi, T. et al. (2021) 'Associations of insomnia with noise annoyance and neighborhood environments: A nationwide cross-sectional study in Japan', *Preventive Medicine Reports*. Elsevier, 23, p. 101416.

Hankard, M., Cerjan, J. and Leasure, J.(2006) *Evaluation of the FHWA Traffic Noise Model, TNM, for Highway Traffic Noise Prediction in the State of Colorado* (No. CDOT-2005-21). Colorado Department of Transportation, Research Branch.

Hao, G. et al. (2022) 'Associations of PM2.5 and road traffic noise with mental health: Evidence from UK Biobank', *Environmental Research*. Elsevier Inc., 207(October 2021), p. 112221. doi: 10.1016/j.envres.2021.112221.

Harrison, R. M. et al. (1997) 'Sources and processes affecting concentrations of PM10 and

PM2.5 particulate matter in Birmingham (U.K.)', *Atmospheric Environment*, 31(24), pp. 4103–4117. doi: https://doi.org/10.1016/S1352-2310(97)00296-3.

Harrison, R. M. et al. (2021) 'More mileage in reducing urban air pollution from road traffic', *Environment International*. Elsevier Ltd, 149(August 2020), p. 106329. doi: 10.1016/j.envint.2020.106329.

Héritier, H. et al. (2018) 'Diurnal variability of transportation noise exposure and cardiovascular mortality: a nationwide cohort study from Switzerland', *International journal of hygiene and environmental health*. Elsevier, 221(3), pp. 556–563.

Hitchins, J. et al. (2000) 'Concentrations of submicrometre particles from vehicle emissions near a major road', *Atmospheric environment*. Elsevier, 34(1), pp. 51–59.

Hoffmann, B. et al. (2007) 'Residential exposure to traffic is associated with coronary atherosclerosis', *Circulation*. Am Heart Assoc, 116(5), pp. 489–496.

Hopkins, C. and Lam, Y. (2009) 'Sound fields near building facades–comparison of finite and semi-infinite reflectors on a rigid ground plane', *Applied Acoustics*. Elsevier, 70(2), pp. 300–308.

Hosker, R. P. (1984) 'Flow and diffusion near obstacles', *Atmospheric science and power production*. Technical Information Centre, US Department of Energy.

Hu, S. et al. (2009) 'A wide area of air pollutant impact downwind of a freeway during pre-sunrise hours', *Atmospheric Environment*. Elsevier, 43(16), pp. 2541–2549.

Hu, X. et al. (2021) The potential impacts of electric vehicles on urban air quality in Shanghai City. *Sustainability*, *13*(2), pp.496.

Huang, F. et al. (2013) 'The impacts of short-term exposure to noise and traffic-related air pollution on heart rate variability in young healthy adults', *Journal of exposure science & environmental epidemiology*, 23(5), pp. 559–564. doi: 10.1038/jes.2013.21.

Huang, B. et al. (2017) 'Acoustic amenity analysis for high-rise building along urban expressway : Modeling traffic noise vertical propagation using neural networks', *Transportation Research Part D*. Elsevier Ltd, 53, pp. 63–77. doi: 10.1016/j.trd.2017.04.001.

Huang, Y. et al. (2021) 'A review of strategies for mitigating roadside air pollution in urban street canyons', *Environmental Pollution*. Elsevier, 280, p. 116971. doi: 10.1016/J.ENVPOL.2021.116971.

Huss, A. et al. (2010) ‘Aircraft noise, air pollution, and mortality from myocardial infarction’, *Epidemiology*. JSTOR, pp. 829–836.

Ibili, F. et al. (2022) ‘Statistical modelling for urban roads traffic noise levels’, *Scientific African*. Elsevier B.V., 15, p. e01131. doi: 10.1016/j.sciaf.2022.e01131.

Ishiyama, T. and Hashimoto, T. (2000) ‘Impact of sound quality on annoyance caused by road traffic noise: an influence of frequency spectra on annoyance’, *JSAE review*, 21(2), pp. 225–230. doi: 10.1016/S0389-4304(99)00090-9.

Islam, S. and Kalita, K. (2017) ‘Assessment of Traffic Noise in Guwahati city , India’, pp. 3335–3339.

ISO, I. S. O. (2003) ‘TS 15666 acoustics—assessment of noise annoyance by means of social and socio-acoustic surveys’, *Geneva: International Organization for Standardization*.

Jacquemin, B. et al. (2007) ‘Annoyance due to air pollution in Europe’, *International Journal of Epidemiology*, 36(4), pp. 809–820. doi: 10.1093/ije/dym042.

Jagniatinskis, A. and Fiks, B. (2014) ‘Assessment of environmental noise from long-term window microphone measurements’, *Applied Acoustics*. Elsevier, 76, pp. 377–385.

Jain, S. and Barthwal, V. (no date) ‘Health impact assessment of auto rickshaw and cab drivers due to exposure to vehicular pollution in Delhi: an integrated approach’. doi: 10.1007/s11356-021-16058-9/Published.

Jamir, L., Nongkynrih, B. and Gupta, S. K. (2014) ‘Community noise pollution in urban India: Need for public health action’, *Indian journal of community medicine: official publication of Indian Association of Preventive & Social Medicine*. Wolters Kluwer--Medknow Publications, 39(1), p. 8.

Jiménez-Uribe, D. A. et al. (2020) ‘Influence of vehicular traffic on environmental noise spectrum in the tourist route of Santa Marta City’, *Energy Reports*. Elsevier, 6, pp. 818–824. doi: 10.1016/J.EGYR.2019.11.008.

Jodeh, S. et al. (2018) ‘Indoor and outdoor air quality analysis for the city of Nablus in Palestine: seasonal trends of PM10, PM5.0, PM2.5, and PM1.0 of residential homes’, *Air Quality, Atmosphere & Health*, 11(2), pp. 229–237. doi: 10.1007/s11869-017-0533-5.

Kalaiarasan, G., Balakrishnan, R. M. and Sethunath, N. A. (2018) ‘Source apportionment studies on particulate matter (PM 10 and PM 2 . 5) in ambient air of urban Mangalore , India', *Journal of Environmental Management*. Elsevier Ltd, 217, pp. 815–824. doi: 10.1016/j.jenvman.2018.04.040.

Kalaiselvi, R. and Ramachandraiah, A. (2010) 'Environmental noise mapping study for heterogeneous traffic conditions', in *Proceedings of 20th international congress on acoustics, ICA*, pp. 23–27.

Kalaiselvi, R. and Ramachandraiah, A. (2016) 'Honking noise corrections for traffic noise prediction models in heterogeneous traffic conditions like India', *Applied Acoustics*. Elsevier Ltd, 111, pp. 25–38. doi: 10.1016/j.apacoust.2016.04.003.

Kalawapudi, K. et al. (2020) 'Noise pollution in Mumbai Metropolitan Region (MMR): An emerging environmental threat', *Environmental Monitoring and Assessment*, 192(2), pp. 1–20. doi: 10.1007/s10661-020-8121-9.

Kälsch, F. et al. (2013) 'Are air pollution and traffic noise independently associated with atherosclerosis: the Heinz Nixdorf Recall Study', *European heart journal*, 35(13), pp. 853–860. doi: 10.1093/eurheartj/eht426.

Kamineni, A. et al. (2019) 'Modelling of noise pollution due to heterogeneous highway traffic in India', *Transport and Telecommunication Journal*, 20(1), pp. 22–39.

Karanasiou, A. et al. (2014) 'Assessment of personal exposure to particulate air pollution during commuting in European cities—Recommendations and policy implications', *Science of the Total Environment*. Elsevier, 490, pp. 785–797.

Karimi, A. et al. (2010) 'Noise induced hearing loss risk assessment in truck drivers', *Noise and Health*, 12(46), pp. 49–55. doi: 10.4103/1463-1741.59999.

Karner, A. A., Eisinger, D. S. and Niemeier, D. A. (2010) 'Near-Roadway Air Quality: Synthesizing the Findings from Real-World Data', *Environmental Science & Technology*. American Chemical Society, 44(14), pp. 5334–5344. doi: 10.1021/es100008x.

Khan, J. et al. (2018) 'Science of the Total Environment Road traf fi c air and noise pollution exposure assessment – A review of tools and techniques', *Science of the Total Environment*. Elsevier B.V., 634, pp. 661–676. doi: 10.1016/j.scitotenv.2018.03.374.

Kheirbek, I. et al. (2016) 'The contribution of motor vehicle emissions to ambient fine particulate matter public health impacts in New York City : a health burden assessment', *Environmental Health*. Environmental Health. doi: 10.1186/s12940-016-0172-6.

Khomenko, S. et al. (2022) ‘Impact of road traffic noise on annoyance and preventable mortality in European cities: A health impact assessment’, *Environment international*. Elsevier, 162, p. 107160.

Kim, K. H. et al. (2015) ‘Influence of wind direction and speed on the transport of particle-bound PAHs in a roadway environment’, *Atmospheric Pollution Research*, 6(6), pp. 1024–1034. doi: https://doi.org/10.1016/j.apr.2015.05.007.

Kim, M. et al. (2012) ‘Road Traffic Noise’, 43(4), pp. 353–360. doi: 10.1016/j.amepre.2012.06.014.

King, E. A. et al. (2016) ‘A combined assessment of air and noise pollution on the High Line , New York City’, *Transportation Research Part D*. Elsevier Ltd, 42, pp. 91–103. doi: 10.1016/j.trd.2015.11.003.

King, E. A. (2022) ‘Here, There, and Everywhere: How the SDGs Must Include Noise Pollution in Their Development Challenges’, *Environment: Science and Policy for Sustainable Development*. Taylor & Francis, 64(3), pp. 17–32.

King, E. A., Murphy, E. and Mcnabola, A. (2009) ‘Reducing pedestrian exposure to environmental pollutants : A combined noise exposure and air quality analysis approach’, *Transportation Research Part D*. Elsevier Ltd, 14(5), pp. 309–316. doi: 10.1016/j.trd.2009.03.005.

Klæboe, R. et al. (2000) ‘Oslo traffic study–part 1: an integrated approach to assess the combined effects of noise and air pollution on annoyance’, *Atmospheric environment*. Elsevier, 34(27), pp. 4727–4736.

Klæboe, R. et al. (2005) ‘The impact of an adverse neighbourhood soundscape on road traffic noise annoyance’, *Acta Acustica united with Acustica*. S. Hirzel Verlag, 91(6), pp. 1039–1050.

Klæboe, R., Amundsen, A. H. and Fyhri, A. (2008) ‘Annoyance from vehicular air pollution : A comparison of European exposure – response relationships’, *Atmospheric Environment*. Elsevier Ltd, 42(33), pp. 7689–7694. doi: 10.1016/j.atmosenv.2008.04.049.

Klingberg, J. et al. (2017) ‘Science of the Total Environment In fl uence of urban vegetation on air pollution and noise exposure – A case study in Gothenburg , Sweden’, *Science of the Total Environment*. Elsevier B.V., 599–600, pp. 1728–1739. doi:

10.1016/j.scitotenv.2017.05.051.

Koczorowski, M. et al. (123AD) 'Environmental noise exposure is associated with atherothrombotic risk'. doi: 10.1038/s41598-022-06825-0.

Kozawa, K. H., Winer, A. M. and Fruin, S. A. (2012) 'Ultrafine particle size distributions near freeways: Effects of differing wind directions on exposure', *Atmospheric Environment*. Elsevier, 63, pp. 250–260.

Kumar, A. et al. (2018) 'Study of Air and Noise Pollution in Mega Cities of India BT - Environmental Pollution', in Singh, V. P., Yadav, S., and Yadava, R. N. (eds). Singapore: Springer Singapore, pp. 77–84.

Kumar, D. et al. (2020) 'Comparative analysis of building insulation material properties and performance', *Renewable and Sustainable Energy Reviews*. Elsevier Ltd, 131(June), p. 110038. doi: 10.1016/j.rser.2020.110038.

Kumar, P. et al. (2021) 'Science of the Total Environment In-car particulate matter exposure across ten global cities', *Science of the Total Environment*. The Authors, 750, p. 141395. doi: 10.1016/j.scitotenv.2020.141395.

Kundu Chowdhury, A., Debsarkar, A. and Chakrabarty, S. (2015) 'Critical assessment of day time traffic noise level at curbside open-air microenvironment of Kolkata City, India.', *Journal of environmental health science & engineering*, 13, p. 65. doi: 10.1186/s40201-015-0219-6.

Kundu Chowdhury, A., Debsarkar, A. and Chakrabarty, S. (2016) 'Assessment of combined Noise-Air quality and combined exposure to Noise-Air pollution at the curbside open-air microenvironment of Kolkata city, India', *Pollution*. Department of Civil Engineering (Environmental Engineering Division), Jadavpur University, Kolkata – 700032, West-Bengal, India, 2(1), pp. 35–47. doi: 10.7508/pj.2016.01.004.

Lan, Y. et al. (2020) 'Transportation noise exposure and anxiety: A systematic review and meta-analysis', *Environmental research*. Elsevier, 191, p. 110118.

Laxmi, V. et al. (2019) 'An innovative approach of urban noise monitoring using cycle in Nagpur, India', *Environmental Science and Pollution Research*. Environmental Science and Pollution Research, 26(36), pp. 36812–36819. doi: 10.1007/s11356-019-06817-0.

Lee, E. Y. et al. (2014) 'Assessment of traf fi c-related noise in three cities in the United States $', *Environmental Research*. Elsevier, 132, pp. 182–189. doi:

10.1016/j.envres.2014.03.005.

Lefèvre, M. et al. (2020) ‘Understanding the relationship between air traffic noise exposure and annoyance in populations living near airports in France’, *Environment International*. Elsevier, 144(August), p. 106058. doi: 10.1016/j.envint.2020.106058.

Li, B., Qiu, Z. and Zheng, J. (2021) ‘Impacts of noise barriers on near-viaduct air quality in a city: A case study in Xi’an’, *Building and Environment*. Elsevier Ltd, 196(February), p. 107751. doi: 10.1016/j.buildenv.2021.107751.

Li, J. et al. (2021) ‘Exposure and perception of PM2.5 pollution on the mental stress of pregnant women’, *Environment International*. Elsevier Ltd, 156, pp. 106686. doi: 10.1016/j.envint.2021.106686.

Liang, B. et al. (2019) ‘Pollution characteristics of metal pollutants in $PM_{2.5}$ and comparison of risk on human health in heating and non-heating seasons in Baoding, China’, *Ecotoxicology andEnvironmentalSafety*,170,pp.166–171.doi:https://doi.org/10.1016/j.ecoenv.2018.11.075.

Lim, J. T.et al. (2021) ‘Long-Term Exposure to Air Pollution, Road Traffic Noise, and Heart Failure Incidence: The Danish Nurse Cohort.’, *Journal of the American Heart Association*. Wiley-Blackwell, 10(20), pp. e021436. doi: 10.1161/jaha.121.021436.

Lim, S. S. et al. (2012) ‘A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010’, *The lancet*. Elsevier, 380(9859), pp. 2224–2260.

Limaye, V. S. and Schöpp, W. (2019) ‘Applying Integrated Exposure-Response Functions to PM 2 . 5 Pollution in India’. doi: 10.3390/ijerph16010060.

Lipfert, F. W. et al. (2006) ‘Traffic density as a surrogate measure of environmental exposures in studies of air pollution health effects : Long-term mortality in a cohort of US veterans’, 40, pp. 154–169. doi: 10.1016/j.atmosenv.2005.09.027.

Lipowicz, A. and Lopuszanska, M. (2005) ‘Marital differences in blood pressure and the risk of hypertension among Polish men’, *European journal of epidemiology*. Springer, 20, pp. 421–427.

Liu, C.-S. et al. (2016) ‘Original Contribution Occupational Noise Frequencies and the Incidence of Hypertension in a Retrospective Cohort Study’. doi: 10.1093/aje/kwv333.

Liu, C. et al. (2014) 'The associations between traffic-related air pollution and noise with blood pressure in children: Results from the GINIplus and LISAplus studies', *International Journal of Hygiene and Environmental Health*, 217(4–5), pp. 499–505. doi: 10.1016/j.ijheh.2013.09.008.

Mandal, P., Prakash, M. and Bassin, J. K. (2012) 'Impact of Diwali celebrations on urban air and noise quality in Delhi City, India', *Environmental monitoring and assessment*. Springer, 184, pp. 209–215.

Mann, S. and Singh, G. (2022) 'Traffic noise monitoring and modelling — an overview', *Environmental Science and Pollution Research*. Springer Berlin Heidelberg, 29(37), pp. 55568–55579. doi: 10.1007/s11356-022-21395-4.

Martenies, S. E. and Batterman, S. A. (2018) 'Effectiveness of Using Enhanced Filters in Schools and Homes to Reduce Indoor Exposures to PM 2.5 from Outdoor Sources and Subsequent Health Benefits for Children with Asthma', *Environmental Science and Technology*, 52(18), pp. 10767–10776. doi: 10.1021/acs.est.8b02053.

Martins, N. R. and Carrilho, G. (2018) 'Impact of PM2 . 5 in indoor urban environments : A review', 42(July), pp. 259–275. doi: 10.1016/j.scs.2018.07.011.

Mateus, M., Dias Carrilho, J. and Gameiro Da Silva, M. (2015) 'An experimental analysis of the correction factors adopted on environmental noise measurements performed with window-mounted microphones', *Applied Acoustics*, 87, pp. 212–218. doi: 10.1016/j.apacoust.2014.06.019.

McNabola, A., Broderick, B. M. and Gill, L. W. (2006) 'Experimental and numerical investigation of idling car exposure'.

Memoli, G. et al. (2008) 'Testing the acoustical corrections for reflections on a façade', *Applied Acoustics*, 69(6), pp. 479–495. doi: 10.1016/j.apacoust.2007.05.006.

Meng, M. et al. (2021) 'Spatial distribution characteristics of PM 2 . 5 concentration around residential buildings in urban traffic-intensive areas : From the perspectives of health and safety', *Safety Science*. Elsevier Ltd, 141(May), p. 105318. doi: 10.1016/j.ssci.2021.105318.

Miedema, H. M. E. (2007) 'Annoyance caused by environmental noise: Elements for evidence-based noise policies', *Journal of Social Issues*, 63(1), pp. 41–57. doi: 10.1111/j.1540-4560.2007.00495.x.

Miedema, H. M. and Oudshoorn, C. G. (2001) 'Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals.', *Environmental health perspectives*, 109(4), pp. 409–416.

Mimani, A. and Singh, R. (2021) 'Anthropogenic noise variation in Indian cities due to the COVID-19 lockdown during March-to-May 2020 a)'. Acoustical Society of America, 3216(May 2020). doi: 10.1121/10.0006966.

Miranville, A. (2019) 'Annual Report 2018', *AIMS Mathematics*, 4(1), pp. 166–169. doi: 10.3934/Math.2019.1.166.

Mishra, A. et al. (2021) 'Effect of COVID-19 lockdown on noise pollution levels in an Indian city: a case study of Kanpur.', *Environmental science and pollution research international*, 28(33), pp. 46007–46019. doi: 10.1007/s11356-021-13872-z.

Mohammed, M. O. A. et al. (2016) 'Chemosphere Distribution patterns , in fi ltration and health risk assessment of PM2 . 5- bound PAHs in indoor and outdoor air in cold zone', 155, pp. 70–85.

Molnár, P., Janhäll, S. and Hallquist, M. (2002) 'Roadside measurements of fine and ultrafine particles at a major road north of Gothenburg', *Atmospheric Environment*. Elsevier, 36(25), pp. 4115–4123.

Moshammer, H. et al. (2019) 'Acute effects of air pollution and noise from road traffic in a panel of young healthy adults', *International Journal of Environmental Research and Public Health*, 16(5). doi: 10.3390/ijerph16050788.

Mueller, N. et al. (2017) 'Urban and transport planning related exposures and mortality: a health impact assessment for cities', *Environmental health perspectives*. National Institute of Environmental Health Sciences, 125(1), pp. 89–96.

Mueller, W. et al. (2020) 'Urban greenspace and the indoor environment: Pathways to health via indoor particulate matter, noise, and road noise annoyance', *Environmental research*. Elsevier, 180, p. 108850.

Munir, S. et al. (2021) 'Temporal and seasonal variations of noise pollution in urban zones : a case study in Pakistan'. Environmental Science and Pollution Research, pp. 29581–29589.

Münzel Mette; Daiber, Andreas, T. S. (2021) 'Transportation noise pollution and cardiovascular disease.', *Nature reviews. Cardiology*. Nature Publishing Group, 18(9), pp. 619–636. doi: 10.1038/s41569-021-00532-5.

Münzel, T., Sørensen, M. and Daiber, A. (2021) 'Transportation noise pollution and cardiovascular disease', *Nature Reviews Cardiology*, 18(9), pp. 619–636. doi: 10.1038/s41569-021-00532-5.

Murphy, E., King, E. A. and Rice, H. J. (2009) 'Estimating human exposure to transport noise in central Dublin, Ireland', *Environment International*. Elsevier Ltd, 35(2), pp. 298–302. doi: 10.1016/j.envint.2008.07.026.

Ndrepepa, A. and Twardella, D. (2011) 'Relationship between noise annoyance from road traffic noise and cardiovascular diseases: a meta-analysis', *Noise and health*. Medknow Publications, 13(52), p. 251.

Nedic, V. et al. (2014) 'Comparison of classical statistical methods and arti fi cial neural network in traf fi c noise prediction', 49, pp. 24–30. doi: 10.1016/j.eiar.2014.06.004.

Nieuwenhuijsen, M. J. (2015) *Exposure assessment in environmental epidemiology*. Oxford University Press, USA.

Nieuwenhuijsen, M. J. (2016) 'Urban and transport planning, environmental exposures and health-new concepts, methods and tools to improve health in cities', *Environmental health*. Springer, 15, pp. 161–171.

Nieuwenhuijsen, M. J. (2021) 'New urban models for more sustainable , liveable and healthier cities post covid19 ; reducing air pollution , noise and heat island effects and increasing green space and physical activity', *Environment International*. Elsevier Ltd, 157, p. 106850. doi: 10.1016/j.envint.2021.106850.

de Noronha Castro Pinto, F. A. and Moreno Mardones, M. D. (2009) 'Noise mapping of densely populated neighborhoods—example of Copacabana, Rio de Janeiro—Brazil', *Environmental monitoring and assessment*. Springer, 155, pp. 309–318.

Nungate, R. and Alam, W. (2022) 'Traffic Noise Pollution Assessment in Major Road Junctions of Imphal City, Manipur (India)', *Nature Environment and Pollution Technology*, 21(2), pp. 457–468. doi: 10.46488/NEPT.2022.V21I02.004.

Ögren, M. and Molnar, P. (2014) 'Correlation between Noise and Nox in Gothenburg 1975-2010', in *ISEE Conference Abstracts*.

Okada, Y., Yoshihisa, K. and Kuno, K. (2010) 'Simple calculation model for noise propagation in city street canyons based on a diffusion method', *Acoustical science and technology*.

Acoustical Society of Japan, 31(1), pp. 95–101.

Okokon, E. O. et al. (2018) 'Traffic noise, noise annoyance and psychotropic medication use', *Environment international*. Elsevier, 119, pp. 287–294.

Onat, B., Sahin, U. A. and Akyuz, T. (2013) 'A tm spheric P ollution', *Atmospheric Pollution Research*. Elsevier, 4(1), pp. 101–105. doi: 10.5094/APR.2013.010.

Paiva, K. M., Cardoso, M. R. A. and Zannin, P. H. T. (2019) 'Exposure to road traffic noise: Annoyance, perception and associated factors among Brazil's adult population', *Science of The Total Environment*, 650, pp. 978–986. doi: https://doi.org/10.1016/j.scitotenv.2018.09.041.

Pandian, S., Gokhale, S. and Ghoshal, A. K. (2009) 'Evaluating effects of traffic and vehicle characteristics on vehicular emissions near traffic intersections', *Transportation Research Part D: Transport and Environment*. Elsevier Ltd, 14(3), pp. 180–196. doi: 10.1016/j.trd.2008.12.001.

Pant, P., Guttikunda, Sarath K. and Peltier, R. E. (2016) 'Exposure to particulate matter in India: A synthesis of findings and future directions', *Environmental Research*, 147, pp. 480–496. doi: 10.1016/j.envres.2016.03.011.

Pant, P. and Harrison, R. M. (2013) 'Estimation of the contribution of road traffic emissions to particulate matter concentrations from field measurements: A review', *Atmospheric Environment*. doi: 10.1016/j.atmosenv.2013.04.028.

Park, E. H. et al. (2018) 'Characteristics of PM2.5 and its chemical constituents in Beijing, Seoul, and Nagasaki', *Air Quality, Atmosphere & Health*, 11(10), pp. 1167–1178. doi: 10.1007/s11869-018-0616-y.

Park, S. H., Lee, P. J. and Jeong, J. H. (2018) 'Effects of noise sensitivity on psychophysiological responses to building noise', *Building and Environment*. Elsevier, 136, pp. 302–311.

Pasquier, A. et al. (2017) 'ScienceDirect ScienceDirect ScienceDirect Considering criteria related to spatial variabilities for the assessment Considering criteria related to spatial variabilities for the assessment of air pollution from traffic of air pollution from traffic', *Transportation Research Procedia*. Elsevier B.V., 25, pp. 3354–3369. doi: 10.1016/j.trpro.2017.05.210.

Patel, R., Kumar, P. and Shivam, S. (2022) 'Recent advancements in the challenges and strategies of globally used traffic noise prediction models', *Environmental Science and Pollution Research*. Springer Berlin Heidelberg, pp. 48168–48184. doi: 10.1007/s11356-022-20693-1.

Pateraki, S. et al. (2019) 'Levels, Sources and Health Risk of PM2.5 and PM1-Bound PAHs across the Greater Athens Area: The Role of the Type of Environment and the Meteorology', *Atmosphere*. doi: 10.3390/atmos10100622.

Patton, A. P. et al. (2014) 'Spatial and temporal differences in traffic-related air pollution in three urban neighborhoods near an interstate highway.', *Atmospheric environment (Oxford, England : 1994)*, 99, pp. 309–321. doi: 10.1016/j.atmosenv.2014.09.072.

Petri, D. et al. (2021a) 'Effects of exposure to road, railway, airport and recreational noise on blood pressure and hypertension', *International journal of environmental research and public health*. MDPI, 18(17), p. 9145.

Petri, D. et al. (2021b) 'Effects of Exposure to Road, Railway, Airport and Recreational Noise on Blood Pressure and Hypertension', *Public Health*, 18. doi: 10.3390/ijerph18179145.

PHFI, A. (2014) 'Save the Children', *State of India's Newborns 2014*.

Picaut, J. et al. (2005) 'Experimental study of sound propagation in a street', *Applied Acoustics*. Elsevier, 66(2), pp. 149–173.

Pinsonnault-Skvarenina, A. et al. (2021) 'Predictors of noise annoyance from construction of a large metropolitan highway project', *Transportation Research Part D: Transport and Environment*, 94(March). doi: 10.1016/j.trd.2021.102787.

Pitchika, A. et al. (2017a) 'Long-term associations of modeled and self-reported measures of exposure to air pollution and noise at residence on prevalent hypertension and blood pressure', *Science of the Total Environment*. Elsevier B.V., 593–594(2), pp. 337–346. doi: 10.1016/j.scitotenv.2017.03.156.

Pitchika, A. et al. (2017b) 'Long-term associations of modeled and self-reported measures of exposure to air pollution and noise at residence on prevalent hypertension and blood pressure', *Science of The Total Environment*. Elsevier, 593–594, pp. 337–346. doi: 10.1016/J.SCITOTENV.2017.03.156.

Powazka, E. et al. (2002) 'A cross-sectional study of occupational noise exposure and blood pressure in steelworkers', *Noise and Health*, 5(17), pp. 15–22. Available at: https://www.noiseandhealth.org/article.asp?issn=1463-1741.

Prasad, C. et al. (2022) ‘Association between traffic noise-induced psychophysiological , and socio-demographic factors of motorcycle riders’, *Applied Acoustics*. Elsevier Ltd, 196, p. 108898. doi: 10.1016/j.apacoust.2022.108898.

Prasad Das, C. et al. (2022) ‘Association between traffic noise-induced psychophysiological, and socio-demographic factors of motorcycle riders’, *Applied Acoustics*. Elsevier, 196, p. 108898. doi: 10.1016/J.APACOUST.2022.108898.

Quirt, J. D. (1985) ‘Sound fields near exterior building surfaces’, *The Journal of the Acoustical Society of America*. Acoustical Society of America, 77(2), pp. 557–566.

Rakowska Kachun; Townsend, T.M.; Chan, Ka Lok; Westerdahl, Dane; Ng, Simon; Močnik, Griša; Drinovec, Luka; Ning, Zhi, A. W. (2014) ‘Impact of traffic volume and composition on the air quality and pedestrian exposure in urban street canyon’, *Atmospheric Environment*, 98(NA), pp. 260–270. doi: 10.1016/j.atmosenv.2014.08.073.

Ranjan, R., Kumar, S. and Singh, R.(2023) ‘Monitoring of traffic noise pollution in urban Patna, Bihar, India. *Noise & Vibration Worldwide*, pp 09-57.

Ranpise, R. B. and Tandel, B. N. (2022) ‘Assessment and Appraisal of Morning Peak Time Urban Road Traffic Noise at Selected Locations of Major Arterial Roads of Surat City, India’, *Asian Journal of Water, Environment and Pollution*. doi: 10.3233/ajw220012.

Reckelhoff, J. F. (2001) ‘Gender differences in the regulation of blood pressure’, *Hypertension*. Am Heart Assoc, 37(5), pp. 1199–1208.

De Roos, A. J. et al. (2014) ‘Proximity to traffic, ambient air pollution, and community noise in relation to incident rheumatoid arthritis’, *Environmental Health Perspectives*. NLM-Export, 122(10), pp. 1075–1080.

Ross, Z. et al. (2011) ‘Noise, air pollutants and traffic: Continuous measurement and correlation at a high-traffic location in New York City’, *Environmental Research*. Academic Press, 111(8), pp. 1054–1063. doi: 10.1016/J.ENVRES.2011.09.004.

Roswall, N. et al. (2017) ‘Long-term residential road traffic noise and NO2 exposure in relation to risk of incident myocardial infarction–A Danish cohort study’, *Environmental research*. Elsevier, 156, pp. 80–86.

Rotko, T. et al. (2002) ‘Determinants of perceived air pollution annoyance and association between annoyance scores and air pollution (PM2.5, NO2) concentrations in the European EXPOLIS study’, *Atmospheric Environment*, 36(29), pp. 4593–4602. doi:

10.1016/S1352-2310(02)00465-X.

Rotko, T. (2004) '*Social Aspects of Air Pollution : Sociodemographic Differences in Exposure , Perceived Annoyance and Concern about Air Pollution*', Laboratory of Air Hygiene, Department of Environmental Health National Public Health Institute, Kuopio, Finland and Department of Sociology University of Helsinki, Helsinki, Finland.

Rudolph, K. E. et al. (2019) 'Environmental noise and sleep and mental health outcomes in a nationally representative sample of urban US adolescents', *Environmental Epidemiology*. Wolters Kluwer Health, 3(4).

Ruuskanen, J. et al. (2001) 'Concentrations of ultrafine, fine and PM2. 5 particles in three European cities', *Atmospheric Environment*. Elsevier, 35(21), pp. 3729–3738.

Ryou, H. gon, Heo, J. and Kim, S.-Y. (2018) 'Source apportionment of PM10 and PM2.5 air pollution, and possible impacts of study characteristics in South Korea', *Environmental Pollution*, 240, pp. 963–972. doi: https://doi.org/10.1016/j.envpol.2018.03.066.

Ryu, H. et al. (2017) 'Spatial statistical analysis of the effects of urban form indicators on road-traffic noise exposure of a city in South Korea', *Applied Acoustics*. The Author(s), 115, pp. 93–100. doi: 10.1016/j.apacoust.2016.08.025.

Sabapathy, A., V Santhosh Ragavan, K. and Saksena, S. (2012) 'An assessment of two-wheeler CO and PM10 exposures along arterial main roads in Bangalore city, India', *The Open Atmospheric Science Journal*, 6(1).

Saini, P. and Sharma, M. (2020) 'Cause and Age-specific premature mortality attributable to PM2.5 Exposure: An analysis for Million-Plus Indian cities', *Science of the Total Environment*. Elsevier B.V., 710, p. 135230. doi: 10.1016/j.scitotenv.2019.135230.

Sanok, S. et al. (2022) 'Road traffic noise impacts sleep continuity in suburban residents: Exposure-response quantification of noise-induced awakenings from vehicle pass-bys at night', *Science of The Total Environment*. Elsevier, 817, p. 152594.

Schultz, P. and Warner, T. T. (1982) 'Characteristics of summertime circulations and pollutant ventilation in the Los Angeles basin', *Journal of Applied Meteorology and Climatology*, 21(5), pp. 672–682.

Shamsipour, M. et al. (2022) 'Burden of diseases attributed to traffic noise in the metropolis of Tehran in 2017', *Environmental Pollution*. Elsevier, 301, p. 119042. doi: 10.1016/J.ENVPOL.2022.119042.

Sharma, A., Massey, D. D. and Taneja, A. (2018) 'Urban Climate A study of horizontal distribution pattern of particulate and gaseous pollutants based on ambient monitoring near a busy highway', *Urban Climate*. Elsevier, 24(July 2017), pp. 643–656. doi: 10.1016/j.uclim.2017.08.003.

Sharma, S., Khare, M. and Kota, S. H. (2022) 'Action Plans to Reduce PM2.5 Concentrations in Hotspots of Delhi-NCR Using a One-way Coupled Modeling Approach', *Aerosol and Air Quality Research*, 22(6). doi: 10.4209/aaqr.210377.

Shepherd, D. et al. (2016) 'The covariance between air pollution annoyance and noise annoyance, and its relationship with health-related quality of life', *International journal of environmental research and public health*. MDPI, 13(8), p. 792.

Shukla, A. K. et al. (2009) 'Performance of FHWA model for predicting traffic noise: A case study of Metropolitan city, Lucknow (India)', *Transport*, 24(3), pp. 234–240.

Silva, L. T. and Mendes, J. F. G. (2012) 'City Noise-Air : An environmental quality index for cities', *Sustainable Cities and Society*. Elsevier B.V., 4, pp. 1–11. doi: 10.1016/j.scs.2012.03.001.

Singal, S. P. (2005) *Noise pollution and control strategy*. Alpha Science Int'l Ltd.

Singh, D. et al. (2016) 'Statistical modeling of O3, NOx, CO, PM2. 5, VOCs and noise levels in commercial complex and associated health risk assessment in an academic institution', *Science of the Total Environment*. Elsevier, 572, pp. 586–594.

Singh, J. and Payra, S. (2022) 'An analysis of particulate pollution using urban aerosol pollution island intensity over Delhi , India', *Environmental Monitoring and Assessment*. Springer International Publishing. doi: 10.1007/s10661-022-10573-z.

Singh, V., Singh, S. and Biswal, A. (2021) 'Science of the Total Environment Exceedances and trends of particulate matter (PM 2 . 5) in fi ve Indian megacities', *Science of the Total Environment*. Elsevier B.V., 750, p. 141461. doi: 10.1016/j.scitotenv.2020.141461.

Sonaviya, D.R. and Tandel, B.N.(2020). Integrated road traffic noise mapping in urban Indian context. *Noise Mapping*, *7*(1), pp.99-113.

Song, S. (2016) 'Transport Emissions & Social Cost Assessment: Methodology Guide', p. 110. Availableat:https://files.wri.org/d8/s3fspublic/Transport_Emissions_Social_Cost_Assessment_Methodology_Guide.pdf.

Soni, A. R. *et al.* (2022) 'Noise prediction and environmental noise capacity for urban traffic of

Mumbai', *Applied Acoustics*. Elsevier Ltd, 188, p. 108516. doi: 10.1016/j.apacoust.2021.108516.

Sørensen, M. et al. (2015) 'Exposure to long-term air pollution and road traffic noise in relation to cholesterol: a cross-sectional study', *Environment international*. Elsevier, 85, pp. 238–243.

Sreekanth, V., Mahesh, B. and Niranjan, K. (2018) 'Urban Climate Gradients in PM 2 . 5 over India : Five city study', *Urban Climate*. Elsevier, 25(January), pp. 99–108. doi: 10.1016/j.uclim.2018.06.001.

Srimuruganandam, B. and Nagendra, S. M. S. (2011) 'Characteristics of particulate matter and heterogeneous traf fi c in the urban area of India', *Atmospheric Environment*. Elsevier Ltd, 45(18), pp. 3091–3102. doi: 10.1016/j.atmosenv.2011.03.014.

Srinivas, K. and Dinesh Kumar, P. K. (2006) 'Atmospheric forcing on the seasonal variability of sea level at Cochin, southwest coast of India', *Continental Shelf Research*, 26(10), pp. 1113–1133. doi: 10.1016/j.csr.2006.03.010.

Stansfeld, S. A. (2015) 'Noise effects on health in the context of air pollution exposure', *International Journal of Environmental Research and Public Health*, 12(10), pp. 12735–12760. doi: 10.3390/ijerph121012735.

Steele, C. (2001) 'A critical review of some tra c noise prediction models', 62.

Tandel, B. N. and Macwan, J. E. M. (2017) 'Road traffic noise exposure and hearing impairment among traffic policemen in Surat, Western India', *Journal of The Institution of Engineers (India): Series A*. Springer, 98, pp. 101–105.

Tezel-Oguz, M. N. et al. (2023) 'Investigation of simultaneous effects of noise barriers on near-road noise and air pollutants', *Science of the Total Environment*. Elsevier B.V., 892(June), p. 164754. doi: 10.1016/j.scitotenv.2023.164754.

Thakre, C. et al. (2020) 'Traffic noise prediction model of an Indian road: an increased scenario of vehicles and honking', *Environmental Science and Pollution Research*. Environmental Science and Pollution Research, 27(30), pp. 38311–38320. doi: 10.1007/s11356-020-09923-6.

Tiwari, S. et al. (2016) 'Assessment of PM 2.5 and PM 10 over Guwahati in Brahmaputra River Valley : Temporal evolution , source apportionment and meteorological dependence'.

Tiwari, S. et al. (2017) 'Assessment of PM2.5 and PM10 over Guwahati in Brahmaputra River

Valley: Temporal evolution, source apportionment and meteorological dependence', *Atmospheric Pollution Research*. Elsevier Ltd, 8(1), pp.13–28.doi: 10.1016/j.apr.2016.07.008.

Tobías, A. et al. (2015) 'Health impact assessment of traffic noise in Madrid (Spain)', *Environmental research*. Elsevier, 137, pp. 136–140.

Tonne, S. et al. (2008) 'Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities', *Occupational and environmental medicine,* 65(9), pp. 620–627. doi: 10.1136/oem.2007.036533.

Tonne, C. et al. (2016) 'Long-term traffic air and noise pollution in relation to mortality and hospital readmission among myocardial infarction survivors', *International journal of hygiene and environmental health*. Elsevier, 219(1), pp. 72–78.

UN (2014) 'World urbanization prospects. *United Nations: San Francisco, CA, USA.*

Vienneau, D. et al. (2015) 'Years of life lost and morbidity cases attributable to transportation noise and air pollution: A comparative health risk assessment for Switzerland in 2010', *International Journal of Hygiene and Environmental Health*. Elsevier GmbH., 218(6), pp. 514–521. doi: 10.1016/j.ijheh.2015.05.003.

Vij, G. S. and Agrawal, M. L. (2013) 'A review paper on R&D efforts in assessing the traffic noise on highways', *Recent Research in Science and Technology*, 5(5).

Vijay, R. et al. (2015) 'Assessment of honking impact on traffic noise in urban traffic environment of Nagpur, India', *Journal of Environmental Health Science and Engineering*, 13(1). doi: 10.1186/s40201-015-0164-4.

Waked, A. and Charbel, A. (2012) 'Emissions of air pollutants from road transport in Lebanon and other countries in the Middle East region', 61, pp. 446–452. doi: 10.1016/j.atmosenv.2012.07.064.

Wang, B. et al. (2021) 'The carbon components in indoor and outdoor PM2.5 in winter of Tianjin', *Scientific Reports*, 11(1), p. 17881. doi: 10.1038/s41598-021-97530-x.

Wang, J. S. and Chan, T. L. (2006) 'Roadside measurement and prediction of CO and PM 2 . 5 dispersion from on-road vehicles in Hong Kong', 11, pp. 242–249. doi: 10.1016/j.trd.2006.04.002.

Wang, V. et al. (2016) 'Temporal and spatial variations in road traf fi c noise for different frequency components in metropolitan Taichung , Taiwan', *Environmental Pollution*.

Elsevier Ltd, 219, pp. 174–181. doi: 10.1016/j.envpol.2016.10.055.

Watson, A. Y., Bates, R. R. and Kennedy, D. (1988) ‘Atmospheric transport and dispersion of air pollutants associated with vehicular emissions’, in *Air pollution, the automobile, and public health*. National Academies Press (US).

Weber, N., Haase, D. and Franck, U. (2014) ‘Assessing modelled outdoor traffic-induced noise and air pollution around urban structures using the concept of landscape metrics’, *Landscape and Urban Planning*. Elsevier, 125, pp. 105–116.

WHO (2011) ‘*Burden of disease from environmental noise: Quantification of healthy life years lost in Europe*’. *World Health Organization: Regional Office for Europe.*

WHO (2015) ‘World Health Day 2013: measure your blood pressure, reduce your risk’, G*eneva, Switzerland:World Health Organisation.*Availablefrom: *http://www.who.int/mediacentre/news/releases/2013/world_health_day_20130403/en/.Accessed February*, 19.

WHO(2018)‘Environmental Noise Guidelines for the European Region’.*World Health Organization. Regional Office for Europe*

WHO (2021)‘Health topics-air pollution; 2020’. *Word Health Organisation.* Accessed [18 September2021]Availablefromhttps://www.who.int/health-topics/air-pollution#tab=tab_1

WRI (2023) 'Southeast Asian Cities Have Some of the Most Polluted Air in the World. El Niño Is Making it Worse'. *World Resources Institute*.Accessed [1December 2023] Available from https://www.wri.org/insights/air-pollution-southeast-asia-cities-jakarta-el-nino

Xie, X. et al. (2018) ‘Long-term exposure to fine particulate matter and tachycardia and heart rate: Results from 10 million reproductive-age adults in China.’, *Environmental pollution (Barking, Essex : 1987)*. England, 242(Pt B), pp. 1371–1378. doi: 10.1016/j.envpol.2018.08.022.

Xing, Y. and Brimblecombe, P. (2018) ‘Science of the Total Environment Dispersion of traf fi c derived air pollutants into urban parks’, *Science of the Total Environment*. Elsevier B.V., 622–623, pp. 576–583. doi: 10.1016/j.scitotenv.2017.11.340.

Yadav, A. et al. (2022) ‘Modelling of traffic noise in the vicinity of urban road intersections’, *Transportation Research Part D*. Elsevier Ltd, 112(September), p. 103474. doi: 10.1016/j.trd.2022.103474.

Yang, W., Kim, M.-J. and Moon, H. J. (2018) 'Effects of indoor temperature and background noise on floor impact noise perception', *Indoor and Built Environment*. SAGE Publications Ltd STM, 28(4), pp. 454–469. doi: 10.1177/1420326X17753708.

Zhang, Q. et al. (2022) 'Cardiovascular effects of traffic-related air pollution: A multi-omics analysis from a randomized, crossover trial', *Journal of Hazardous Materials*. Elsevier, 435, p. 129031. doi: 10.1016/J.JHAZMAT.2022.129031.

Zhou, Y. and Levy, J. I. (2007) 'Factors influencing the spatial extent of mobile source air pollution impacts: a meta-analysis', *BMC public health*. BioMed Central, 7(1), pp. 1–11.

Zuo, F. et al. (2014a) 'Temporal and spatial variability of traffic-related noise in the City of Toronto, Canada', *Science of the Total Environment*, 472, pp. 1100–1107. doi: 10.1016/j.scitotenv.2013.11.138.

Zuo, F. et al. (2014b) 'Temporal and spatial variability of traffic-related noise in the City of Toronto, Canada', *Science of the Total Environment*. Elsevier, 472, pp. 1100–1107.

Table A-1 Spearman- rho correlation between traffic noise and $PM_{2.5}$

		Street										Office
		L_{peak}	L_{max}	L_{min}	L_{eq}	L_{10}	L_{50}	L_{90}	L_{95}	$NC_{(L90)}$	$NC_{(L95)}$	$PM_{2.5}$
Office	L_{peak}	-.194	-.104	-.140	-.165	-.092	-.130	-.260	-.240	-.128	-.116	-.337*
	L_{max}	-.147	-.122	-.035	-.152	-.111	-.082	-.130	-.110	-.085	-.038	-.380**
	L_{min}	-.107	-.151	-.350*	-.240	-.132	-.215	-.343*	-.325*	-.028	.008	-.202
	L_{eq}	-.182	-.142	-.161	-.189	-.145	-.103	-.217	-.194	-.109	-.066	-.400**
	L_{10}	-.179	-.151	-.084	-.203	-.174	-.127	-.180	-.157	-.068	-.029	-.369*
	L_{50}	-.162	-.125	-.158	-.186	-.155	-.078	-.204	-.182	-.136	-.089	-.370*
	L_{90}	-.152	-.157	-.357*	-.277	-.177	-.223	-.339*	-.320*	-.056	-.024	-.184
	L_{95}	-.165	-.187	-.420**	-.309*	-.195	-.259	-.379**	-.363*	-.076	-.040	-.157
	$NC_{(L90)}$	-.052	-.017	.288	.008	-.046	.029	.127	.139	-.004	-.001	-.195
	$NC_{(L95)}$	.011	.088	.384**	.113	.056	.130	.214	.227	.030	.023	-.197
	$PM_{2.5}$	.344*	.284	.267	.285	.230	.255	.299*	.313*	-.229	-.245	.032
Street	$PM_{2.5}$	.076	.120	.098	.130	.076	.062	.111	.104	-.002	-.052	1

*Correlation is significant at the 0.05 level ; **Correlation is significant at the 0.01 level

Table A-2 Spearman- rho correlation between traffic noise and $PM_{2.5}$ and meteorological variable

		T_{st}	T_{of}	$\%RH_{st}$	$\%RH_{of}$	*SR*	*ATMP*	*WS*
Street	L_{peak}	-.224	-.229	.181	.076	.325*	.256	.174
	L_{max}	-.289	-.291	.177	.078	.299*	.339*	.111
	L_{min}	-.116	-.231	-.056	-.180	.318*	.315*	-.003
	L_{eq}	-.355*	-.315*	-.022	-.146	.356*	.377**	.155
	L_{10}	-.393**	-.290	.076	-.029	.300*	.336*	.190
	L_{50}	-.371*	-.290	-.055	-.163	.279	.327*	.100
	L_{90}	-.324*	-.405**	-.011	-.158	.419**	.509**	.153
	L_{95}	-.332*	-.390**	.003	-.141	.396**	.499**	.138
	$NC_{(L90)}$	-.027	-.357*	.027	-.041	.180	.249	-.164
	$NC_{(L95)}$	-.023	-.320*	.010	-.039	.135	.199	-.198
	$PM_{2.5}$	-.087	-.352*	-.080	-.150	.441**	.395**	.149
Office	L_{peak}	-.167	.326*	-.054	.133	-.441**	-.350*	-.429**
	L_{max}	-.015	.231	-.195	-.041	-.384**	-.307*	-.427**
	L_{min}	-.170	.351*	-.024	.183	-.495**	-.441**	-.467**
	L_{eq}	-.096	.314*	-.207	-.020	-.450**	-.386**	-.431**
	L_{10}	-.028	.276	-.183	-.042	-.460**	-.333*	-.466**
	L_{50}	-.132	.355*	-.221	.012	-.435**	-.421**	-.437**
	L_{90}	-.124	.393**	.004	.251	-.491**	-.473**	-.374*
	L_{95}	-.104	.411**	.017	.284	-.492**	-.458**	-.345*
	$NC_{(L90)}$	.115	-.076	-.106	-.216	-.133	.106	-.161
	$NC_{(L95)}$	.036	-.090	-.073	-.216	-.136	.070	-.159
	$PM_{2.5}$	.345*	.179	-.053	.015	-.018	-.094	.205

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

where, '*Tst*' and 'T_{of}' are the street side ambient and office indoor temperature, respectively; '$\%RH_{st}$'and '$\%RH_{of}$' are the street side ambient and office indoor relative humidity, respectively; '*SR*' is the solar radiation, '*ATMP*' is the atmospheric pressure and '*WS*' is the wind speed.

Table A-3 Questionnaire

Sl No.	Questions	Responses
Demographic information		
1.	Age	0: <20 1: 20-40 2: 41-60 3: >60
2.	Gender	0: M 1: F 2: other
3.	Occupation	0: Student 1: Service 2: Business 3: Housewife 4: Retired 5: Others
4.	Since when you have been living in this residence?	0: <10 year 1: 10 year- 20 year 2: >20 year
B. Details of residential places		
5.	Building age	0: <10 year 1: 10-20 year 2: >20year
6.	Building facing	0: Roadside 1: Not roadside
7.	Distance from residential building to adjacent road	0: <2 m 1: 2m-3m 2: >3m
8.	Wall construction material	0: Brick wall 1: Glass 2: Mud 3: AAC block 4: Others (Specify)
9.	Location of window	0: Roadside 1: Not roadside
10.	Location of door	0: Roadside 1: Not roadside
11.	Family income (monthly)(INR)	0: <20K 1: 20K-40K 2: 41K-60K 3: 61K-80K 4: >80K 5: other
C. Indoor Air Pollution Sources		
12.	Smoking habit	0: No 1: Yes
13.	No. of smokers	0: None 1: one 2: two 3: more than two

Table A-3 (Continued)

14.	Fuel type	0: Firewood 1: Sawdust 2: Tree residue 3: Straw 4: Rice husk 5: Jute Sticks 6: Animal residue 7: Charcoal 8: Kerosene 9: Piped natural gas 10: LPG 11: Bio gas 12: Electricity 13: Others (specify) ……………………………
D. Indoor Noise Pollution Sources		
15.	Other indoor noise sources (specify)	0: Noise from furniture movement 1: noise from human conversation 2: noise from home appliance 3: other
16.	Noise events during sleeping time	0: No 1: Yes
E. Annoyance Response		
17.	Degree of annoyance experienced at home	0: no annoyance 1: slight annoyance 2: medium annoyance 3: high annoyance
18.	Degree of annoyance experienced at your workplace	0: no annoyance 1: slight annoyance 2: medium annoyance 3: high annoyance
19.	Degree of annoyance experienced near the roadside	0: no annoyance 1: slight annoyance 2: medium annoyance 3: high annoyance
F. Outdoor air and noise pollution sources		
20.	Main outdoor noise source	0: Vehicular traffic 1: honking 2: loudspeaker operation 3: crowd 4: any other
21.	Main outdoor air pollution source	0: Vehicular traffic 1: garbage incineration 2: industrial stack emission 3: roadside cooking 4: roadside construction activities 5: Other
22.	Degree of traffic operation in day time	0: Slight 1: medium 2: high
23.	Degree of traffic operation in evening	0: Slight 1: medium 2: high
24.	Degree of traffic operation in night time	0: Slight 1: medium 2: high
25.	Status of traffic flow	0: No flow 1: free flow 2: moderate flow 3: congested flow
26.	Breathing trouble near the roadside	0: No 1: Yes
G. Health Problems		
27.	What health problems have you experienced?	0: hearing disorders 1: speech interference 2: stress 3: fatigue 4: annoyance 5: cardiac problems 6: hypertension 7: No
28.	Time of experience the health issues	0: Never 1: morning 2: afternoon 3: evening 4: night 5: sometimes

Table A-3 (Continued)

29.	Frequency of occurring health disorders	0: Never 1: sometimes 2: always
30.	Duration of experience the health disorders?	0: Never 1: since few days 2: since some months 3: since some
31.	Masks use	0: Never 1: sometimes 2: always
32.	Hearing aid uses	0: No 1: Yes
H. Combine exposure of traffic air and noise pollution		
33.	Which one is most problematic for your health?	0: traffic air pollution 1: traffic induced noise pollution 2: both 3: none

Table A-4 Questionnaire response of street vendors

Questionnaire	Options	Frequency (n)	% Response
Age	< 20 y	1	2.17
	20-40 y	31	67.39
	41-60 y	10	21.74
	>60 y	4	8.7
Gender	Male	41	89.13
	Female	5	10.87
Living duration	< 10 y	16	34.78
	10 - 20 y	8	17.39
	> 20 y	22	47.83
Building age	< 10 y	9	19.57
	10 - 20 y	10	21.74
	> 20 y	27	58.7
Building facing	Roadside	7	15.22
	Not Roadside	39	84.78
Building vicinity	< 2m	9	19.57
	> 3m	37	80.43
Wall construction material	Brick wall	45	97.83
	Other	1	2.17
Window location	Roadside	39	84.78
	Not Roadside	7	15.22
Door location	Roadside	37	80.43
	Not Roadside	9	19.57
Family income (in INR)	< 20k	37	80.43
	20k-40k	6	13.04
	41k -60k	2	4.35
	> 80k	1	2.17
Indoor noise	Furniture movement	1	2.17
	Human conversation	5	10.87
	Others	40	86.96
Noise perception during sleeping	No	29	63.04
	Yes	17	36.96
Home Annoyance	No	35	76.09
	Slight	4	8.70
	Medium	4	8.70
	High	3	6.52
Workplace Annoyance	No	16	34.78
	Slight	3	6.52
	Medium	4	8.70

Table A-4(continued)

	High	23	50
Roadside Annoyance	No	1	2.17
	Slight	1	2.17
	Medium	32	69.57
	High	12	26.09
Average Annoyance Score (AAS)		1.41±0.62	
Traffic operation at day	Medium	3	6.52
	High	43	93.48
Traffic operation at evening	Medium	6	13.04
	High	40	86.96
Traffic operation at night	Slight	4	8.7
	Medium	15	32.61
	High	27	58.7
Traffic flow status	Moderate flow	9	19.57
	Congested flow	37	80.43
Outdoor pollution sources	Traffic	42	2.17
	Others	4	8.69
Health issues	Auditory, Stress, Fatigue and Annoyance	2	4.35
	Speech interference, Stress, Fatigue and Annoyance	19	41.3
	Stress, Fatigue and Annoyance	8	17.39
	Other issue (Cardiac, respiratory etc.)	17	36.96
Time of experiencing health effect	Never	2	4.35
	Morning	14	30.43
	Afternoon	0	0
	Evening	25	54.35
	Night	5	10.87
Frequency of occurring health issue	Never	1	2.17
	Sometimes	9	19.57
	Frequent	36	78.26
Duration of experiencing health issue	Never	2	4.35
	Since few months	1	2.17
	Since few years	43	93.48
Smoking	No smoking	27	58.7
	Smoking	19	41.3
Number of smoker	None	19	41.3
	One	25	54.35
	More than two	2	4.35
Fuel	LPG and or other smoky fuel	4	8.7
	LPG	37	80.43

Table A-4 (continued)

	Electric cook stove	2	4.35
	LPG and Electric cook stove	3	6.52
Masks used	Never	42	91.3
	Sometimes	3	6.52
	Always	1	2.17
Hearing aid	None	46	100
Breathing trouble	No problem	8	17.4
	Breathing problems	38	82.6
Most Problematic Traffic Emission	Air	18	39.13
	Noise	14	30.43
	Both	8	17.39
	No problem	6	13.04

Table A-5 Questionnaire response of office workers

Questionnaire	Options	Frequency (n)	% Response
Age	20-40 y	18	17.07
	41-60 y	86	80.49
	> 60 y	4	2.44
Gender	Male	91	85.37
	Female	17	14.63
Living Duration	< 10 y	25	24.39
	10 - 20 y	23	21.95
	> 20 y	57	53.66
Building Age	< 10 y	24	21.95
	10 - 20 y	27	24.39
	> 20 y	57	53.66
Building Facing	Roadside	50	46.34
	Not Roadside	58	53.66
Building Vicinity	< 2 m	39	36.59
	2-3 m	8	7.31
	> 3 m	61	56.10
Wall Construction Material	Brick wall	105	97.2
	Other	3	2.8
Window Location	Roadside	44	41.46
	Not Roadside	64	58.54
Door Location	Roadside	42	39.02
	Not Roadside	66	60.98
Family Income (in INR)	< 20k	13	12.0
	20k- 40k	45	41.7
	41k- 60k	24	22.2
	61k- 80k	16	14.8
	>80k	10	9.3
Indoor noise source	Furniture noise	3	2.8
	Human conversation	80	74.1
	Other	25	23.2
Noise Perception During Sleeping	No	61	56.10
	Yes	47	43.90
Home Annoyance	No	42	39.02
	Slight	45	41.46
	Medium	18	17.07
	High	3	2.44
Workplace Annoyance	No	45	41.50
	Slight	37	34.10
	Medium	21	19.50
	High	5	4.90
Roadside Annoyance	No	26	24.40
	Slight	42	39.02
	Medium	24	21.95
	High	16	14.63

Table A-5(continued)

Average Annoyance Score (AAS)		0.88±0.65	
Degree of traffic operation in day	Slight	33	30.6
	Medium	41	38.0
	High	34	31.5
Degree of traffic operation in evening	Slight	35	32.4
	Medium	45	41.7
	High	27	25.0
Degree of traffic operation in night	Slight	41	38.0
	Medium	52	48.1
	High	15	13.9
Traffic flow status	No flow	2	1.9
	Free flow	34	31.5
	Moderate flow	56	51.9
Main outdoor air and noise pollution source	Only traffic	58	53.7
	Multiple outdoor sources including traffic	50	46.3
Health problems	Multiple health issues including cardiac, respiratory issues	103	95.4
	Existing HTN	5	4.6
Time of Experiencing Health Issue	Never	10	9.3
	Morning	4	3.7
	Afternoon	8	7.4
	Evening	86	79.6
Frequency of Health Disorder	Never	12	11.1
	Morning	52	48.1
	Afternoon	44	40.7
Duration of Experiencing health Issues	Never	20	18.5
	Since Few Days	13	12.0
	Since Some Years	75	69.4
	Always	10	9.2
Smoking	No	88	81.5
	Yes	24	20.4
Number of smokers	None	82	75.9
	One	22	20.4
	Two	2	1.9
	More than two	2	1.9
Fuel type	Only LPG	83	76.9
	Other fuels or combination of fuels including LPG	25	23.1
Masks used	Never	83	76.9
	Sometimes	20	18.5

Table A-5 (continued)

	Always	5	4.6
Hearing aid used	Never	99	91.7
	Since few days	2	1.9
	Since some months	1	0.9
	Since some years	6	5.5
Breathing trouble	No problem	40	37
	Breathing problems	68	63
Most Problematic Traffic Emission	Air	22	20.4
	Noise	14	12
	Both	69	64
	No problem	3	2.8

Table A-6 Spearman correlation of street vendors' noise and $PM_{2.5}$ exposure, annoyance response and health parameters

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
A	1																																																
B	.749**	1																																															
C	.426**	.595**	1																																														
D	.657**	.869**	.742**	1																																													
E	.741**	.907**	.593**	.940**	1																																												
F	.467**	.707**	.757**	.921**	.784**	1																																											
G	.376*	.567**	.924**	.726**	.574**	.763**	1																																										
H	.380**	.563**	.923**	.717**	.568**	.752**	.998**	1																																									
I	.044	.202	.023	.083	.092	.032	.069	.051	1																																								

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250 Hz; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s: Roadside annoyance; t: Average annoyance score; u: SBP; v: DBP; w: HR; ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-6 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
J	.022	.174	.014	.081	.082	.053	.066	.049	.980**	1																																							
K	0.027	0.126	0.091	0.096	0.134	0.0837	0.144	0.159	-0.002	0.057	1																																						
L	0.163	0.152	0.193	0.264	0.218	0.228	0.283	0.279	0.064	0.025	-0.030	1																																					
M	0.140	0.123	0.026	0.125	0.150	0.166	0.016	0.031	-.421**	-.404**	0.061	0.204	1																																				
N	-0.074	-0.179	0.018	-0.069	-0.085	-0.128	-0.103	-0.101	-.604**	-.630**	0.004	0.021	0.182	1																																			
O	-0.142	-0.060	.311*	0.024	-0.100	0.102	.324*	.343*	-0.070	-0.033	0.194	-0.018	-0.057	0.126	1																																		
P	-0.035	0.037	0.238	0.070	0.028	0.023	0.209	0.207	0.024	0.019	0.158	.458**	-0.055	0.175	0.270	1																																	
Q	0.025	0.113	.375*	0.235	0.170	0.225	.395**	.393**	0.020	0.023	0.158	.419**	-0.136	0.187	0.285	.429**	1																																

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250 Hz; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s: Roadside annoyance; t: Average annoyance score; u: SBP; v: DBP; w: HR; ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-6 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
R	-0.048	0.127	.415**	.301*	0.162	.359*	.474**	.465**	0.133	0.171	0.230	0.170	-0.029	0.067	.525**	0.088	.435**	1																															
S	0.133	0.261	.544**	.336*	0.263	.338*	.522**	.518**	0.131	0.116	-0.057	0.257	-0.088	0.129	0.158	.362*	.330*	0.210	1																														
T	0.088	0.126	.479**	0.275	0.101	.385**	.479**	.483**	-0.044	-0.052	-0.096	.369*	-0.068	0.088	0.285	.414**	.429**	0.144	.595**	1																													
U	0.043	0.209	.638**	.366*	0.208	.469**	.628**	.631**	-0.026	0.009	0.005	0.207	-0.001	-0.086	.410**	.338*	.579**	0.259	.425**	.691**	1																												
V	.339*	.479**	.678**	.587**	.427**	.620**	.717**	.723**	-0.045	-0.038	0.048	0.218	0.086	-0.004	.333*	0.253	.388**	0.175	.424**	.617**	.662**	1																											
W	0.171	.363*	.609**	.432**	.293*	.494**	.680**	.683**	0.098	0.116	0.091	0.194	0.007	-0.039	.439**	.328*	.482**	.363*	.550**	.622**	.687**	.720**	1																										
X	0.261	.354*	.514**	.476**	.373*	.500**	.498**	.496**	-0.094	-0.027	0.115	0.076	0.267	-0.031	0.084	0.252	0.150	0.187	0.139	.423**	.598**	.495**	.430**	1																									

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250 Hz; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s: Roadside annoyance; t: Average annoyance score; u: SBP; v: DBP; w: HR; ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-6 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Y	.401**	.485**	.574**	.562**	.489**	.597**	.662**	.680**	-0.170	-0.148	0.238	0.102	0.249	-0.028	0.074	0.128	0.095	0.079	0.258	.412**	.484**	.668**	.460**	.645**	1																								
Z	.318*	.535**	.506**	.571**	.576**	.581**	.546**	.540**	0.086	0.088	0.269	0.036	0.165	-0.150	-0.002	0.025	0.177	0.189	0.179	.297*	.398**	.460**	.423**	.527**	.610**	1																							
a	.507**	.519**	.607**	.533**	.501**	.538**	.568**	.577**	-0.107	-0.105	0.005	0.098	0.269	-0.113	0.043	0.232	0.077	-0.133	.324*	.440**	.571**	.576**	.419**	.577**	.689**	.554**	1																						
b	.530**	.535**	.498**	.541**	.536**	.479**	.457**	.478**	-0.119	-0.136	0.197	0.238	.304*	-0.092	0.174	0.266	0.168	-0.062	0.212	.341*	.445**	.514**	0.277	.419**	.522**	.391**	.746**	1																					
c	.411**	.572**	.783**	.646**	.569**	.668**	.727**	.733**	-0.037	-0.059	0.035	0.134	0.227	-0.065	0.225	0.165	0.223	0.252	.402**	.446**	.582**	.510**	.497**	.556**	.519**	.550**	.748**	.677**	1																				
d	.429**	.597**	.666**	.687**	.638**	.684**	.686**	.674**	0.134	0.135	0.113	0.105	0.131	0.009	0.146	0.050	0.173	.393**	0.278	0.197	.309*	.395**	.431**	.422**	.446**	.629**	.493**	.402**	.710**	1																			
e	.391**	.467**	.767**	.623**	.498**	.661**	.772**	.773**	-0.115	-0.134	0.023	0.215	0.121	0.116	.303*	0.171	.321*	0.268	.544**	.455**	.565**	.703**	.608**	.389**	.561**	.440**	.649**	.542**	.716**	.632**	1																		

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250 Hz; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s: Roadside annoyance; t: Average annoyance score; u: SBP; v: DBP; w: HR; ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-6 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
f	.522**	.692**	.658**	.821**	.714**	.825**	.655**	.651**	0.125	0.143	0.081	0.245	0.092	-0.099	0.047	0.096	0.255	0.280	.467**	.364*	.405**	.614**	.515**	.353*	.461**	.429**	.537**	.490**	.640**	.629**	.727**	1																	
g	.292*	.595**	.477**	.639**	.540**	.579**	.441**	.429**	0.271	0.261	-0.002	0.100	0.005	-0.146	0.027	-0.122	0.063	.337*	0.120	-0.038	0.040	0.234	0.228	0.107	0.017	0.142	0.045	0.083	.370*	.390**	0.256	.589**	1																
h	.419**	.569**	.571**	.663**	.548**	.696**	.556**	.534**	0.018	0.015	0.121	0.261	0.062	0.138	0.035	0.039	0.141	.403**	.332*	0.181	0.063	.327*	0.234	0.178	.300*	0.264	0.176	0.080	.389**	.543**	.454**	.615**	.617**	1															
i	.444**	.598**	.750**	.706**	.554**	.724**	.734**	.716**	0.147	0.126	0.014	0.285	-0.035	-0.090	0.280	0.280	.330*	.344*	.463**	.574**	.591**	.630**	.667**	.436**	.423**	.497**	.603**	.506**	.690**	.609**	.721**	.747**	.439**	.572**	1														
j	.438**	.550**	.731**	.630**	.513**	.659**	.715**	.710**	0.070	0.049	0.114	.295*	0.096	-0.091	.357*	.321*	.400**	.303*	.501**	.621**	.666**	.693**	.742**	.442**	.480**	.506**	.641**	.593**	.704**	.527**	.763**	.685**	0.260	.398**	.907**	1													
k	.507**	.543**	.701**	.626**	.524**	.624**	.637**	.627**	0.040	0.021	0.095	.291*	0.052	0.089	0.277	0.275	.377**	.370*	.544**	.566**	.499**	.586**	.611**	.374*	.350*	.471**	.511**	.456**	.622**	.530**	.767**	.685**	.296*	.507**	.797**	.879**	1												

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250 Hz; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s: Roadside annoyance; t: Average annoyance score; u: SBP; v: DBP; w: HR; ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-6 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
l	.528**	.541**	.653**	.611**	.522**	.584**	.559**	.557**	-0.072	-0.076	0.118	.295*	0.131	0.187	0.269	0.274	.335*	.335*	.517**	.523**	.409**	.564**	.553**	.350*	.335*	.366*	.480**	.449**	.601**	.475**	.741**	.672**	.327*	.532**	.707**	.800**	.939**	1											
m	.503**	.430**	.517**	.504**	.461**	.496**	.438**	.430**	-0.076	-0.079	-0.011	.355*	0.149	0.091	0.166	0.251	.339*	0.198	.505**	.528**	.403**	.451**	.442**	.332*	0.221	.313*	.426**	.422**	.569**	.403**	.633**	.570**	0.194	.467**	.641**	.752**	.852**	.887**	1										
n	.562**	.480**	.406**	.497**	.493**	.451**	.322*	.327*	-0.199	-0.215	0.032	.394**	.294*	0.169	0.017	0.239	0.195	0.127	.426**	.456**	0.227	.336*	0.249	.307*	0.274	0.253	.444**	.527**	.549**	.334*	.545**	.562**	0.141	.409**	.487**	.588**	.753**	.786**	.829**	1									
o	.464**	.325*	.325*	.331*	.348*	0.229	0.263	0.269	-0.116	-0.134	0.176	.362*	0.171	.317*	0.182	0.208	.403**	.306*	.444**	.331*	0.171	0.229	0.285	0.092	0.105	0.176	0.167	.314*	.350*	0.280	.447**	.350*	0.058	.349*	.358*	.495**	.700**	.762**	.759**	.756**	1								
p	.341*	0.289	0.246	0.270	0.232	0.237	0.199	0.217	-0.210	-0.230	-0.122	0.087	0.103	0.149	0.109	0.170	0.125	-0.144	0.234	.410**	.332*	.438**	0.274	.293*	.381**	0.116	.470**	.430**	0.268	-0.021	.380**	.291*	-0.101	-0.060	0.207	.370*	.444**	.414**	0.274	.466**	0.276	1							
q	0.020	0.111	-0.057	0.093	0.145	0.031	0.074	0.079	-0.204	-0.191	0.012	0.028	0.101	-0.052	0.057	0.009	-0.038	0.052	-0.072	-0.125	0.035	-0.032	0.030	0.089	0.111	-0.005	0.020	0.110	-0.068	-0.051	0.079	0.004	-0.037	-0.168	-0.050	-0.001	-0.015	0.001	-0.036	-0.036	-0.057	0.185	1						
r	.294*	.225	.306*	.419**	.343*	.418**	.310*	.273	.151	.182	-.141	.058	.046	-.001	-.138	.048	-.007	-.087	-.006	-.117	-.106	-.061	.000	.042	.074	.085	.003	.114	.046	.003	.048	.041	.384*	.219	.276	.140	.405**	.485**	.286	.324*	.267	-.326*	.364*	1					

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250 Hz; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s: Roadside annoyance; t: Average annoyance score; u: SBP; v: DBP; w: HR; ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-6 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
s	-.115	-.248	-.097	-.194	-.172	-.184	-.195	-.187	-.236	-.230	.182	.031	.075	.376**	-.114	.151	.051	-.151	-.066	.031	-.066	.023	-.137	.160	.095	.050
t	-0.115	-0.248	-0.097	-0.161	-0.135	-0.150	-0.118	-0.110	-0.259	-0.249	0.182	0.031	0.075	.376**	-0.114	0.151	0.051	-0.151	-0.066	0.031	-0.066	0.023	-0.137	0.160	0.095	0.050
u	0.023	-0.058	0.040	-0.149	-0.205	-0.107	0.044	0.039	0.089	0.032	-0.246	-0.040	-0.233	-0.175	0.103	0.013	-0.087	-0.025	-0.015	0.123	-0.004	-0.109	-0.002	-0.196	-0.190	-.295*
v	0.168	0.131	0.104	0.015	0.009	-0.027	0.106	0.100	0.268	0.218	-0.097	0.073	-0.250	-0.282	-0.027	0.011	-0.120	-0.057	0.003	0.089	-0.023	-0.116	-0.171	-0.099	-0.102	-0.136
w	-0.116	-0.038	0.236	0.105	0.041	0.195	0.238	0.235	0.086	0.130	0.198	0.228	-0.001	-0.179	-0.130	0.009	0.047	-0.006	0.077	0.060	0.165	0.027	-0.031	0.098	0.153	0.061

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
s	-.059	.085	-.075	-.049	-.063	-.200	-.309*	-.145	-.294*	-.232	-.120	-.098	-.155	-.027	.033	.155	-.263	-.571**	1				
t	-0.059	0.085	-0.075	-0.049	-0.063	-0.200	-.309*	-0.145	-.294*	-0.232	-0.120	-0.098	-0.155	-0.027	0.033	0.155	-0.263	-.571**	-.333*	1			
u	-0.115	-0.155	-0.086	-0.151	-0.031	-0.105	0.065	-0.009	0.078	0.035	0.062	-0.064	-0.079	0.015	-0.143	0.160	0.143	0.134	-.266	-0.266	1		
v	0.009	-0.063	0.006	-0.042	-0.041	0.014	0.149	0.093	0.119	0.051	0.088	-0.002	-0.012	0.056	-0.086	0.134	0.079	0.045	-.255	-0.255	0.787	1	
w	0.145	0.100	0.147	0.140	0.047	0.123	-0.014	0.117	0.149	0.115	-0.028	-0.090	-0.018	-0.006	-0.134	-0.145	-0.241	0.075	-.071	-0.071	-0.124	0.074	1

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250 Hz; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s: Roadside annoyance; t: Average annoyance score; u: SBP; v: DBP; w: HR; ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-7 Spearman correlation of street vendors ‘questionnaire, annoyance response and health

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g
A	1																																
B	-.230	1																															
C	.286	.034	1																														
D	.418**	0	.335*	1																													
E	-.145	-.046	.060	.048	1																												
F	.040	-.184	.105	.036	.681**	1																											

where, A:Age; B: Gender; C:Living duration; D:Building age; E: Building facing; F:Building vicinity; G:Wall construction material; H:Window location; I: Door location; J:Family income; K:Indoor noise; L:Noise perception during sleep; M: Traffic operation at day; N:Traffic operation at evening; O:Traffic operation at night; P:Traffic flow status; Q:Outdoor traffic; R:Health problems; S:Time of experiencing health effect; T: Frequency of occurring health issue; U:Duration of experiencing health issue; V:Smoking;W: Number of smoker; X: Fuel; Y:Mask used; Z: Most problematic stressor; a: Home Annoyance; b:Workplace Annoyance; c: Roadside Annoyance; d:Average Annoyance Score; e:Systollic blood pressure; f: Diastolic blood pressure; g: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-7(Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g
G	.217	-.052	.147	.119	.063	.063	1																										
H	-.023	-.148	-.119	0.000	-.158	-.251	-.063	1																									
I	.023	.004	-.243	-.044	.056	.055	-.074	.706**	1																								
J	.136	.187	.061	-.127	.066	-.155	-.073	.102	.039	1																							
K	-.006	.175	-.144	.225	-.025	-.141	.262	-.109	-.206	-.012	1																						

where, A:Age; B: Gender; C:Living duration; D:Building age; E: Building facing; F:Building vicinity; G:Wall construction material; H:Window location; I: Door location; J:Family income; K:Indoor noise; L:Noise perception during sleep; M: Traffic operation at day; N:Traffic operation at evening; O:Traffic operation at night; P:Traffic flow status; Q:Outdoor traffic; R:Health problems; S:Time of experiencing health effect; T: Frequency of occurring health issue; U:Duration of experiencing health issue; V:Smoking;W: Number of smoker; X: Fuel; Y:Mask used; Z: Most problematic stressor; a: Home Annoyance; b:Workplace Annoyance; c: Roadside Annoyance; d:Average Annoyance Score; e:Systollic blood pressure; f: Diastolic blood pressure; g: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-7 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g
L	.068	-.123	-.011	.181	.074	.002	.195	.177	.190	-.145	.055	1																					
M	-.012	.092	-.065	.141	.133	.305*	.039	-.378**	-.314*	-.322*	.202	.020	1																				
N	.118	-.280	-.095	.052	-.164	-.010	.058	-.195	-.134	.471**	-.299*	.163	.421**	1																			
O	.252	-.346*	.193	.033	-.237	.070	-.148	-.091	-.236	-.186	-.159	.183	.103	.437**	1																		

where, A:Age; B: Gender; C:Living duration; D:Building age; E: Building facing; F:Building vicinity; G:Wall construction material; H:Window location; I: Door location; J:Family income; K:Indoor noise; L:Noise perception during sleep; M: Traffic operation at day; N:Traffic operation at evening; O:Traffic operation at night; P:Traffic flow status; Q:Outdoor traffic; R:Health problems; S:Time of experiencing health effect; T: Frequency of occurring health issue; U:Duration of experiencing health issue; V:Smoking;W: Number of smoker; X: Fuel; Y:Mask used; Z: Most problematic stressor; a: Home Annoyance; b:Workplace Annoyance; c: Roadside Annoyance; d:Average Annoyance Score; e:Systollic blood pressure; f: Diastolic blood pressure; g: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-7 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g
P	-.291*	.172	-.162	-.088	.249	.181	.074	.056	.105	-.015	.002	-.190	.092	-.028	-.305*	1																	
Q	.029	-.140	-.144	.111	.084	.247	.046	-.098	-.055	-.041	.051	.236	.563**	.353*	.225	.055	1																
R	-.052	.019	.059	-.049	-.069	-.139	-.099	.107	.127	-.299*	-.086	.088	-.017	.180	.069	-.002	.031	1															
S	-.222	.038	.149	-.084	.053	-.017	-.106	-.294*	-.232	.075	.045	.030	.007	-.122	.036	-.124	-.015	.144	1														
T	-.198	.184	.079	-.174	.064	.044	.078	-.207	-.259	.017	.075	-.047	.069	-.051	-.338*	0.000	.032	.060	.180	1													

where, A:Age; B: Gender; C:Living duration; D:Building age; E: Building facing; F:Building vicinity; G:Wall construction material; H:Window location; I: Door location; J:Family income; K:Indoor noise; L:Noise perception during sleep; M: Traffic operation at day; N:Traffic operation at evening; O:Traffic operation at night; P:Traffic flow status; Q:Outdoor traffic; R:Health problems; S:Time of experiencing health effect; T: Frequency of occurring health issue; U:Duration of experiencing health issue; V:Smoking;W: Number of smoker; X: Fuel; Y:Mask used; Z: Most problematic stressor; a: Home Annoyance; b:Workplace Annoyance; c: Roadside Annoyance; d:Average Annoyance Score; e:Systollic blood pressure; f: Diastolic blood pressure; g: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-7 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g
U	.174	-.178	-.149	-.211	-.112	-.111	.039	.112	.130	.129	-.077	-.170	-.070	.148	-.064	-.130	.217	.087	-.169	.121	1												
V	.195	-.293*	-.033	.142	-.013	.125	-.125	-.110	-.080	-.075	.030	.364*	.222	.325*	.687**	-.254	.259	-.171	-.033	-.418**	-.144	1											
W	-.187	-.009	-.112	.042	.262	.196	-.173	-.034	-.054	.045	.062	.238	.140	-.039	-.118	.031	.221	.126	-.110	.026	.306*	.047	1										
X	.051	0.000	-.042	.005	-.272	-.231	0.000	.243	.114	.237	.000	-.205	-.373*	-.273	-.134	-.249	-.184	-.257	-.244	-.005	0.000	-.288	-.277	1									
Y	.166	.135	-.045	-.252	-.289	-.049	-.046	-.131	-.152	.428**	.130	-.236	.081	-.348*	-.033	-.228	.095	-.107	.104	-.016	.081	-.106	-.060	.339*	1								

where, A:Age; B: Gender; C:Living duration; D:Building age; E: Building facing; F:Building vicinity; G:Wall construction material; H:Window location; I: Door location; J:Family income; K:Indoor noise; L:Noise perception during sleep; M: Traffic operation at day; N:Traffic operation at evening; O:Traffic operation at night; P:Traffic flow status; Q:Outdoor traffic; R:Health problems; S:Time of experiencing health effect; T: Frequency of occurring health issue; U:Duration of experiencing health issue; V:Smoking;W: Number of smoker; X: Fuel; Y:Mask used; Z: Most problematic stressor; a: Home Annoyance; b:Workplace Annoyance; c: Roadside Annoyance; d:Average Annoyance Score; e:Systollic blood pressure; f: Diastolic blood pressure; g: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-7 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g
Z	.163	-.149	.037	-.032	0.000	-.088	.153	-.024	-.174	-.180	.057	.089	-.007	.128	.311*	-.299*	-.029	.159	.058	.100	-.170	.164	-.264	-.076	-.151	1							
a	.214	.137	.299*	.013	-.476**	-.353*	-.083	.073	-.144	.118	-.099	-.247	-.235	-.091	.067	-.221	-.175	-.082	-.026	.170	.146	-.100	-.107	.249	.213	.122	1						
b	.071	-.130	.309*	-.029	-.202	-.080	.142	-.195	-.432**	-.014	-.037	-.061	.138	.221	.337*	-.407**	.128	-.116	.240	.258	.040	.217	-.049	-.047	.029	.229	.364*	1					
c	.166	-.164	-.022	.191	-.051	.072	-.070	-.074	.108	-.125	.121	.106	-.058	-.085	.222	.231	.104	.214	.075	-.413**	-.062	.153	.003	-.185	.025	-.044	-.263	-.571**	1				

where, A:Age; B: Gender; C:Living duration; D:Building age; E: Building facing; F:Building vicinity; G:Wall construction material; H:Window location; I: Door location; J:Family income; K:Indoor noise; L:Noise perception during sleep; M: Traffic operation at day; N:Traffic operation at evening; O:Traffic operation at night; P:Traffic flow status; Q:Outdoor traffic; R:Health problems; S:Time of experiencing health effect; T: Frequency of occurring health issue; U:Duration of experiencing health issue; V:Smoking;W: Number of smoker; X: Fuel; Y:Mask used; Z: Most problematic stressor; a: Home Annoyance; b:Workplace Annoyance; c: Roadside Annoyance; d:Average Annoyance Score; e:Systollic blood pressure; f: Diastolic blood pressure; g: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-7 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g
d	.210	-.046	.400**	.022	-.408**	-.233	.052	-.131	-.389**	.045	-.042	-.182	-.072	.043	.340*	-.380**	-.036	-.104	.214	.159	.071	.133	-.101	.053	.173	.222	.766**	.833**	-.333*	1			
e	-.061	-.058	.017	.212	.093	-.024	.107	0.000	-.041	-.042	-.039	.022	-.255	-.044	-.213	-.303*	-.188	.105	-.053	.070	.006	-.188	.186	.129	-.103	-.035	.143	.134	-.266	.128	1		
f	-.089	-.021	-.065	.162	.021	-.100	.202	.023	-.056	-.074	.053	.037	-.176	0.000	-.228	-.157	-.194	-.066	-.178	.073	-.027	-.210	.014	.061	-.197	-.022	.079	.045	-.255	.024	.787**	1	
g	-.055	-.061	-.018	-.238	.219	.245	.253	-.027	-.052	.196	-.063	-.156	-.003	-.216	.038	.196	-.086	-.186	.003	-.046	-.157	-.088	-.217	-.160	.103	-.024	-.241	.075	-.071	-.046	-.124	.074	1

where, A:Age; B: Gender; C:Living duration; D:Building age; E: Building facing; F:Building vicinity; G:Wall construction material; H:Window location; I: Door location; J:Family income; K:Indoor noise; L:Noise perception during sleep; M: Traffic operation at day; N:Traffic operation at evening; O:Traffic operation at night; P:Traffic flow status; Q:Outdoor traffic; R:Health problems; S:Time of experiencing health effect; T: Frequency of occurring health issue; U:Duration of experiencing health issue; V:Smoking;W: Number of smoker; X: Fuel; Y:Mask used; Z: Most problematic stressor; a: Home Annoyance; b:Workplace Annoyance; c: Roadside Annoyance; d:Average Annoyance Score; e:Systollic blood pressure; f: Diastolic blood pressure; g: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-8 Spearman correlation analysis of street vendors' noise and $PM_{2.5}$ exposure and questionnaire response, annoyance

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
q	-.176	-.072	-.151	-.064	-.005	-.067	-.233	-.229	-.103	-.083	.211	.019	.012	.010	.000	.083	.115	.149	-.161	-.161	-.132
r	.313*	.087	-.034	.039	.108	-.029	.111	.116	-.169	-.145	-.155	-.092	.076	-.008	-.076	-.087	.016	-.210	.171	.105	.034
s	.164	-.050	.034	-.111	-.071	-.109	-.057	-.049	-.189	-.123	.112	-.130	-.011	-.004	-.080	.070	-.074	-.087	-.051	-.015	.050
t	.138	.011	-.171	-.135	-.064	-.154	-.265	-.264	0.000	-.020	.103	.057	.042	-.069	-.288	.049	-.085	-.152	-.110	-.074	-.185
u	.048	.021	.171	.034	.016	.126	.107	.108	-.215	-.201	-.075	-.153	.166	.071	-.089	-.134	-.071	-.034	.066	.048	.071

	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
q	-.232	-.322*	-.045	-.093	-.002	-.161	.010	-.067	-.100	-.164	-.102	.008	-.042	-.236	-.249	-.153	-.132	-.128	.030	.037	-.049
r	.055	.158	-.034	.197	.076	.387**	.197	.079	-.008	.155	.034	-.250	-.171	.118	.187	.113	.150	.134	.108	.171	.303*
s	-.069	-.005	.218	.157	.112	.109	-.025	-.046	-.145	-.142	-.089	-.105	-.061	-.108	-.124	-.035	-.047	-.004	.029	.010	.050
t	-.357*	-.292	-.168	-.230	-.018	-.007	.101	.012	-.200	-.203	-.057	.016	-.023	-.118	-.131	.054	.070	.040	.242	.221	.108
u	-.057	.048	.057	.112	.116	.100	-.203	.178	.096	.052	.021	-.007	.267	.057	.034	.066	.062	.089	.107	.082	-.107

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Age; r:Gender; s: Living duration; t:Building age; u:Building facing; v: Building vicinity; w:Wall construction material; x: Window location; y: Door location; z: Family income; A1: Indoor noise; B1: Noise perception during sleeping; C1: Traffic operation at day; D1: Traffic operation at evening; E1:Traffic operation at night; F1:Traffic flow status; G1:Outdoor traffic; H1: Health issues; I1: Time of experiencing health issues; J1:Frequency of occurring health issue; K1:Duration of experiencing health issue; L1:Smoking; M1: Number of smoker; N1:Fuel; O1: Masks used; P1:Most Problematic stressor ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-8 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
v	.051	.123	.137	.195	.164	.237	.044	.045	-.284	-.268	.104	-.045	.312*	.192	-.124	-.218	-.081	-.035	.035	.106	.050	.051	.018	.172	.187	.198	.039	-.038	.164	.065	.046	.143	.203	.319*	.080	.021	.062	.056	.091	.254	.112	-.025
w	.208	.241	.253	.253	.242	.253	.208	.209	.231	.248	.118	-.039	-.140	-.208	.118	.039	-.197	-.017	.241	.095	.107	-.017	.039	.095	.051	-.017	.253	.241	.253	.241	.140	.230	.241	.208	.253	.197	.230	.152	.118	.152	.073	.095
x	-.130	-.057	-.221	.119	.100	.112	-.011	-.011	.023	.043	.084	-.116	-.253	-.189	-.100	-.093	.014	-.084	-.212	-.214	-.057	-.039	-.148	-.139	-.185	-.278	-.294*	-.080	-.262	-.289	-.139	.002	.066	-.153	-.180	-.089	-.103	-.066	-.048	-.089	-.096	-.021
y	-.060	.039	-.186	.198	.198	.186	-.048	-.046	-.128	-.091	-.043	-.175	.025	-.052	-.012	-.035	-.107	-.163	-.163	-.188	-.109	.068	-.111	-.014	-.080	-.192	-.105	.027	-.105	-.188	-.056	.101	.085	-.085	-.114	-.027	-.060	-.010	.008	.089	-.054	.142
z	-.294*	-.300*	-.336*	-.254	-.161	-.215	-.150	-.151	-.180	-.143	-.053	-.390**	-.337*	.044	-.098	-.126	-.066	-.258	-.197	-.216	-.198	-.240	-.259	-.307*	-.209	-.215	-.170	-.310*	-.333*	-.335*	-.261	-.368*	-.447**	-.342*	-.355*	-.259	-.247	-.238	-.189	-.251	-.231	.046

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Age; r:Gender; s: Living duration; t:Building age; u:Building facing; v: Building vicinity; w:Wall construction material; x: Window location; y: Door location; z: Family income; A1: Indoor noise; B1: Noise perception during sleeping; C1: Traffic operation at day; D1: Traffic operation at evening; E1:Traffic operation at night; F1:Traffic flow status; G1:Outdoor traffic; H1: Health issues; I1: Time of experiencing health issues; J1:Frequency of occurring health issue; K1:Duration of experiencing health issue; L1:Smoking; M1: Number of smoker; N1:Fuel; O1: Masks used; P1:Most Problematic stressor ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-8 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
A1	-.196	-.158	-.007	-.177	-.217	-.128	-.043	-.035	.118	.122	-.054	-.033	-.137	-.040	.199	.079	.143	.136	.226	.297*	.204	-.107	.030	-.044	-.136	-.067	.049	.118	.214	-.015	-.100	-.111	-.048	-.117	-.004	-.019	-.007	-.006	.000	-.047	.075	.004
B1	.117	.070	-.044	.122	.197	.065	.027	.031	.002	.009	.005	-.107	-.103	-.036	-.068	.007	.110	-.071	-.300*	-.231	-.056	-.243	-.127	.015	-.287	-.173	-.053	-.036	.056	-.041	-.151	-.090	.273	.008	-.066	-.100	-.097	-.056	-.042	-.036	-.002	-.114
C1	.381**	.302*	.209	.066	.093	.010	-.040	-.040	.223	.226	.269	.182	.196	.063	.036	-.073	.242	.275	.176	.123	.129	.176	.129	.076	.196	.328*	.269	.275	.302*	.298*	.229	.342*	.209	.342*	.275	.209	.262	.262	.262	.295*	.315*	-.083
D1	.272	.272	.058	.066	.100	.041	-.063	-.071	.256	.222	.263	.207	.141	-.073	.185	.005	-.097	.284	-.102	-.083	-.126	.053	.007	.019	.068	.151	.005	.112	.092	.238	.083	.156	.219	.384**	.229	.165	.141	.151	.168	.170	.170	-.243
E1	-.234	-.306*	-.281	-.279	-.231	-.274	-.402**	-.404**	-.139	-.118	.378**	.067	.138	.231	.039	-.030	-.078	.207	-.432**	-.342*	-.300*	-.377**	-.316*	-.060	-.174	-.080	-.460**	-.220	-.345*	-.165	-.397**	-.401**	-.061	-.019	-.291*	-.349*	-.347*	-.311*	-.268	-.245	-.114	-.494**

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Age; r:Gender; s: Living duration; t:Building age; u:Building facing; v: Building vicinity; w:Wall construction material; x: Window location; y: Door location; z: Family income; A1: Indoor noise; B1: Noise perception during sleeping; C1: Traffic operation at day; D1: Traffic operation at evening; E1:Traffic operation at night; F1:Traffic flow status; G1:Outdoor traffic; H1: Health issues; I1: Time of experiencing health issues; J1:Frequency of occurring health issue; K1:Duration of experiencing health issue; L1:Smoking; M1: Number of smoker; N1:Fuel; O1: Masks used; P1:Most Problematic stressor ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-8 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
F1	.171	.159	.192	.171	.128	.263	.265	.284	-.118	-.085	.204	-.167	.180	-.118	-.066	-.244	-.206	-.177	.138	.138	.241	.341*	.138	.241	.526**	.254	.448**	.328*	.262	.165	.341*	.254	-.188	.068	.118	.225	.130	.180	.080	.105	.083	.291*
G1	.175	.251	-.061	.164	.263	.117	-.015	-.021	.088	.082	.154	-.112	-.079	-.063	-.173	-.350*	-.112	.056	-.141	-.258	-.229	-.058	-.099	-.118	-.012	.180	-.052	.009	-.010	.097	-.038	.032	.224	.225	-.020	-.124	-.032	-.038	-.039	.012	-.014	-.229
H1	.034	-.100	.025	-.144	-.185	-.127	.068	.075	.040	.059	-.021	.202	.078	.005	.199	.109	.138	.163	-.025	.099	.148	.159	.313*	.205	.134	-.117	-.009	-.019	-.002	-.014	.029	-.124	-.013	-.088	-.037	.046	-.022	.009	.006	-.062	-.033	.000
I1	.029	-.105	.126	-.153	-.139	-.162	-.026	-.030	-.056	-.039	-.183	.113	-.073	.191	.258	.235	.206	.120	.217	.195	.215	.017	.275	.159	-.152	.095	.080	.035	.140	.103	.133	-.068	-.197	-.072	.197	.198	.205	.174	.274	.162	.163	.041
J1	.150	.321*	.381**	.352*	.274	.369*	.552**	.545**	.152	.118	-.250	.107	-.130	-.135	.182	-.128	.218	.213	.305*	.224	.322*	.268	.440**	.071	.156	.165	.226	.012	.305*	.123	.337*	.325*	.393**	.301*	.438**	.389**	.325*	.263	.230	.024	.065	.210

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Age; r:Gender; s: Living duration; t:Building age; u:Building facing; v: Building vicinity; w:Wall construction material; x: Window location; y: Door location; z: Family income; A1: Indoor noise; B1: Noise perception during sleeping; C1: Traffic operation at day; D1: Traffic operation at evening; E1:Traffic operation at night; F1:Traffic flow status; G1:Outdoor traffic; H1: Health issues; I1: Time of experiencing health issues; J1:Frequency of occurring health issue; K1:Duration of experiencing health issue; L1:Smoking; M1: Number of smoker; N1:Fuel; O1: Masks used; P1:Most Problematic stressor ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-8 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
K1	-.138	.119	-.039	.121	.102	.115	.116	.103	.173	.174	-.022	.096	-.244	-.152	.096	.013	-.001	.267	.101	-.008	-.078	.117	.087	.007	.090	.053	-.227	-.317*	-.223	-.074	-.076	-.062	.074	.155	-.102	-.093	-.001	-.053	-.107	-.098	-.090	.116
L1	-.278	-.241	-.341*	-.288	-.203	-.260	-.537**	-.536**	-.052	-.017	.314*	-.133	.163	.236	.050	-.027	.015	.198	-.424**	-.323*	-.208	-.454**	-.294*	-.118	-.278	-.038	-.356*	-.228	-.249	-.053	-.411**	-.278	-.091	-.111	-.288	-.313*	-.278	-.268	-.273	-.171	-.053	-.407**
M1	.035	.117	-.036	-.002	.016	.018	.125	.132	.081	.086	.034	-.009	-.047	-.100	-.091	-.018	.166	-.068	.012	.064	.004	.087	.224	-.073	.079	-.026	-.139	-.276	-.114	-.071	-.092	-.100	.094	.130	-.158	-.104	-.067	-.025	-.073	-.064	.007	.040
N1	-.066	-.037	-.241	-.018	.009	-.162	-.091	-.097	-.079	-.161	-.305*	-.201	-.077	.036	-.151	-.127	-.322*	-.270	-.190	-.304*	-.380**	-.144	-.339*	-.367*	-.331*	-.347*	-.234	-.010	-.233	-.297*	-.246	-.229	.054	-.271	-.219	-.247	-.224	-.221	-.266	-.195	-.190	.072
O1	-.138	-.129	-.156	-.131	-.082	-.213	-.195	-.192	-.046	-.034	-.034	-.077	-.124	.085	.032	-.019	.187	-.143	-.016	.048	.021	.058	-.038	-.093	-.123	-.103	-.093	.091	-.201	-.187	-.175	-.219	-.191	-.400**	-.220	-.185	-.233	-.251	-.207	-.214	-.219	.113
P1	-.037	-.068	.097	-.014	-.036	.031	-.017	-.015	-.059	-.061	0.000	.205	.163	.138	.132	.021	.050	.255	.009	-.066	-.049	-.178	-.051	.003	-.079	-.134	-.126	-.024	.066	.083	.111	.053	.176	.192	.053	-.005	.035	.102	.108	.045	-.011	-.341*

where, A: L_{peak}; B: L_{max}; C: L_{min}; D: L_{eq}; E: L_{10}; F: L_{50}; G: L_{90}; H: L_{95}; I: $NC_{(L90)}$; J: $NC_{(L95)}$; K: 20 Hz; L: 25 Hz; M:31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz;V:250; W: 315 Hz; X:400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b:1000 Hz; c: 1250 Hz; d:1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000 Hz; j: 6300 Hz; k: 8000 Hz; l: 10000 Hz; m: 12500 Hz; n: 16000 Hz; o:20000 Hz; p: $PM_{2.5}$; q: Age; r:Gender; s: Living duration; t:Building age; u:Building facing; v: Building vicinity; w:Wall construction material; x: Window location; y: Door location; z: Family income; A1: Indoor noise; B1: Noise perception during sleeping; C1: Traffic operation at day; D1: Traffic operation at evening; E1:Traffic operation at night; F1:Traffic flow status; G1:Outdoor traffic; H1: Health issues; I1: Time of experiencing health issues; J1:Frequency of occurring health issue; K1:Duration of experiencing health issue; L1:Smoking; M1: Number of smoker; N1:Fuel; O1: Masks used; P1:Most Problematic stressor ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-9 Spearman correlation of office workers' noise and $PM_{2.5}$ exposure, annoyance and blood pressure

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
A	1																																																
B	.810**	1																																															
C	.610**	.675**	1																																														
D	.843**	.915**	.810**	1																																													
E	.874**	.947**	.663**	.944**	1																																												
F	.735**	.802**	.850**	.950**	.820**	1																																											
G	.661**	.704**	.944**	.848**	.701**	.881**	1																																										

where, A : L_{peak} ; B : L_{max} ; C : L_{min} ; D: L_{eq} ; E : L_{10} ; F: L_{50} ; G: L_{90} ; H: L_{95}; I :$NC_{(L90)}$; J: $NC_{(L95)}$; K : 20 Hz; L:25 Hz; M :31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz; V: 250 Hz; W: 315 Hz; X: 400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b: 1000 Hz; c:1250 Hz; d: 1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000Hz; j:6300 Hz; k: 8000Hz; l:10000 Hz; m:12500 Hz; n:16000 Hz; o: 20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s:Roadside annoyance; t: Average annoyance score; u: Systolic blood pressure; v: Diastolic blood pressure; w: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-9 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
H	.637**	.687**	.937**	.828**	.680**	.862**	.983**	1																																									
I	.382**	.425**	-.192*	.236*	.493**	.045	-.208*	-.210*	1																																								
J	.432**	.471**	-.118	.304**	.547**	.118	-.125	-.174	.943**	1																																							
K	-.193*	-.144	-.107	-.141	-.183	-.130	-.067	-.068	-.118	-.115	1																																						
L	-.131	-.129	-.151	-.166	-.138	-.181	-.125	-.118	.005	-.020	.096	1																																					
M	-.036	.088	.074	.110	.057	.116	.096	.098	-.066	-.045	.224*	.090	1																																				
N	.001	.006	.019	.000	-.044	.019	.059	.021	-.152	-.082	.149	-.125	.445**	1																																			

where, A : L_{peak} ; B : L_{max} ; C : L_{min} ; D: L_{eq} ; E : L_{10} ; F: L_{50} ; G: L_{90} ; H: L_{95}; I :$NC_{(L90)}$; J: $NC_{(L95)}$; K : 20 Hz; L:25 Hz; M :31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz; V: 250 Hz; W: 315 Hz; X: 400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b: 1000 Hz; c:1250 Hz; d: 1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000Hz; j:6300 Hz; k: 8000Hz; l:10000 Hz; m:12500 Hz; n:16000 Hz; o: 20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s:Roadside annoyance; t: Average annoyance score; u: Systolic blood pressure; v: Diastolic blood pressure; w: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-9 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
O	-.105	-.079	.058	-.085	-.139	-.051	.057	.055	-.261**	-.221*	.096	.034	.388**	.497**	1																																		
P	.149	.149	.264**	.179	.135	.192*	.313**	.288**	-.158	-.102	-.123	-.193*	.160	.203*	.336**	1																																	
Q	.182	.199*	.128	.204*	.166	.223*	.184	.185	-.019	-.001	-.068	-.035	.143	.203*	-.022	.177	1																																
R	.327**	.297**	.437**	.349**	.247*	.349**	.485**	.481**	-.270**	-.232*	-.183	.026	.182	.101	.236*	.270**	.323**	1																															
S	.088	.139	.139	.159	.119	.174	.213*	.217*	-.131	-.121	-.111	.031	.220*	.275**	.266**	.280**	.326**	.429**	1																														
T	.308**	.296**	.442**	.349**	.243*	.391**	.466**	.454**	-.259**	-.216*	-.103	.055	.209*	.271**	.353**	.251**	.248**	.510**	.427**	1																													
U	.453**	.450**	.619**	.523**	.403**	.572**	.633**	.627**	-.224*	-.184	-.104	-.002	.197*	.137	.096	.232*	.371**	.616**	.372**	.612**	1																												

where, A : L_{peak} ; B : L_{max} ; C : L_{min} ; D: L_{eq} ; E : L_{10} ; F: L_{50} ; G: L_{90} ; H: L_{95}; I :$NC_{(L90)}$; J: $NC_{(L95)}$; K : 20 Hz; L:25 Hz; M :31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz; V: 250 Hz; W: 315 Hz; X: 400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b: 1000 Hz; c:1250 Hz; d: 1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000Hz; j:6300 Hz; k: 8000Hz; l:10000 Hz; m:12500 Hz; n:16000 Hz; o: 20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s:Roadside annoyance; t: Average annoyance score; u: Systolic blood pressure; v: Diastolic blood pressure; w: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-9 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
V	.332**	.357**	.328**	.367**	.355**	.375**	.299**	.291**	.200*	.196*	.006	-.075	-.293**	-.412**	-.226*	-.013	-.033	.027	-.176	.072	.137	1																											
W	.407**	.430**	.532**	.509**	.404**	.529**	.549**	.544**	-.155	-.074	.076	-.148	-.029	.052	.140	.131	.098	.148	.026	.370**	.393**	.248**	1																										
X	.580**	.675**	.728**	.746**	.644**	.776**	.754**	.733**	-.026	.037	-.046	-.185	.048	-.076	-.041	.172	.163	.291**	.035	.311**	.503**	.365**	.550**	1																									
Y	.490**	.621**	.592**	.617**	.569**	.615**	.598**	.590**	.091	.131	.009	-.192*	-.039	-.192*	-.134	.169	.017	.173	-.085	.258**	.357**	.530**	.473**	.726**	1																								
Z	.563**	.639**	.654**	.691**	.643**	.685**	.675**	.687**	.100	.115	-.133	-.150	-.054	-.212*	-.237*	.165	.071	.256**	.049	.239*	.404**	.415**	.506**	.688**	.749**	1																							
a	.634**	.680**	.650**	.724**	.674**	.700**	.674**	.683**	.109	.125	-.133	-.092	-.082	-.324**	-.211*	.134	.061	.381**	.038	.233*	.404**	.459**	.419**	.664**	.667**	.856**	1																						
b	.589**	.654**	.713**	.695**	.615**	.680**	.725**	.736**	-.027	-.016	-.182	-.148	-.009	-.139	-.057	.263**	.143	.436**	.110	.310**	.512**	.377**	.436**	.616**	.665**	.810**	.828**	1																					

where, A : L_{peak} ; B : L_{max} ; C : L_{min} ; D: L_{eq} ; E : L_{10} ; F: L_{50} ; G: L_{90} ; H: L_{95}; I :$NC_{(L90)}$; J: $NC_{(L95)}$; K : 20 Hz; L:25 Hz; M :31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz; V: 250 Hz; W: 315 Hz; X: 400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b: 1000 Hz; c:1250 Hz; d: 1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000Hz; j:6300 Hz; k: 8000Hz; l:10000 Hz; m:12500 Hz; n:16000 Hz; o: 20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s:Roadside annoyance; t: Average annoyance score; u: Systolic blood pressure; v: Diastolic blood pressure; w: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-9 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
c	.636**	.661**	.667**	.703**	.647**	.690**	.694**	.704**	.066	.076	-.121	-.124	-.026	-.242*	-.116	.221*	.073	.410**	.065	.309**	.515**	.357**	.439**	.696**	.685**	.830**	.856**	.862**	1																				
d	.581**	.610**	.632**	.671**	.607**	.664**	.651**	.649**	.073	.106	-.077	-.112	-.058	-.302**	-.091	.229*	.005	.295**	.027	.246*	.359**	.428**	.429**	.654**	.681**	.766**	.809**	.786**	.846**	1																			
e	.657**	.622**	.669**	.689**	.610**	.675**	.683**	.677**	.031	.072	-.181	-.204*	.021	-.097	.014	.368**	.190*	.391**	.163	.354**	.518**	.357**	.428**	.583**	.584**	.661**	.729**	.780**	.733**	.828**	1																		
f	.700**	.714**	.681**	.757**	.697**	.737**	.727**	.708**	.097	.153	-.060	-.177	.184	.095	.090	.375**	.254**	.363**	.204*	.334**	.562**	.208*	.441**	.599**	.398**	.442**	.513**	.524**	.591**	.598**	.718**	1																	
g	.513**	.543**	.451**	.569**	.536**	.530**	.464**	.454**	.136	.169	-.034	-.121	.234*	.262**	.059	.102	.305**	.236*	.281**	.219*	.383**	.029	.220*	.292**	.055	.062	.179	.158	.153	.134	.329**	.695**	1																
h	.646**	.609**	.521**	.658**	.620**	.597**	.542**	.534**	.115	.147	-.023	-.103	.212*	.322**	.125	.033	.245*	.326**	.322**	.435**	.489**	.083	.290**	.336**	.178	.189*	.281**	.343**	.284**	.236*	.440**	.580**	.726**	1															
i	.611**	.431**	.407**	.473**	.449**	.423**	.420**	.426**	.054	.065	-.048	-.048	.158	.216*	.171	.115	.127	.393**	.317**	.542**	.495**	.072	.257**	.270**	.199*	.229*	.328**	.366**	.397**	.330**	.493**	.459**	.392**	.766**	1														
j	.556**	.381**	.396**	.426**	.381**	.383**	.417**	.424**	.015	.030	.071	-.109	.190*	.196*	.210*	.114	.136	.366**	.214*	.437**	.437**	.093	.235*	.279**	.208*	.205*	.283**	.341**	.382**	.312**	.469**	.504**	.351**	.668**	.813**	1													

where, A : L_{peak} ; B : L_{max} ; C : L_{min} ; D: L_{eq} ; E : L_{10} ; F: L_{50} ; G: L_{90} ; H: L_{95}; I :$NC_{(L90)}$; J: $NC_{(L95)}$; K : 20 Hz; L:25 Hz; M :31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz; V: 250 Hz; W: 315 Hz; X: 400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b: 1000 Hz; c:1250 Hz; d: 1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000Hz; j:6300 Hz; k: 8000Hz; l:10000 Hz; m:12500 Hz; n:16000 Hz; o: 20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s:Roadside annoyance; t: Average annoyance score; u: Systolic blood pressure; v: Diastolic blood pressure; w: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-9 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
k	.558**	.404**	.450**	.462**	.419**	.425**	.456**	.457**	.030	.049	-.003	-.059	.237*	.112	.207*	.113	.106	.419**	.186	.479**	.483**	.107	.237*	.316**	.205*	.248**	.307**	.340**	.369**	.303**	.444**	.497**	.335**	.612**	.763**	.907**	1												
l	.659**	.482**	.472**	.555**	.511**	.520**	.481**	.482**	.095	.121	-.092	-.147	.272**	.149	.237*	.133	.147	.405**	.173	.406**	.430**	.116	.275**	.393**	.241*	.291**	.387**	.406**	.417**	.376**	.536**	.562**	.408**	.645**	.753**	.809**	.871**	1											
m	.587**	.446**	.403**	.504**	.466**	.479**	.406**	.405**	.138	.149	-.026	-.220*	.337**	.344**	.296**	.118	.193*	.233*	.231*	.402**	.353**	-.015	.267**	.335**	.183	.240*	.262**	.327**	.297**	.269**	.460**	.463**	.396**	.651**	.711**	.729**	.731**	.861**	1										
n	.591**	.457**	.356**	.480**	.465**	.432**	.354**	.360**	.194*	.199*	.017	-.315**	.244*	.302**	.247**	.081	.156	.185	.174	.318**	.296**	.062	.257**	.325**	.223*	.231*	.295**	.323**	.309**	.280**	.445**	.438**	.396**	.611**	.687**	.679**	.608**	.771**	.909**	1									
o	.524**	.426**	.374**	.461**	.427**	.435**	.343**	.358**	.153	.147	-.015	-.311**	.168	.232*	.230*	.070	.155	.121	.152	.275**	.268**	.144	.306**	.344**	.238*	.264**	.327**	.330**	.301**	.295**	.473**	.418**	.381**	.546**	.579**	.580**	.479**	.687**	.831**	.949**	1								
p	.118	-.032	.084	.055	.010	.069	.085	.073	-.090	-.056	.019	.074	.167	.046	-.092	-.161	-.003	.141	-.091	-.013	.026	-.062	.000	-.001	-.149	-.031	.031	.027	.042	-.003	.016	.115	.139	.152	.201*	.185	.201*	.194*	.101	.083	.026	1							
q	-.002	-.044	.115	-.004	-.047	.021	.119	.136	-.127	-.152	.121	.084	.060	.128	.151	.048	.026	.156	.058	.111	.090	.015	.121	.000	-.106	-.067	-.068	.008	-.022	-.026	.043	.139	.043	.066	.096	.153	.131	.053	.054	-.038	-.032	.261**	1						

where, A : L_{peak} ; B : L_{max} ; C : L_{min} ; D: L_{eq} ; E : L_{10} ; F: L_{50} ; G: L_{90} ; H: L_{95}; I :$NC_{(L90)}$; J: $NC_{(L95)}$; K : 20 Hz; L:25 Hz; M :31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz; V: 250 Hz; W: 315 Hz; X: 400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b: 1000 Hz; c:1250 Hz; d: 1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000Hz; j:6300 Hz; k: 8000Hz; l:10000 Hz; m:12500 Hz; n:16000 Hz; o: 20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s:Roadside annoyance; t: Average annoyance score; u: Systolic blood pressure; v: Diastolic blood pressure; w: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-9 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
r	-.029	-.067	.109	-.010	-.059	.018	.093	.114	-.120	-.155	.030	-.015	.079	.149	.146	.069	-.016	.138	.006	.155	.093	-.027	.185	-.002	-.082	-.073	-.085	-.042	-.049	-.051	.027	.123	.071	.047	.066	.073	.082	.027	.051	-.056	-.046	.235*	.892**	1					
s	-.036	-.006	-.005	.014	.010	.061	-.001	-.012	.003	.004	-.089	-.266**	-.034	-.047	-.061	.149	.145	.002	.004	-.086	.042	.080	-.107	.025	.041	.024	.038	.030	.056	-.026	.021	-.018	-.069	-.100	-.132	-.136	-.155	-.130	-.079	-.059	-.040	-.195*	-.007	.035	1				
t	-.045	-.060	.088	-.015	-.057	.035	.085	.099	-.125	-.161	.021	-.136	.068	.080	.083	.112	.075	.127	.020	.043	.094	.033	.039	.003	-.058	-.043	-.039	.015	.004	-.032	.057	.105	.031	-.016	-.025	.018	.003	-.046	-.004	-.092	-.077	.090	.748**	.787**	.586**	1			
u	.106	.075	-.034	.089	.135	.069	.001	-.046	.134	.213*	-.152	-.168	-.136	.001	-.175	.083	-.018	-.058	.095	-.001	.041	.072	-.036	.114	.091	.144	.120	.021	.070	-.041	-.014	-.031	-.044	-.001	-.062	-.110	-.101	-.041	-.022	-.023	-.038	-.064	-.162	-.124	.171	-.052	1		
v	.091	.013	-.141	-.010	.058	-.055	-.099	-.154	.170	.245*	-.102	-.121	-.095	.046	-.081	.076	-.051	-.041	.075	-.041	-.076	-.035	-.057	-.031	-.007	.047	.040	-.032	-.024	-.061	-.008	-.027	-.027	-.039	-.047	-.016	.000	.076	.096	.084	.035	-.056	-.112	-.107	.005	-.104	.744**	1	
w	.038	.074	.027	.105	.100	.143	.089	.064	.082	.095	-.039	.011	.051	.024	.036	.170	.083	-.035	.105	-.034	.050	-.015	-.019	.155	.089	.062	.048	.108	.083	.158	.175	.129	.069	.034	.047	.021	.022	.012	.057	.050	.054	-.023	-.020	-.031	.102	.046	.053	.131	1

where, A : L_{peak} ; B : L_{max} ; C : L_{min} ; D: L_{eq} ; E : L_{10} ; F: L_{50} ; G: L_{90} ; H: L_{95}; I : $NC_{(L90)}$; J: $NC_{(L95)}$; K : 20 Hz; L:25 Hz; M :31.5 Hz; N: 40 Hz; O: 50 Hz; P: 63 Hz; Q: 80 Hz; R: 100 Hz; S: 125 Hz; T:160 Hz; U: 200 Hz; V: 250 Hz; W: 315 Hz; X: 400 Hz; Y: 500 Hz; Z: 630 Hz; a: 800 Hz; b: 1000 Hz; c:1250 Hz; d: 1600 Hz; e:2000 Hz; f: 2500 Hz; g: 3150 Hz; h: 4000 Hz; i: 5000Hz; j:6300 Hz; k: 8000Hz; l:10000 Hz; m:12500 Hz; n:16000 Hz; o: 20000 Hz; p: $PM_{2.5}$; q: Home annoyance; r: Workplace annoyance; s:Roadside annoyance; t: Average annoyance score; u: Systolic blood pressure; v: Diastolic blood pressure; w: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-10 Spearman correlation of office workers' questionnaire, annoyance and blood pressure

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i
A	1																																		
B	-.244*	1																																	
C	-.073	-.048	1																																
D	-.146	-.023	.064	1																															
E	.140	-.009	-.151	-.049	1																														
F	.067	-.100	-.092	-.043	.370**	1																													
G	.098	-.162	.068	.466**	-.117	-.010	1																												
H	.105	-.178	.028	.522**	-.082	-.020	.852**	1																											

where, A: Age; B: Gender; C: Building facing; D: Building vicinity; E : Building age; F:Living duration; G:Window location; H:Door Location; I:Wall construction material; J: Family income; K:Number of smokers; L:Indoor noise; M: Noise perception during sleeping; N: Main outdoor air pollution source ; O: Traffic operation in day; P: Traffic operation in evening; Q: Traffic operation in night; R: Traffic flow status; S:Health issues; T:Time of experiencing health issue; U: Frequency of health disorder; V: Duration of experiencing health issues; W: Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Type of fuel used; a: Smoking; b: Degree of breathing problem near traffic signal; c: Home annoyance; d: Workplace annoyance; e: Roadside annoyance; f: Average annoyance score; g: Systolic blood pressure; h: Diastolic blood pressure; i: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-10 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i
I	-.040	.146	.061	.072	-.034	.113	-.022	-.034	1																										
J	.058	-.032	.142	.104	.041	-.116	.012	-.017	.011	1																									
K	-.070	-.058	.018	.117	-.114	-.084	0.000	-.010	-.169	.054	1																								
L	.078	-.162	-.074	-.031	-.088	-.073	-.099	-.047	-.066	.020	.014	1																							
M	-.235*	.116	-.050	-.178	.074	.094	-.181	-.212*	.043	-.066	.131	.026	1																						
N	-.295**	.007	.108	-.103	-.127	-.010	-.189	-.149	-.078	.085	.354**	.133	.524**	1																					
O	.112	.025	-.053	-.350**	-.007	-.007	-.390**	-.437**	.079	-.040	-.022	.052	.441**	.135	1																				
P	.267**	.009	-.120	-.324**	.026	-.001	-.328**	-.375**	.031	-.003	.034	-.024	.481**	.143	.765**	1																			

where, A: Age; B: Gender; C: Building facing; D: Building vicinity; E : Building age; F:Living duration; G:Window location; H:Door Location; I:Wall construction material; J: Family income; K:Number of smokers; L:Indoor noise; M: Noise perception during sleeping; N: Main outdoor air pollution source ; O: Traffic operation in day; P: Traffic operation in evening; Q: Traffic operation in night; R: Traffic flow status; S:Health issues; T:Time of experiencing health issue; U: Frequency of health disorder; V: Duration of experiencing health issues; W: Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Type of fuel used; a: Smoking; b: Degree of breathing problem near traffic signal; c: Home annoyance; d: Workplace annoyance; e: Roadside annoyance; f: Average annoyance score; g: Systolic blood pressure; h: Diastolic blood pressure; i: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-10 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i
Q	.157	.066	-.089	-.352**	-.028	.093	-.283**	-.357**	.200*	-.098	-.069	-.140	.460**	-.018	.747**	.804**	1																		
R	.265**	-.027	-.020	-.273**	.121	-.025	-.226*	-.242*	-.006	.084	-.165	.055	-.015	-.018	.633**	.592**	.479**	1																	
S	.166	.115	.127	-.161	-.065	-.222*	.011	.002	.072	.077	.049	.068	.121	.020	.049	.129	.138	-.026	1																
T	.036	.058	-.004	-.100	-.016	.008	-.059	-.090	.015	.091	-.052	.064	.123	.167	.104	.027	.006	.037	-.048	1															
U	.089	-.121	-.254**	-.104	-.023	.085	-.031	-.098	.232*	.136	.024	.129	.227*	.111	.177	.183	.227*	-.019	-.069	.545**	1														
V	-.001	-.017	.041	-.007	-.060	-.049	-.021	-.140	.135	.061	.075	.090	.239*	.167	.195*	.117	.093	.040	-.002	.658**	.658**	1													
W	-.235*	.021	.040	-.047	-.076	-.022	-.172	-.109	.098	-.037	-.013	-.041	.166	.140	.050	.119	.049	-.093	-.042	-.168	-.098	-.185	1												

where, A: Age; B: Gender; C: Building facing; D: Building vicinity; E : Building age; F:Living duration; G:Window location; H:Door Location; I:Wall construction material; J: Family income; K:Number of smokers; L:Indoor noise; M: Noise perception during sleeping; N: Main outdoor air pollution source ; O: Traffic operation in day; P: Traffic operation in evening; Q: Traffic operation in night; R: Traffic flow status; S:Health issues; T:Time of experiencing health issue; U: Frequency of health disorder; V: Duration of experiencing health issues; W: Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Type of fuel used; a: Smoking; b: Degree of breathing problem near traffic signal; c: Home annoyance; d: Workplace annoyance; e: Roadside annoyance; f: Average annoyance score; g: Systolic blood pressure; h: Diastolic blood pressure; i: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-10 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i
X	.010	-.008	-.065	-.067	-.193*	-.241*	-.027	.037	-.079	.102	-.042	-.075	.001	-.021	.018	-.001	-.007	-.097	-.064	-.020	-.068	-.095	.026	1											
Y	.240*	-.083	-.102	.009	.147	.094	.273**	.283**	.057	-.270**	.032	.012	-.077	-.254**	-.173	-.043	-.015	-.046	.117	-.096	.020	-.007	-.294**	-.115	1										
Z	-.012	.004	-.129	-.102	.076	.017	-.089	-.110	.152	.056	-.037	.012	.040	-.025	.101	.022	.030	.000	-.038	.090	.165	.064	.131	-.059	-.126	1									
a	-.045	-.065	.021	.109	-.106	-.068	.021	0.000	-.170	.042	.995**	.023	.133	.346**	-.010	.055	-.046	-.145	.056	-.049	.040	.082	-.015	-.062	.045	-.052	1								
b	.189	.000	.135	-.196*	.071	.151	-.277**	-.320**	.008	.057	-.027	.081	.108	.137	.560**	.417**	.460**	.495**	-.011	.176	.145	.165	-.059	.024	-.166	.026	-.011	1							
c	-.152	.153	-.095	-.029	-.060	-.019	.015	-.021	.192*	-.245*	.101	-.109	.440**	-.255**	.048	.100	.333**	-.003	.105	-.248*	-.031	-.093	.085	-.013	.140	-.044	.103	-.111	1						
d	-.141	.072	-.040	-.006	-.085	-.049	.074	.012	.122	-.165	.165	-.110	.438**	-.135	.067	.344	.418*	.066	.095	-.274**	-.088	-.078	.073	.066	.098	-.076	.171	-.042	.937**	1					

where, A: Age; B: Gender; C: Building facing; D: Building vicinity; E : Building age; F:Living duration; G:Window location; H:Door Location; I:Wall construction material; J: Family income; K:Number of smokers; L:Indoor noise; M: Noise perception during sleeping; N: Main outdoor air pollution source ; O: Traffic operation in day; P: Traffic operation in evening; Q: Traffic operation in night; R: Traffic flow status; S:Health issues; T:Time of experiencing health issue; U: Frequency of health disorder; V: Duration of experiencing health issues; W: Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Type of fuel used; a: Smoking; b: Degree of breathing problem near traffic signal; c: Home annoyance; d: Workplace annoyance; e: Roadside annoyance; f: Average annoyance score; g: Systolic blood pressure; h: Diastolic blood pressure; i: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-10 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i
e	.249**	.009	.114	-.164	.089	.082	-.192*	-.285**	.022	-.022	-.109	-.041	.024	.014	.553**	.513**	.471**	.550**	.053	.092	.048	.087	-.022	-.005	-.087	.046	-.088	.793**	-.007	.035	1				
f	-.007	.117	.036	-.118	-.020	.011	-.081	-.176	.188	-.171	.069	-.142	.250**	-.113	.366**	.347**	.492**	.304**	.100	-.153	.027	.003	.066	.054	.022	-.039	.087	.402**	.748**	.787**	.586**	1			
g	.270**	-.402**	-.050	-.057	.004	.133	.057	.043	-.067	.137	-.074	-.001	-.066	-.178	.116	.138	.168	.252**	.036	-.028	-.046	-.106	-.126	.137	-.029	.064	-.075	.221*	-.162	-.124	.171	-.052	1		
h	.146	-.483**	.040	.006	.000	-.001	.187	.144	-.137	.099	-.088	.008	-.064	-.121	-.041	.002	-.020	.099	-.077	.043	.022	.028	-.114	.204*	.032	.075	-.093	.006	-.112	-.107	.005	-.104	.744**	1	
i	.017	-.013	.202*	-.255**	-.133	-.241*	-.158	-.185	.033	.286**	-.134	-.192*	-.040	-.082	.073	.075	.096	.124	-.043	.045	-.056	-.035	.047	.203*	-.077	.019	-.141	.075	-.020	-.031	.102	.046	.053	.131	1

where, A: Age; B: Gender; C: Building facing; D: Building vicinity; E : Building age; F:Living duration; G:Window location; H:Door Location; I:Wall construction material; J: Family income; K:Number of smokers; L:Indoor noise; M: Noise perception during sleeping; N: Main outdoor air pollution source ; O: Traffic operation in day; P: Traffic operation in evening; Q: Traffic operation in night; R: Traffic flow status; S:Health issues; T:Time of experiencing health issue; U: Frequency of health disorder; V: Duration of experiencing health issues; W: Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Type of fuel used; a: Smoking; b: Degree of breathing problem near traffic signal; c: Home annoyance; d: Workplace annoyance; e: Roadside annoyance; f: Average annoyance score; g: Systolic blood pressure; h: Diastolic blood pressure; i: Heart rate ***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-11 Spearman correlation of office noise and $PM_{2.5}$ exposure and questionnaire response

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
q	-.015	-.036	-.087	.019	.006	-.148	-.040	-.048	-.001	.080	-.001	-.013	-.035	-.005	.022	.073	.058	.071	.221*	-.135	-.020
r	.050	-.012	-.035	.028	-.073	-.132	.039	.010	-.098	.196*	.024	-.052	-.134	-.058	-.008	.073	.032	.034	.251**	-.122	-.002
S	-.085	.133	-.025	.039	-.070	-.227*	-.077	-.094	.024	.099	.095	-.073	.053	-.115	.085	.029	.075	-.012	.266**	-.003	.045

	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
q	-.123	.025	.027	.054	.124	-.011	-.105	-.015	-.036	-.087	.019	.006	-.148	-.040	-.048	-.001	.080	-.001	-.013	-.035	-.005
r	-.093	.013	.022	-.056	.233*	.009	-.074	.050	-.012	-.035	.028	-.073	-.132	.039	.010	-.098	.196*	.024	-.052	-.134	-.058
S	.000	.070	-.021	-.125	.295**	.080	.099	-.085	.133	-.025	.039	-.070	-.227*	-.077	-.094	.024	.099	.095	-.073	.053	-.115

where, A:Age; B:Gender; C: Building facing; D:Building vicinity; E: Building age; F: Living duration; G: Window location; H: Door location; I: Wall construction material; J:Family income; K: Number of smoker; L:Indoor noise; M:Noise perception during sleeping; N: Outdoor pollution source; O:Traffic operation in day; P:Traffic operation in evening; Q:Traffic operation in night; R:Traffic flow status; S: Health issues; T: Time of experiencing health issue; U: Frequency of health issues; V: Duration of experiencing health issues; W:Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Fuel type; a: Smoking habit; b: Degree of breathing problem near traffic signal; c: L_{peak}; d: L_{max}; e: L_{min}; f: L_{eq}; g: L_{10}; h: L_{50}; i: L_{90}; j: L_{95}; k: $NC_{(L90)}$; l: $NC_{(L95)}$; m: 20 Hz; n: 25 Hz; o:31.5 Hz; p: 40 Hz; q: 50 Hz; r: 63 Hz; s: 80 Hz; t: 100 Hz; u: 125 Hz; v:160 Hz; w: 200 Hz; x:250 Hz; y: 315 Hz; z:400 Hz; A1: 500 Hz; B1: 630 Hz; C1: 800 Hz; D1:1000 Hz; E1: 1250 Hz; F1:1600 Hz; G1:2000 Hz; H1: 2500 Hz; I1: 3150 Hz; J1: 4000 Hz; K1: 5000 Hz; L1: 6300 Hz; M1: 8000 Hz; N1:10000 Hz; O1: 12500 Hz; P1: 16000 Hz; Q1:20000 Hz; R1: $PM_{2.5}$

***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-11 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
t	.015	.014	-.051	.028	-.078	-.187	-.066	-.086	-.059	.211*	.032	-.069	-.077	-.052	.092	.141	.108	.065	.268**	-.128	-.001
u	.087	-.067	-.042	.010	-.064	-.142	-.040	-.054	-.102	.165	.023	-.064	-.102	-.035	.030	.139	.073	.064	.273**	-.149	-.063
v	-.029	.067	-.032	.001	-.078	-.187	-.136	-.163	-.036	.219*	-.006	-.084	-.036	-.069	.142	.131	.129	.080	.233*	-.083	.039
w	-.075	.118	-.014	-.040	-.045	-.171	-.119	-.142	-.005	.121	.083	-.053	.075	-.093	.163	.091	.161	.015	.271**	-.033	.076

	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
t	-.108	.112	.052	-.114	.200*	.018	-.053	.015	.014	-.051	.028	-.078	-.187	-.066	-.086	-.059	.211*	.032	-.069	-.077	-.052
u	-.144	.039	.053	-.013	.159	.010	-.062	.087	-.067	-.042	.010	-.064	-.142	-.040	-.054	-.102	.165	.023	-.064	-.102	-.035
v	-.056	.134	.065	-.169	.209*	-.021	.009	-.029	.067	-.032	.001	-.078	-.187	-.136	-.163	-.036	.219*	-.006	-.084	-.036	-.069
w	-.011	.040	-.010	-.117	.261**	.067	-.037	-.075	.118	-.014	-.040	-.045	-.171	-.119	-.142	-.005	.121	.083	-.053	.075	-.093

where, A:Age; B:Gender; C: Building facing; D:Building vicinity; E: Building age; F: Living duration; G: Window location; H: Door location; I: Wall construction material; J:Family income; K: Number of smoker; L:Indoor noise; M:Noise perception during sleeping; N: Outdoor pollution source; O:Traffic operation in day; P:Traffic operation in evening; Q:Traffic operation in night; R:Traffic flow status; S: Health issues; T: Time of experiencing health issue; U: Frequency of health issues; V: Duration of experiencing health issues; W:Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Fuel type; a: Smoking habit; b: Degree of breathing problem near traffic signal; c: L_{peak}; d: L_{max}; e: L_{min}; f: L_{eq}; g: L_{10}; h: L_{50}; i: L_{90}; j: L_{95}; k: $NC_{(L90)}$; l: $NC_{(L95)}$; m: 20 Hz; n: 25 Hz; o:31.5 Hz; p: 40 Hz; q: 50 Hz; r: 63 Hz; s: 80 Hz; t: 100 Hz; u: 125 Hz; v:160 Hz; w: 200 Hz; x:250 Hz; y: 315 Hz; z:400 Hz; A1: 500 Hz; B1: 630 Hz; C1: 800 Hz; D1:1000 Hz; E1: 1250 Hz; F1:1600 Hz; G1:2000 Hz; H1: 2500 Hz; I1: 3150 Hz; J1: 4000 Hz; K1: 5000 Hz; L1: 6300 Hz; M1: 8000 Hz; N1:10000 Hz; O1: 12500 Hz; P1: 16000 Hz; Q1:20000 Hz; R1: $PM_{2.5}$

***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-11 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
x	-.089	.138	-.034	-.047	-.061	-.179	-.124	-.143	.005	.133	.090	-.043	.101	-.074	.164	.080	.163	-.003	.280**	-.026	.110	.012	.050	-.026	-.126	.269**	.073	-.051	-.089	.138	-.034	-.047	-.061	-.179	-.124	-.143	.005	.133	.090	-.043	.101	-.074
y	.184	-.193*	-.002	.034	-.015	.042	.089	.083	-.124	.073	-.102	-.045	-.190*	.063	-.207*	-.018	-.143	-.015	.059	-.192*	-.222*	-.236*	-.074	.099	.102	-.061	-.106	-.057	.184	-.193*	-.002	.034	-.015	.042	.089	.083	-.124	.073	-.102	-.045	-.190*	.063
z	.142	-.202*	.028	.075	.004	.044	.079	.076	-.124	.039	-.127	-.070	-.215*	.015	-.200*	-.013	-.136	.002	.053	-.200*	-.290**	-.270**	-.054	.091	.114	-.035	-.130	-.056	.142	-.202*	.028	.075	.004	.044	.079	.076	-.124	.039	-.127	-.070	-.215*	.015
A1	-.252**	.144	-.016	-.053	-.071	.005	-.109	-.090	-.035	-.063	-.029	.095	.000	.031	.047	-.107	-.002	-.125	-.166	-.106	-.105	-.084	.016	.070	-.288**	-.052	-.033	-.074	-.252**	.144	-.016	-.053	-.071	.005	-.109	-.090	-.035	-.063	-.029	.095	.000	.031

where, A:Age; B:Gender; C: Building facing; D:Building vicinity; E: Building age; F: Living duration; G: Window location; H: Door location; I: Wall construction material; J:Family income; K: Number of smoker; L:Indoor noise; M:Noise perception during sleeping; N: Outdoor pollution source; O:Traffic operation in day; P:Traffic operation in evening; Q:Traffic operation in night; R:Traffic flow status; S: Health issues; T: Time of experiencing health issue; U: Frequency of health issues; V: Duration of experiencing health issues; W:Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Fuel type; a: Smoking habit; b: Degree of breathing problem near traffic signal; c: L_{peak}; d: L_{max}; e: L_{min}; f: L_{eq}; g: L_{10}; h: L_{50}; i: L_{90}; j: L_{95}; k: $NC_{(L90)}$; l: $NC_{(L95)}$; m: 20 Hz; n: 25 Hz; o:31.5 Hz; p: 40 Hz; q: 50 Hz; r: 63 Hz; s: 80 Hz; t: 100 Hz; u: 125 Hz; v:160 Hz; w: 200 Hz; x:250 Hz; y: 315 Hz; z:400 Hz; A1: 500 Hz; B1: 630 Hz; C1: 800 Hz; D1:1000 Hz; E1: 1250 Hz; F1:1600 Hz; G1:2000 Hz; H1: 2500 Hz; I1: 3150 Hz; J1: 4000 Hz; K1: 5000 Hz; L1: 6300 Hz; M1: 8000 Hz; N1:10000 Hz; O1: 12500 Hz; P1: 16000 Hz; Q1:20000 Hz; R1: $PM_{2.5}$

***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-11 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
B1	.092	.122	-.200*	-.136	.131	.033	-.068	-.025	.008	-.164	-.032	.213*	-.067	-.187	-.250**	-.176	-.254**	-.132	.126	-.129	-.086
C1	-.152	.124	.011	-.006	-.010	-.020	-.029	-.024	-.017	.185	.144	-.094	-.005	.058	.022	.099	-.020	-.054	.039	-.110	.001
D1	-.075	.078	.038	-.045	-.037	-.013	-.025	.027	-.002	.138	.178	.058	.028	.083	.103	.104	.068	.129	-.020	-.058	-.068
E1	-.171	.189	.141	.015	-.066	-.075	-.030	.015	-.101	.082	.172	-.026	.081	.014	-.051	-.002	-.075	-.041	-.041	.133	.024

	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
B1	-.181	.006	-.144	.164	-.055	-.037	-.288**	.092	.122	-.200*	-.136	.131	.033	-.068	-.025	.008	-.164	-.032	.213*	-.067	-.187
C1	.004	.137	.052	-.215*	.046	.140	-.042	-.152	.124	.011	-.006	-.010	-.020	-.029	-.024	-.017	.185	.144	-.094	-.005	.058
D1	.043	.013	.031	-.153	.020	.184	-.009	-.075	.078	.038	-.045	-.037	-.013	-.025	.027	-.002	.138	.178	.058	.028	.083
E1	.098	.047	.018	-.085	.069	.175	-.065	-.171	.189	.141	.015	-.066	-.075	-.030	.015	-.101	.082	.172	-.026	.081	.014

where, A:Age; B:Gender; C: Building facing; D:Building vicinity; E: Building age; F: Living duration; G: Window location; H: Door location; I: Wall construction material; J:Family income; K: Number of smoker; L:Indoor noise; M:Noise perception during sleeping; N: Outdoor pollution source; O:Traffic operation in day; P:Traffic operation in evening; Q:Traffic operation in night; R:Traffic flow status; S: Health issues; T: Time of experiencing health issue; U: Frequency of health issues; V: Duration of experiencing health issues; W:Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Fuel type; a: Smoking habit; b: Degree of breathing problem near traffic signal; c: L_{peak}; d: L_{max}; e: L_{min}; f: L_{eq}; g: L_{10}; h: L_{50}; i: L_{90}; j: L_{95}; k: $NC_{(L90)}$; l: $NC_{(L95)}$; m: 20 Hz; n: 25 Hz; o:31.5 Hz; p: 40 Hz; q: 50 Hz; r: 63 Hz; s: 80 Hz; t: 100 Hz; u: 125 Hz; v:160 Hz; w: 200 Hz; x:250 Hz; y: 315 Hz; z:400 Hz; A1: 500 Hz; B1: 630 Hz; C1: 800 Hz; D1:1000 Hz; E1: 1250 Hz; F1:1600 Hz; G1:2000 Hz; H1: 2500 Hz; I1: 3150 Hz; J1: 4000 Hz; K1: 5000 Hz; L1: 6300 Hz; M1: 8000 Hz; N1:10000 Hz; O1: 12500 Hz; P1: 16000 Hz; Q1:20000 Hz; R1: $PM_{2.5}$

***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-11 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
F1	.158	-.061	.190*	-.016	-.119	.006	.033	.031	-.035	-.057	.107	-.078	.097	-.092	.162	.146	.155	.049	.167	.077	.107	.042	-.114	-.117	.128	.097
G1	.043	.007	.009	-.059	-.094	-.111	-.023	-.008	.118	.168	-.101	.029	.079	.147	.146	.204*	.175	.177	.218*	-.013	.153	-.038	-.016	.066	-.034	.076
H1	-.079	.087	-.096	.061	.011	-.097	-.033	-.037	.140	.147	.146	.101	.216*	-.032	.113	.090	.069	.063	.104	.119	.233*	.020	.077	-.001	.012	.238*
I1	-.028	-.097	-.031	-.163	-.090	-.021	-.087	.001	.157	.152	.031	.186	.253**	.189	.196*	.170	.115	.169	.151	.118	.312**	.051	.074	-.037	-.014	.210*

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
F1	.114	.192*	.158	-.061	.190*	-.016	-.119	.006	.033	.031	-.035	-.057	.107	-.078	.097	-.092
G1	-.093	.040	.043	.007	.009	-.059	-.094	-.111	-.023	-.008	.118	.168	-.101	.029	.079	.147
H1	.126	.000	-.079	.087	-.096	.061	.011	-.097	-.033	-.037	.140	.147	.146	.101	.216*	-.032
I1	.029	.106	-.028	-.097	-.031	-.163	-.090	-.021	-.087	.001	.157	.152	.031	.186	.253**	.189

where, A:Age; B:Gender; C: Building facing; D:Building vicinity; E: Building age; F: Living duration; G: Window location; H: Door location; I: Wall construction material; J:Family income; K: Number of smoker; L:Indoor noise; M:Noise perception during sleeping; N: Outdoor pollution source; O:Traffic operation in day; P:Traffic operation in evening; Q:Traffic operation in night; R:Traffic flow status; S: Health issues; T: Time of experiencing health issue; U: Frequency of health issues; V: Duration of experiencing health issues; W:Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Fuel type; a: Smoking habit; b: Degree of breathing problem near traffic signal; c: L_{peak}; d: L_{max}; e: L_{min}; f: L_{eq}; g: L_{10}; h: L_{50}; i: L_{90}; j: L_{95}; k: $NC_{(L90)}$; l: $NC_{(L95)}$; m: 20 Hz; n: 25 Hz; o:31.5 Hz; p: 40 Hz; q: 50 Hz; r: 63 Hz; s: 80 Hz; t: 100 Hz; u: 125 Hz; v:160 Hz; w: 200 Hz; x:250 Hz; y: 315 Hz; z:400 Hz; A1: 500 Hz; B1: 630 Hz; C1: 800 Hz; D1:1000 Hz; E1: 1250 Hz; F1:1600 Hz; G1:2000 Hz; H1: 2500 Hz; I1: 3150 Hz; J1: 4000 Hz; K1: 5000 Hz; L1: 6300 Hz; M1: 8000 Hz; N1:10000 Hz; O1: 12500 Hz; P1: 16000 Hz; Q1:20000 Hz; R1: $PM_{2.5}$

***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-11(Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
J1	-.071	.067	-.141	.044	-.041	-.092	-.030	.041	.069	.083	.129	.207*	.097	.063	.119	.072	.026	.149	.106	-.031	.120	-.062	.005	-.064	.011	.292**	.111	-.112	-.071	.067	-.141	.044	-.041	-.092	-.030	.041	.069	.083	.129	.207*	.097	.063
K1	-.084	.130	-.155	.046	-.093	-.225*	-.090	-.080	.127	.212*	.021	.070	.174	.013	.164	.102	.109	.051	.185	.031	.180	.025	.082	.072	-.168	.311**	-.002	.052	-.084	.130	-.155	.046	-.093	-.225*	-.090	-.080	.127	.212*	.021	.070	.174	.013
L1	.031	.143	-.023	.145	-.023	-.096	.039	.036	-.185	.090	.012	-.158	-.079	-.201*	-.075	-.104	-.028	.022	.095	-.097	-.121	-.241*	-.098	.081	.024	.036	.003	.004	.031	.143	-.023	.145	-.023	-.096	.039	.036	-.185	.090	.012	-.158	-.079	-.201*
M1	-.227*	.053	-.062	.053	-.091	-.221*	-.088	-.072	-.062	.001	.100	-.089	.070	.056	.165	.004	.080	-.001	.194*	-.053	-.015	.077	.010	-.073	-.137	.136	.098	-.112	-.227*	.053	-.062	.053	-.091	-.221*	-.088	-.072	-.062	.001	.100	-.089	.070	.056

where, A:Age; B:Gender; C: Building facing; D:Building vicinity; E: Building age; F: Living duration; G: Window location; H: Door location; I: Wall construction material; J:Family income; K: Number of smoker; L:Indoor noise; M:Noise perception during sleeping; N: Outdoor pollution source; O:Traffic operation in day; P:Traffic operation in evening; Q:Traffic operation in night; R:Traffic flow status; S: Health issues; T: Time of experiencing health issue; U: Frequency of health issues; V: Duration of experiencing health issues; W:Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Fuel type; a: Smoking habit; b: Degree of breathing problem near traffic signal; c: L_{peak}; d: L_{max}; e: L_{min}; f: L_{eq}; g: L_{10}; h: L_{50}; i: L_{90}; j: L_{95}; k: $NC_{(L90)}$; l: $NC_{(L95)}$; m: 20 Hz; n: 25 Hz; o:31.5 Hz; p: 40 Hz; q: 50 Hz; r: 63 Hz; s: 80 Hz; t: 100 Hz; u: 125 Hz; v:160 Hz; w: 200 Hz; x:250 Hz; y: 315 Hz; z:400 Hz; A1: 500 Hz; B1: 630 Hz; C1: 800 Hz; D1:1000 Hz; E1: 1250 Hz; F1:1600 Hz; G1:2000 Hz; H1: 2500 Hz; I1: 3150 Hz; J1: 4000 Hz; K1: 5000 Hz; L1: 6300 Hz; M1: 8000 Hz; N1:10000 Hz; O1: 12500 Hz; P1: 16000 Hz; Q1:20000 Hz; R1: $PM_{2.5}$

***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

Table A-11 (Continued)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
N1	.052	.047	-.002	-.019	-.045	-.137	-.086	-.150	-.045	.185	-.014	-.118	-.037	-.156	.082	.067	.079	.041	.213*	-.117	-.011	-.044	.001	-.002	-.210*	.231*
O1	.012	.008	.097	.009	-.071	-.225*	-.046	-.064	-.138	.110	.014	-.065	-.040	-.113	.065	.006	.025	.034	.170	-.036	-.040	-.008	-.027	.005	-.107	.212*
P1	.097	-.006	-.048	-.055	-.088	-.244*	-.083	-.112	-.048	.094	-.026	-.073	.064	-.102	.187	.064	.087	.068	.302**	-.021	.059	.044	-.084	.059	-.139	.255**
Q1	.084	.051	-.146	-.009	-.016	-.178	-.038	-.093	-.012	.097	-.095	-.052	-.042	-.224*	.087	.014	.042	.061	.183	.018	.150	.034	-.113	.051	-.041	.280**
R1	.037	.081	-.081	.014	-.078	-.284**	.002	-.020	-.008	.129	.063	-.129	.080	-.145	.123	.089	.097	.013	.179	.123	.246*	.102	-.024	.020	-.107	.276**

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
N1	-.027	-.062	.052	.047	-.002	-.019	-.045	-.137	-.086	-.150	-.045	.185	-.014	-.118	-.037	-.156
O1	-.011	-.042	.012	.008	.097	.009	-.071	-.225*	-.046	-.064	-.138	.110	.014	-.065	-.040	-.113
P1	-.043	.028	.097	-.006	-.048	-.055	-.088	-.244*	-.083	-.112	-.048	.094	-.026	-.073	.064	-.102
Q1	-.108	.016	.084	.051	-.146	-.009	-.016	-.178	-.038	-.093	-.012	.097	-.095	-.052	-.042	-.224*
R1	.053	-.030	.037	.081	-.081	.014	-.078	-.284**	.002	-.020	-.008	.129	.063	-.129	.080	-.145

where, A:Age; B:Gender; C: Building facing; D:Building vicinity; E: Building age; F: Living duration; G: Window location; H: Door location; I: Wall construction material; J:Family income; K: Number of smoker; L:Indoor noise; M:Noise perception during sleeping; N: Outdoor pollution source; O:Traffic operation in day; P:Traffic operation in evening; Q:Traffic operation in night; R:Traffic flow status; S: Health issues; T: Time of experiencing health issue; U: Frequency of health issues; V: Duration of experiencing health issues; W:Masks used; X: Hearing aid used; Y: Most problematic stressor; Z: Fuel type; a: Smoking habit; b: Degree of breathing problem near traffic signal; c: L_{peak}; d: L_{max}; e: L_{min}; f: L_{eq}; g: L_{10}; h: L_{50}; i: L_{90}; j: L_{95}; k: $NC_{(L90)}$; l: $NC_{(L95)}$; m: 20 Hz; n: 25 Hz; o:31.5 Hz; p: 40 Hz; q: 50 Hz; r: 63 Hz; s: 80 Hz; t: 100 Hz; u: 125 Hz; v:160 Hz; w: 200 Hz; x:250 Hz; y: 315 Hz; z:400 Hz; A1: 500 Hz; B1: 630 Hz; C1: 800 Hz; D1:1000 Hz; E1: 1250 Hz; F1:1600 Hz; G1:2000 Hz; H1: 2500 Hz; I1: 3150 Hz; J1: 4000 Hz; K1: 5000 Hz; L1: 6300 Hz; M1: 8000 Hz; N1:10000 Hz; O1: 12500 Hz; P1: 16000 Hz; Q1:20000 Hz; R1: $PM_{2.5}$

***. Correlation is significant at the 0.05 level (2-tailed) and **. Correlation is significant at the 0.01 level (2-tailed).**

LIST OF PUBLICATIONS

Journals

Published

Guha, A.K. and Gokhale, S., (2023). Urban workers' cardiovascular health due to exposure to traffic-originated $PM_{2.5}$ and noise pollution in different microenvironments. **Science of the Total Environment**, 859, p.160268.

Communicated

Guha, A.K. and Gokhale, S.,Urban traffic borne $PM_{2.5}$ and noise impacts on workers' annoyances in different microenvironments .(Atmospheric Pollution Research)

Under Preparation

Guha, A.K. and Gokhale, S., Characterisation of traffic noise source apportionment in heterogeneous urban road environment.

Conferences

Guha, A.K. and Gokhale, S., (2023), Road traffic borne $PM_{2.5}$ and noise indices in an urban roadside microenvironments, **"8th Indian International Conference on Air Quality Management (IICAQM 2023): Measurement, Modelling, Health Risk, and Public Policy.** on 06- 08 December 2023, Indian Institute of Science (IISc),Bangalore, India**.(Third best oral presentation)**

Guha,A.,K.,Chowdhury,R.,Das,R.,Chowdhury, A., K.,Gokhale,S.,(2018), A short term noise study near curb side ambient environment for the vehicular movement, **"Recycle 2018''**,IIT Guwahati (Poster Presentation)

Guha,A.,K.,Gokhale,S.,(2018),A short term ambient noise study in a cement plant, **"Research Conclave,2018''**,IIT Guwahati(Poster Presentation)

Guha,A.,K.,Gokhale,S., (2018), Reduction of the combine impact of traffic originated $PM_{2.5}$ and noise on human being, **"ATIPC,2018"**,IIEST Kolkata (Conference Oral Presentation)