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Assessment of Noise Pollution and Health Impacts of the Exposed Population in an Urban Area of Chhattisgarh, India

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ABSTRACT

The present study aimed to evaluate the possible impact of noise pollution. This study was conducted in Raipur, the capital of Chhattisgarh state, India, to analyze the relationship between noise pollution and health complaints. A total of 18 locations were selected for monitoring noise pollution levels in the morning (9:00-10:30 AM) and evening (7:00-8:30 PM). Noise maps were prepared for both the time interval, and it was found that the highest equivalent noise level (L_{eq})of 81.31 dBA was observed at location L3 whereas the lowest L_{eq} of 63.25 dBA was observed at L16 in the morning and in the evening 77.33 dBA at L3 and 60.14 dBA at L16 were observed. A questionnaire survey was performed on the population (n = 400) exposed to noise and analyzed through a variance-based partial least square (PLS) structural equation model (SEM). From the survey, it was found that most of the respondents are exposed to higher noise levels and are facing health issues of "pain in the ear," "rise in blood pressure," "loss of sleep," "whistling and buzzing" in their ear, "headache," "heaviness" and "efficiency problem." A total of 109 hypotheses were proposed and analyzed through bootstrapping with a subsample size of 5000 in SmartPLS software. 18 hypotheses were found to be significant in the proposed model. SEM analysis revealed an interrelation between noise pollution and health effects. It is recommended that strict regulation in nearby sensitive areas must be imposed and an awareness drive on a large scale shall be conducted to enlighten the city's population regarding noise effects as well as various measures for controlling.

INTRODUCTION

One of the invisible pollutants present in our environment is noise. Any disturbing or unwanted sound that affects the wellbeing and health of a human or any other organism is defined as noise pollution. Air and noise pollution are mainly generated by road traffic, which both affect human health (Stansfeld & Clark 2015). For the community noise, the main source is road traffic. It is well known to everyone that, mainly in larger cities, noise pollution is continuously affecting the exposed population (Wu et al. 2019). Major factors contributing to the higher environmental noise levels are increased rail, road, and air traffic, economic growth, and urbanization (de Souza et al. 2019, Ramanathan & Renuka 2008). The increase in noise levels on roads is mainly due to an increase in the number of vehicles, vehicles type and conditions, road quality, the density of vehicles, and weather conditions (Farooqi et al. 2019, Tabraiz et al. 2015, Gilani & Mir 2021, Hunashal & Patil 2011) Apart from this, festivals also contribute to higher noise levels in India. The Diwali festival is one of the major factors contributing to air and noise pollution throughout the country (Garg et al. 2017). A large number of railway helps improve public transport but cause different harmful effects on the nearby population (Sarikavak & Boxall 2019). Noise from locomotives during idling or operation, bunching, and stretching wagons during braking or acceleration, and noise from the flanging of wheels on the curve is typical noise generated from the railways (Jiang et al. 2015). Electrified rail line causes less air pollution, but at the other end reduction in noise pollution is not observed. Noise from the tire can dominate other sources at 70km.h^{-1} speed of vehicles. Hence noise on the road can be mitigated by limiting the speed in streets in densely populated areas. If the road gradient is reduced by 5%, then 1.5dB of noise can also be reduced by plantations of trees can help in mitigating higher levels of noise. Similarly, reducing 10dB of noise construction of barriers along the road is recommended (Farooqi et al. 2019).

People with higher noise levels in surroundings significantly have higher noise annoyance and stress levels. Continuous exposure to higher noise levels causes permanent or temporary hearing loss. It can induce physiological effects (anxiety, depression), which can be permanent or temporary (de Souza et al. 2019, Al-Mutairi et al. 2011, Juang et al. 2010, Chakraborty & Banerjee 2007). It can also cause high blood pressure, irregular heartbeat, sleep disturbance, and lack of concentration and efficiency (Farooqi et al. 2020, Terry et al. 2021, Hahad et al. 2021). In the middle-aged group, self-reported hypertension and higher noise levels from road traffic are interconnected (Bodin et al. 2009). Noise also affects adversely to children by causing premature birth and low birth weight (Stansfeld &Clark 2015). According to the World Bank Population Report of 2019, India is the second largest country in terms of population worldwide (World Bank 2019). As per the Department of Economic Division (2019) United Nations, India will overtake China by 2027 in terms of population (UN 2019). As of 31st March 2019, India also has 296 million registered vehicles, and an annual growth rate of 9.9 percent during the last ten years (2009 to 2019) was recorded (MORTH 2019). In Raipur, the total number of registered vehicles is 1.5 million, among which 1.4 million are non-transport vehicles and 0.13 million are transport vehicles as of 31st March 2019. The number of registered vehicles in the city has increased by a very large number. The total number of vehicles registered in Raipur City from 2010 to 2019 is shown in Fig. 1, and the percentage of different classes of vehicles as of 31st March 2019 is shown in Fig. 2.

People living near noisy streets and residential areas near highways and railways are most vulnerable to noise pollution. The exposed people mostly face difficulty in sleeping and get awakened at night, as a result of which they feel tired and have work efficiency problems mostly. Also, these populations have short and long-term effects due to higher noise levels (Ristovska & Lekaviciute 2013, Gholami et al. 2012). This study was designed to determine the impacts of noise pollution on the selected target population. Raipur City, the capital of Chhattisgarh state of India, is selected as the study site in the current investigation. To find the relationship between the demographic, physiological, and psychological factors of the exposed population in the study variance-

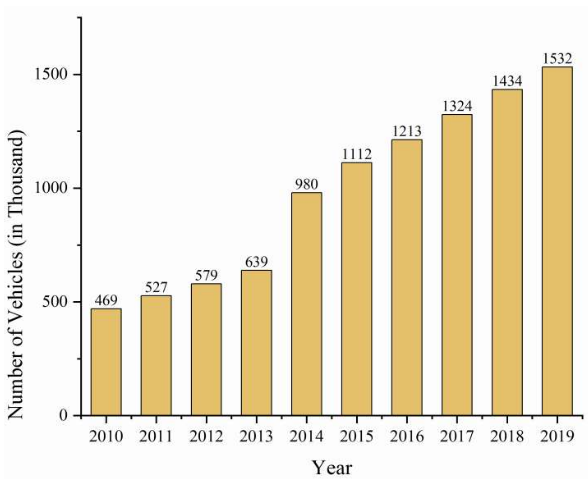

Fig. 1: Total number of registered vehicles.

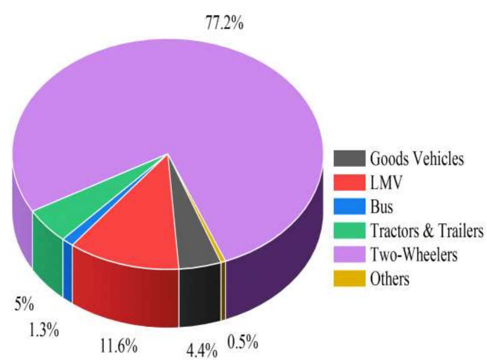

Fig. 2: Different classes of vehicles in Raipur.

based structural equation model (SEM) method is used. This work using SEM is conducted for the first time in the selected study area, which makes it new and different. The previous study by Fhyri and Aasvang (2010) incorporated SEM to find the relationship between traffic noise and heart problems. Also, SEM was used by Fyhri and Klaeboe (2009) to explore the relation between noise from traffic, self-reported health issues, annoyance, and sensitivity. Their study suggested a strong relationship exists between sensitivity to noise and health complaints. Variance-based Partial Least Square (PLS) SEM is mostly preferred over covariance-based (CB-SEM) by most researchers because of its different advantages (Ooi et al. 2018). PLS-SEM performance on a different scale is good, and like other multivariate analysis techniques, it thoroughly evaluates the results, makings it reliable in studying hypothetical theory (Hair et al. 2011. 2012).

MATERIALS AND METHODS

Description of the Study Area

The acoustic study was conducted in Raipur City of Chhattisgarh, India (1st August to 15th September 2022). The City is situated in the East Central part of the state at the latitude of 21° 16'N, longitude 81° 36'E with an altitude of 289.5m above mean sea level. Raipur is the capital of Chhattisgarh, with the highest population density among other state cities. As per the census 2011 of India, the total population in Raipur is 1,010,433, of which 518,611 are male, and 491,822 are female, respectively. The density of the city is 328 people per km^2. The city's climate is sub-humid, with an annual average rainfall of 1489mm, of which 1348mm is received during the monsoon season. Historically it has been found that wind speed in September was 6.8mph. Raipur is well connected to other cities of the state, and it has a wide road network. The city's road network and sampling locations are shown in Fig. 3.

Study Design

This study measured equivalent noise levels (L_{eq}) at major city squares and a questionnaire survey. Random sampling was used for the survey work. The sample size was determined using the formula $4pq.L^{-2}$(Sahu et al. 2020). "p" was taken as 50% with a permissible error of 5%. A 95% confidence limit sample size was determined as 396, rounded to 400. Measurement of L_{eq} was done both in the morning and evening. Noise maps were prepared using the inverse distance weighting (IDW) interpolation method in ArcGIS software. A survey was carried out on the determined sample size, and data were analyzed using PLS-SEM. The detailed methodology of the study is shown in Fig. 4.

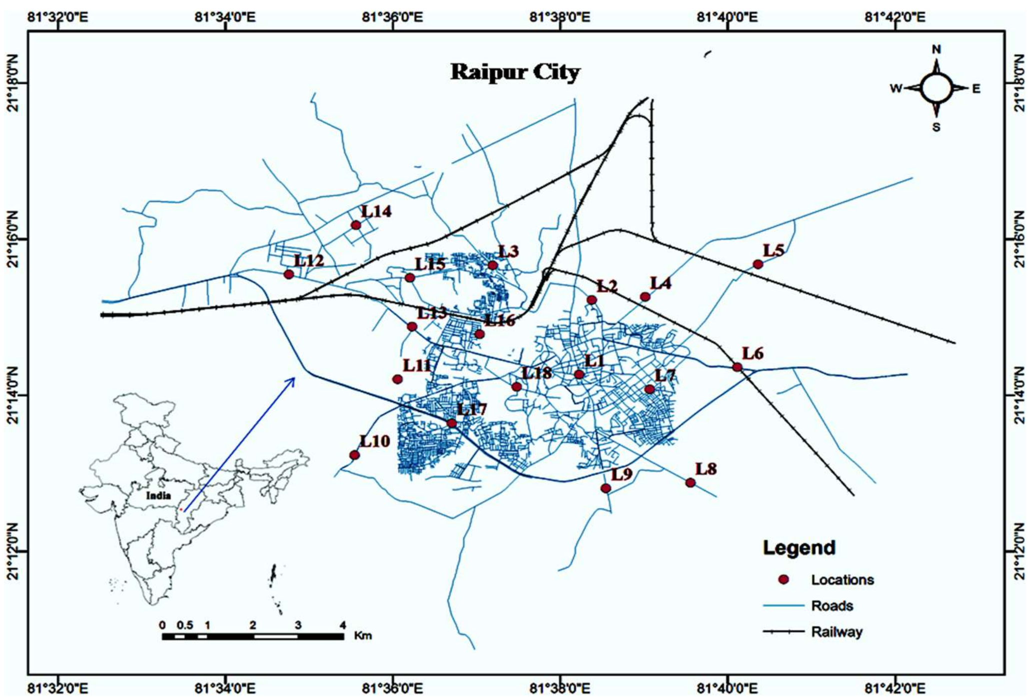

Fig. 3: Study area map.

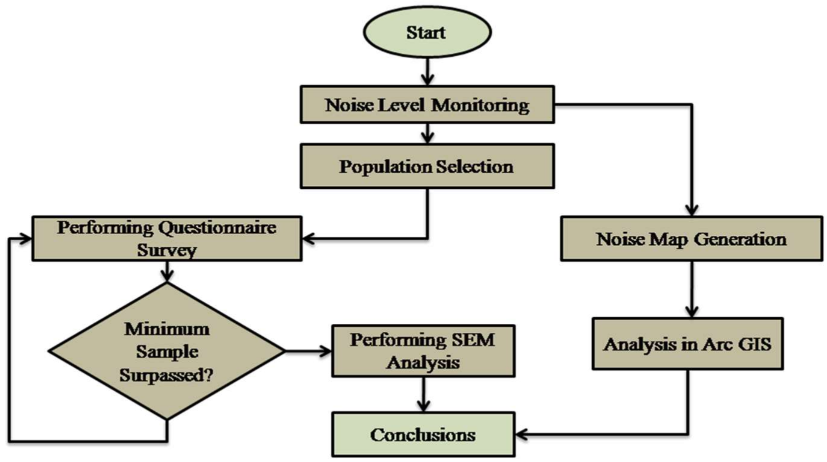

Fig. 4: Methodology of the study.

Noise Measurement and Mapping

Noise levels were observed at 18 locations in the study area using Extech (Model: SL-400) sound level meter (SLM) during the morning (9:00-10:30 AM) and evening (7:00-8:30 PM). The instrument was mounted on a tripod and elevated to 1.5 m above the ground level. ISO 1996-1:2016 standard method was used for measuring noise at different locations (ISO 1996-1 2016). SLM was placed on the side of the road 2m from reflecting objects. L_{eq} was recorded at each location, and an average value was obtained using statistical analysis. The latitude and longitude of each location were recorded and inserted in ArcGIS software to prepare the map. The average L_{eq} of each location was used to perform IDW interpolation in GIS, and noise maps were prepared for each morning and evening, respectively.

Table 1: Framed question for the survey

Noise Exposure Questionnaire You are: __Male __ Female Your Age: ___ Occupation:_________	
Q1	Do you feel that there is noise in your area of work and home that is disturbing you?
Q2	Do you feel that this noise is affecting you?
Q3	Can you say that the high level of noise affects your health?
Q4	How often are you exposed to high noise in your daily routine?
Q5	Due to noise, do you feel pain in your ears after/while listening to music?
Q6	Is there whistling and buzzing in your ears when exposed to higher noise levels?
Q7	Due to noise, do you feel Interference with speech?
Q8	Due to noise, do you feel Annoyance?
Q9	Due to noise, do you feel that you have Efficiency Problems?
Q10	Due to noise, do you feel Loss of sleep/insomnia?
Q11	Due to noise, do you feel Visual Disturbances?
Q12	Due to the noise, do you feel Giddiness?
Q13	Due to noise, do you feel Raise in Blood Pressure?
Q14	Due to noise, do you feel Headache and heaviness?
Q15	Due to noise, do you feel an Increased heart rate and breathing?
Q16	Due to noise, do you feel an Increase in sweating?
Q17	Do your friends say that you are a habitual debater?
6 Point Scale used:	1 - Rarely 2 - Sometimes 3 - Often 4 - Usually 5 - Never 6 - Always

Table 2: Proposed hypothesis for the study

Hypothesis	There is relation between	Hypothesis	There is relation between
HP1	Age and gender	HP55	Q1 and Q3
HP2	Age and occupation	HP56	Q1 and Q4
HP3	Age and Q1	HP57	Q1 and Q5
HP4	Age and Q2	HP58	Q1 and Q6
HP5	Age and Q3	HP59	Q1 and Q7
HP6	Age and Q4	HP60	Q1 and Q8
HP7	Age and Q5	HP61	Q1 and Q9
HP8	Age and Q6	HP62	Q1 and Q10
HP9	Age and Q7	HP63	Q1 and Q11
HP10	Age and Q8	HP64	Q1 and Q12
HP11	Age and Q9	HP65	Q1 and Q13
HP12	Age and Q10	HP66	Q1 and Q14
HP13	Age and Q11	HP67	Q1 and Q15
HP14	Age and Q12	HP68	Q1 and Q16
HP15	Age and Q13	HP69	Q1 and Q17
HP16	Age and Q14	HP70	Q2 and Q5
HP17	Age and Q15	HP71	Q2 and Q6
HP18	Age and Q16	HP72	Q2 and Q7
HP19	Age and Q17	HP73	Q2 and Q8
HP20	Gender and occupation	HP74	Q2 and Q9
HP21	Gender and Q1	HP75	Q2 and Q10
HP22	Gender and Q2	HP76	Q2 and Q11
HP23	Gender and Q3	HP77	Q2 and Q12
HP24	Gender and Q4	HP78	Q2 and Q13
HP25	Gender and Q5	HP79	Q2 and Q14
HP26	Gender and Q6	HP80	Q2 and Q15
HP27	Gender and Q7	HP81	Q2 and Q16
HP28	Gender and Q8	HP82	Q2 and Q17
HP29	Gender and Q9	HP83	Q3 and Q5
HP30	Gender and Q10	HP84	Q3 and Q6
HP31	Gender and Q11	HP85	Q3 and Q7
HP32	Gender and Q12	HP86	Q3 and Q8
HP33	Gender and Q13	HP87	Q3 and Q9
HP34	Gender and Q14	HP88	Q3 and Q10
HP35	Gender and Q15	HP89	Q3 and Q11
HP36	Gender and Q16	HP90	Q3 and Q12
HP37	Gender and Q17	HP91	Q3 and Q13
HP38	Occupation and Q1	HP92	Q3 and Q14
HP39	Occupation and Q2	HP93	Q3 and Q15
HP40	Occupation and Q3	HP94	Q3 and Q16
HP41	Occupation and Q4	HP95	Q3 and Q17
HP42	Occupation and Q5	HP96	Q4 and Q3
HP43	Occupation and Q6	HP97	Q4 and Q5
HP44	Occupation and Q7	HP98	Q4 and Q6
HP45	Occupation and Q8	HP99	Q4 and Q7
HP46	Occupation and Q9	HP100	Q4 and Q8
HP47	Occupation and Q10	HP101	Q4 and Q9
HP48	Occupation and Q11	HP102	Q4 and Q10
HP49	Occupation and Q12	HP103	Q4 and Q11
HP50	Occupation and Q13	HP104	Q4 and Q12
HP51	Occupation and Q14	HP105	Q4 and Q13
HP52	Occupation and Q15	HP106	Q4 and Q14
HP53	Occupation and Q16	HP107	Q4 and Q15
HP54	Occupation and Q17	HP108	Q4 and Q16
		HP109	Q4 and Q17

Questionnaire Survey

Questionnaire surveys were conducted on the population (n = 400) exposed to high noise levels. The questionnaire was divided into different sections containing demographic information of the respondents, such as their age, gender, occupation, and duration of the exposed high noise levels. 6 point scale was used to get the response from the exposed population. “Rarely = 1”, “Sometimes = 2”, “Often = 3”,“Usually = 4”,“Never = 5,” and “Always = 6” were the anchors to the questionnaire. Respondents were asked to fill out the survey form based on their thinking over the last 12 months regarding noise pollution. Questions (Q1- Q17) to assess problems like sleeping, headache, pain in the ear, blood pressure, visualization, sweating, etc., were asked from the respondents. Based on the response received, statistical analysis was carried out to find the impact of noise on the exposed population of the study area. The questions that the respondents were asked are shown in Table 1.

PLS-SEM Hypothesis Development

To investigate the relationship between noise pollution and its effect on the following human hypothesis (HP) was proposed which is shown in Table 2.

Analysis of Data Through PLS-SEM

SEM path analysis is used in this study using Smart-PLS 3.0 software. SEM is expressed as a path model that estimates direct and indirect effects. SEM and path models are more advantageous and powerful than multiple regression models (Davvetas et al. 2020). A total of 109 hypotheses have been developed and examined. The hypothesis has been made by connecting demographical, physiological, and psychological factors. Bootstrap of the developed model was done, and results were obtained by taking 5000 subsamples. The developed model is shown in Fig. 5.

RESULTS AND DISCUSSION

Noise Pollution Monitoring and Mapping

This study included 18 locations for monitoring noise pollution in the morning and evening. Fig. 6 & 7 depict the noise map of the study area, respectively. Table 3 depicts the locations’ detail and the observed average L_{eq} for both intervals. A better understanding can be developed by noise map compared to tabular form. The above-mentioned figure reveals that all the locations have a higher level of noise in the environment. A road network with high traffic volume

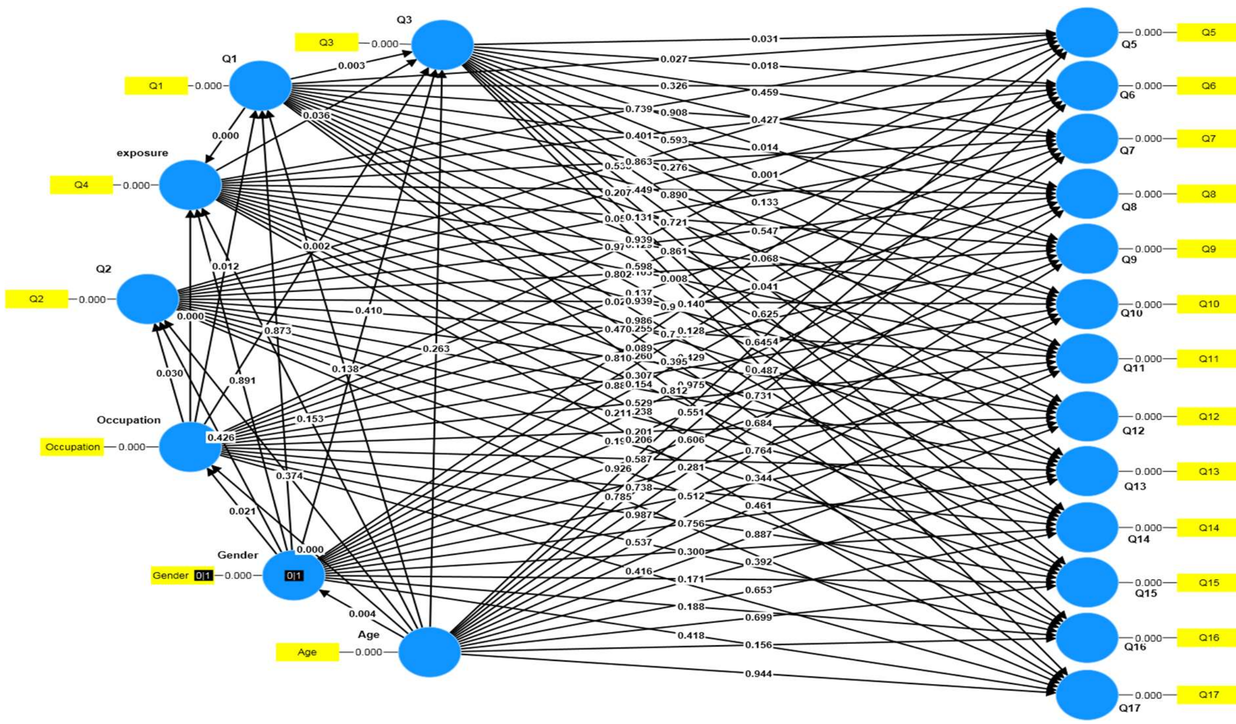

Fig. 5: Developed SEM model in Smart-PLS 3.0.

surrounds all the locations. The Highest L_{eq} of 81.31 dBA was observed at location L3, whereas the lowest L_{eq} of 63.25 dBA was observed at L16 in the morning.

Consequently,77.33 dBA at L3 and 60.14 dBA at L16 were observed in the evening. All the locations breached the ambient standard noise level prescribed by the Central Pollution Control Board (CPCB), New Delhi. While studying, it was found that in the morning, 0% of the locations had noise levels less than 50 dBA, 44.46% fell between 60 to 70 dBA, 33.34% between 70 to 75 dBA, and 22.23% above 75 dBA.

Similarly, in the evening, 0 % below 50dBA, 27.78% between 60 to 70 dBA, 38.8% between 70 to 75 dBA, and 33.34% above 75 dBA, respectively. The noise levels' results are close to those obtained in Delhi City by Mishra et al. (2021). In his study, the morning noise levels varied between 68.5 to 80.4 dBA, whereas evening varied between 71.9 to 83.7 dBA. Pathak et al. (2008) studied Varanasi city of India and found a maximum noise level of 75.3 dBA in their study location. Similar to other studies in India, our results reveal that Raipur is also facing the problem of noise pollution, and exposed people are affected by it.

Questionnaire Analysis

This study included 400 respondents in the questionnaire survey. 73.84% of the respondents were male, whereas 26.16% were female. The average age of the respondents is 30.7 ± 10.69 years. The response analysis was carried out in two phases, one for overall response and the other for a response based on age group. Fig.8 depicts the overall response, whereas Fig. 9 depicts the response in the age group. The questionnaire revealed that respondents suffer from disturbing noise in their workplace or residence. 31.28% of respondents considered "sometimes" they are exposed to a high level of noise, followed by 24.10% "usually," 20.14% "often," 13.34% "always," 9.74% "rarely," and 1.53% "never." Respondents also considered high noise affected their health and caused different physiological and psychological effects. 32.30% of considered pain in the ear "sometimes," followed by 21.53% "never" and 18.97% "often." Consequently, 22.05% reported whistling and buzzing, and 28.71% had interference with the speech in the ear "often." As per the survey report, 34.35%, 28.71%, and 33.34% of the respondents "sometimes" suffer from annoyance, efficiency problems, and sleep loss, respectively. However, 60.51%, 51.79%, and 40.10% "never" suffered from visual disturbance, giddiness, and a rise in blood pressure due to higher noise levels but 12.30%, 19.48%, and 28.20% "sometimes" suffered. 21.5% "often" felt headaches and heaviness due to noise, while 25.12% agreed that their friends say they are habitual debaters. A similar study by Swain & Goswami (2013) in Baripada, India found that due to noise, 41 % of respondents were annoyed, 11% had a loss

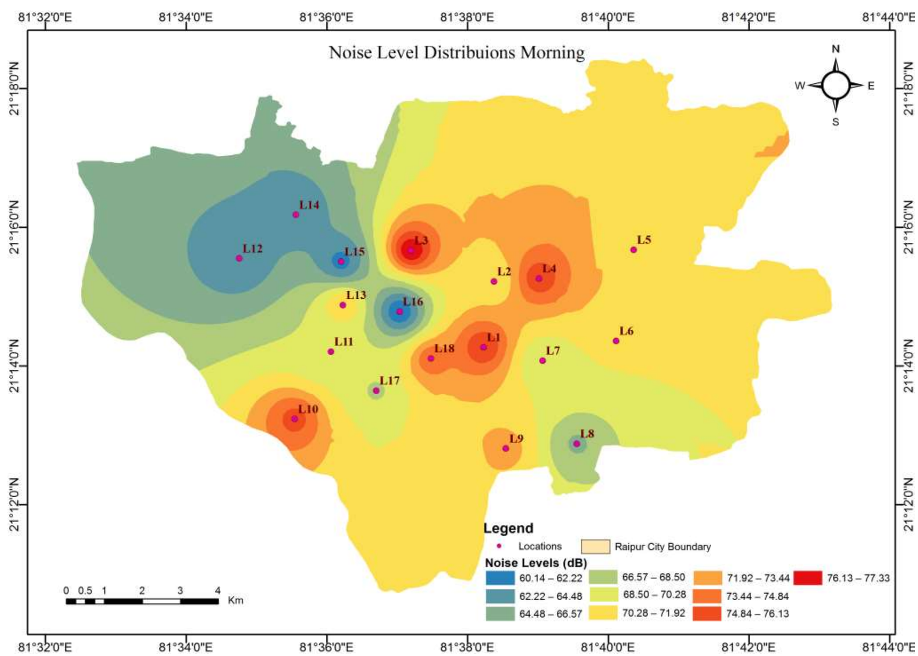

Fig. 6: Noise map of morning noise levels.

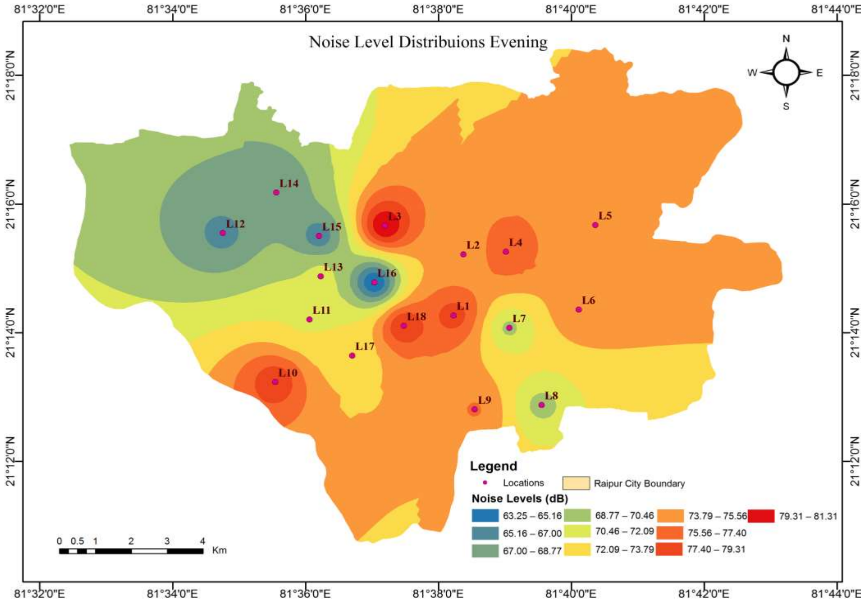

Fig. 7: Noise map of evening noise levels.

Table 3: Observed noise levels during the study

Location	Symbol	Latitude	Longitude	L_{eq} Morning	L_{eq} Evening
City Kotwali	L1	21.23781	81.63712	78.31	76.25
Mekahara	L2	21.25363	81.63961	73.75	70.54
Gudhyari	L3	21.26107	81.6199	81.31	77.33
Pandri	L4	21.25434	81.65025	77.18	75.86
Sankar Nagar	L5	21.26125	81.6727	74.19	71.15
Avanti Vihar	L6	21.23934	81.66855	74.93	70.37
Tagor Nagar	L7	21.23458	81.65112	70.11	68.42
Lalpur	L8	21.21461	81.65923	69.96	66.28
Santoshi Nagar	L9	21.21347	81.64244	75.68	72.53
Raipura	L10	21.22057	81.59239	78.73	75.39
Goal Chowk	L11	21.23674	81.60099	71.95	68.61
AIIMS Raipur	L12	21.25916	81.57929	66.45	62.25
NIT Gate	L13	21.24794	81.60383	70.99	72.24
Kabir Nagar	L14	21.26965	81.59269	67.38	62.83
Kota	L15	21.2584	81.6034	65.95	61.38
Samta Colony	L16	21.24637	81.61728	63.25	60.14
Kushalpur Chowk	L17	21.22737	81.61174	72.25	68.29
Purani Basti	L18	21.23513	81.62466	79.35	74.57

of sleep, and 34 % identified headache as a major problem. A similar response was found in a study by Pathak et al. (2008) and Murthy et al. (2007).

The survey result is analyzed based on age group. It is found that 53.84 % of the respondents below 20 years accept that "sometimes" noise pollution is present in their environment, and 76.92 % feel that noise is affecting their health. Problem-related sleep loss ranges from 30-37 % in the age groups<20, 21-30, and 31-40. This might be because this age group mostly moves around for work, study, and other activities and gets exposed to a higher level of noise. Visual disturbance and sweating have been reported very less by this age group. The rise in blood pressure due to noise in the age group 41-50 is 47.36% "sometimes." All the other effects of noise in the age group are shown graphically. The response of the respondents is shown in Table 4.

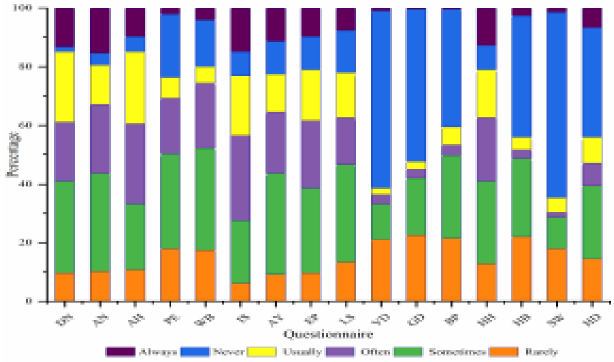

Fig. 8: Self-reported health complaints by the overall exposed population (in Percentage).

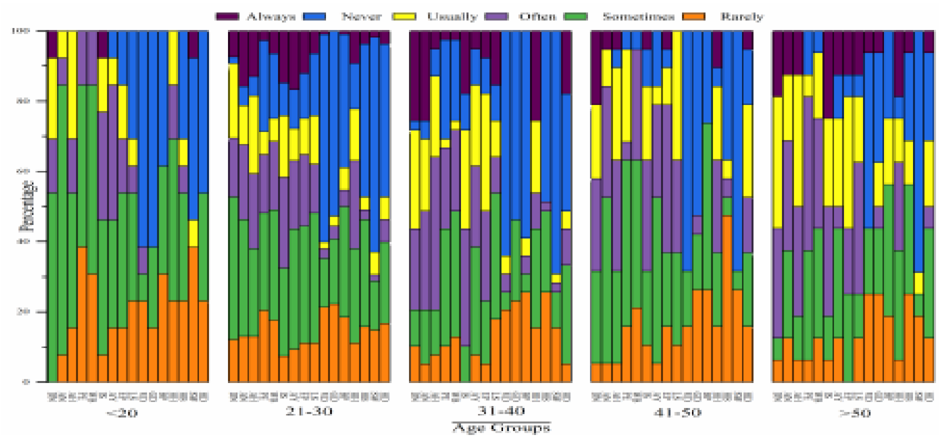

Fig. 9: Self-reported health complaint by age group population (in Percentage).

Table 4: Response of the participated population (in Percentage)

	Symbol	Rarely	Sometimes	Often	Usually	Never	Always
Disturbing Noise	DN	9.74	31.28	20.14	24.10	1.53	13.34
Affecting Noise	AN	10.25	33.34	25.58	13.34	4.10	15.38
Affecting Health	AH	10.76	22.56	27.17	24.61	5.12	9.74
Pain in Ear	PE	17.94	32.30	18.97	7.17	21.53	2.65
Whistling and buzzing	WB	17.43	34.87	22.05	5.64	15.89	4.10
Interference with speech	IS	6.15	21.53	28.71	20.51	8.20	14.87
Annoyance	AY	9.23	34.35	21.02	12.82	11.28	11.28
Efficiency Problems	EP	9.74	28.71	23.07	17.43	11.28	9.74
Loss of sleep	LS	13.34	33.34	15.89	15.38	14.35	7.69
Visual Disturbances	VD	21.02	12.30	3.07	2.05	60.51	1.02
Giddiness	GD	22.56	19.48	3.07	2.56	51.79	0.51
Rise in Blood Pressure	BP	21.53	28.20	3.5	6.15	40.10	0.51
Headache and heaviness	HH	12.82	28.20	21.5	16.41	8.20	12.82
Increase in heart rate and breathing	HB	22.05	26.66	3.07	4.10	41.53	2.56
Sweating	SW	17.94	10.76	1.5	5.12	63.07	1.53
Habitual debater	HD	14.35	25.12	7.69	8.71	37.43	6.67

Table 5: Correlation between responses to the survey.

	Age	Gender	Occupation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17
Age	1.000	-0.170	-0.218	-0.074	-0.083	0.065	-0.118	0.128	0.123	0.022	0.013	0.026	0.057	0.070	0.080	-0.010	0.053	-0.082	-0.081	0.054
Gender	-0.170	1.000	**0.494**	0.210	0.033	0.052	**0.318**	-0.026	-0.046	0.035	-0.042	0.078	0.002	0.019	-0.074	-0.046	0.089	-0.056	0.067	-0.008
Occupation	-0.218	**0.494**	1.000	0.263	0.165	-0.088	**0.456**	-0.081	-0.042	0.128	-0.041	0.100	-0.110	0.000	-0.140	-0.002	0.084	-0.045	-0.049	0.020
Q1	-0.074	0.210	0.263	1.000	0.427	**0.236**	**0.343**	-0.129	-0.018	0.121	0.036	0.153	0.068	-0.109	-0.019	-0.147	0.135	-0.017	-0.068	-0.044
Q2	-0.083	0.033	0.165	**0.427**	1.000	**0.312**	**0.273**	0.012	0.118	**0.214**	0.021	0.114	0.199	-0.142	-0.022	-0.005	0.184	0.077	-0.032	-0.025
Q3	0.065	0.052	-0.088	**0.236**	**0.312**	1.000	0.154	0.147	0.204	0.110	0.067	**0.206**	**0.280**	-0.164	0.059	0.093	**0.214**	0.035	0.067	-0.072
Q4	-0.118	0.318	**0.456**	0.343	**0.273**	0.154	1.000	-0.055	-0.039	0.093	-0.051	0.009	-0.058	-0.147	-0.052	0.050	0.169	-0.097	-0.083	-0.090
Q5	0.128	-0.026	-0.081	-0.129	0.012	0.147	-0.055	1.000	0.412	0.212	0.139	0.103	0.168	0.098	**0.228**	**0.389**	0.122	**0.237**	0.143	0.184
Q6	0.123	-0.046	-0.042	-0.018	0.118	0.204	-0.039	**0.412**	1.000	**0.218**	0.185	0.108	0.087	0.050	**0.240**	**0.264**	0.153	0.198	0.148	0.185
Q7	0.022	0.035	0.128	0.121	**0.214**	0.110	0.093	0.212	0.218	1.000	**0.254**	0.178	**0.361**	0.129	0.129	0.063	0.147	0.156	0.062	0.172
Q8	0.013	-0.042	-0.041	0.036	0.021	0.067	-0.051	0.139	0.185	**0.254**	1.000	**0.221**	0.143	0.033	0.018	0.012	0.117	0.104	0.009	0.055
Q9	0.026	0.078	0.100	0.153	0.114	**0.206**	0.009	0.103	0.108	0.178	**0.221**	1.000	0.202	0.095	-0.015	0.136	0.185	-0.058	-0.016	0.117
Q10	0.057	0.002	-0.110	0.068	0.199	**0.280**	-0.058	0.168	0.087	**0.361**	0.143	**0.202**	1.000	0.055	0.083	0.072	**0.246**	**0.253**	0.077	0.098
Q11	0.070	0.019	0.000	-0.109	-0.142	-0.164	-0.147	0.098	0.050	0.129	0.033	0.095	0.055	1.000	**0.259**	**0.247**	-0.049	0.096	0.102	**0.220**
Q12	0.080	-0.074	-0.140	-0.019	-0.022	0.059	-0.052	0.228	**0.240**	0.129	0.018	-0.015	0.083	**0.259**	1.000	**0.262**	0.040	**0.300**	**0.292**	**0.290**
Q13	-0.010	-0.046	-0.002	-0.147	-0.005	0.093	0.050	**0.389**	**0.264**	0.063	0.012	0.136	0.072	**0.247**	**0.262**	1.000	0.042	**0.306**	0.167	0.145
Q14	0.053	0.089	0.084	0.135	0.184	**0.214**	0.169	0.122	0.153	0.147	0.117	0.185	**0.246**	-0.049	0.040	0.042	1.000	0.059	-0.013	0.167
Q15	-0.082	-0.056	-0.045	-0.017	0.077	0.035	-0.097	**0.237**	0.198	0.156	0.104	-0.058	**0.253**	0.096	**0.300**	**0.306**	0.059	1.000	0.180	**0.253**
Q16	-0.081	0.067	-0.049	-0.068	-0.032	0.067	-0.083	0.143	0.148	0.062	0.009	-0.016	0.077	0.102	**0.292**	0.167	-0.013	0.180	1.000	0.021
Q17	0.054	-0.008	0.020	-0.044	-0.025	-0.072	-0.090	0.184	0.185	0.172	0.055	0.117	0.098	**0.220**	0.290	0.145	0.167	0.253	0.021	1.000

Furthermore, Pearson correlation was measured between the responses received to study their strength of association. Table 5 depicts the correlation result among the survey responses. 12 coefficients were found in a range of 0.30 to 0.49, which states that moderate relation is found between them. Consequently,6 coefficient values were found nearly to 0.5, revealing a strong correlation.

Response Analysis Through PLS-SEM

Based on the result of the questionnaire SEM model was prepared to find the path coefficient and study the relation between the different effects of the noise on the exposed population. The prepared model using Smart PLS software is shown in **Fig. 5**. After bootstrapping, the result shows that 18 hypotheses are supported. The t statistics value greater than 1.96 is taken as supporting, whereas less than that value is rejected. The result of the SEM analysis is shown in Table 6**.** The HP1, HP2, HP20, HP38, HP39, HP40, HP41, HP55, HP56, HP57, HP65, HP75, HP83, HP84, HP87, HP88, HP92 and HP96 are found to be significant. From the significant hypothesis, respondents who agreed that noise pollution in their area are facing health issues like pain in the ear, rise in blood pressure, loss of sleep, whistling and buzzing in their ear, headache, heaviness, and efficiency problem. Also, an association between exposure time and noise affecting health is found to be significant in this study. Seidler et al. (2017) found that exposure to traffic noise results in depression. A similar study on the health effect of noise was carried out by

Table 6: Result of path analysis

Hypothesis		T statistics	P values	Confidence interval		Supported
				2.50%	97.50%	
HP1	**Age > Gender**	**2.871**	**0.004**	**-0.118**	**-0.022**	**Yes**
HP2	**Age > Occupation**	**8.199**	**0**	**0.361**	**0.584**	**Yes**
HP3	Age > Q1	1.484	0.138	-0.037	0.237	No
HP4	Age > Q2	0.889	0.374	-0.215	0.087	No
HP5	Age > Q3	1.118	0.263	-0.063	0.243	No
HP6	Age > Q4	1.431	0.153	-0.039	0.229	No
HP7	Age > Q5	0.461	0.645	-0.101	0.175	No
HP8	Age > Q6	0.36	0.719	-0.149	0.111	No
HP9	Age > Q7	0.343	0.731	-0.19	0.14	No
HP10	Age > Q8	0.408	0.684	-0.198	0.126	No
HP11	Age > Q9	0.301	0.764	-0.126	0.175	No
HP12	Age > Q10	0.946	0.344	-0.076	0.232	No
HP13	Age > Q11	0.737	0.461	-0.094	0.234	No
HP14	Age > Q12	0.142	0.887	-0.169	0.144	No
HP15	Age > Q13	0.857	0.392	-0.217	0.088	No
HP16	Age > Q14	0.45	0.653	-0.153	0.224	No
HP17	Age > Q15	0.387	0.699	-0.205	0.129	No
HP18	Age > Q16	1.42	0.156	-0.051	0.277	No
HP19	Age > Q17	0.071	0.944	-0.171	0.163	No
HP20	**Gender > Occupation**	**2.314**	**0.021**	**-0.615**	**-0.053**	**Yes**
HP21	Gender > Q1	0.16	0.873	-0.321	0.297	No
HP22	Gender > Q2	0.796	0.426	-0.445	0.197	No
HP23	Gender > Q3	0.824	0.41	-0.202	0.5	No
HP24	Gender > Q4	0.137	0.891	-0.324	0.282	No
HP25	Gender > Q5	1.475	0.14	-0.08	0.612	No
HP26	Gender > Q6	1.523	0.128	-0.067	0.606	No
HP27	Gender > Q7	0.791	0.429	-0.203	0.46	No

Table Cont....

Hypothesis		T statistics	P values	Confidence interval		Supported
				2.50%	97.50%	
HP28	Gender > Q8	0.031	0.975	-0.343	0.348	No
HP29	Gender > Q9	0.596	0.551	-0.232	0.443	No
HP30	Gender > Q10	0.516	0.606	-0.226	0.4	No
HP31	Gender > Q11	1.079	0.281	-0.16	0.524	No
HP32	Gender > Q12	0.656	0.512	-0.245	0.462	No
HP33	Gender > Q13	0.31	0.756	-0.399	0.279	No
HP34	Gender > Q14	1.037	0.3	-0.166	0.538	No
HP35	Gender > Q15	1.369	0.171	-0.579	0.106	No
HP36	Gender > Q16	1.315	0.188	-0.584	0.106	No
HP37	Gender > Q17	0.81	0.418	-0.205	0.513	No
HP38	**Occupation > Q1**	**2.509**	**0.012**	**0.047**	**0.376**	**Yes**
HP39	**Occupation > Q2**	**2.165**	**0.03**	**0.02**	**0.36**	**Yes**
HP40	**Occupation > Q3**	**3.169**	**0.002**	**-0.407**	**-0.091**	**Yes**
HP41	**Occupation > Q4**	**5.082**	**0**	**0.212**	**0.478**	**Yes**
HP42	Occupation > Q5	0.077	0.939	-0.191	0.174	No
HP43	Occupation > Q6	0.527	0.598	-0.139	0.229	No
HP44	Occupation > Q7	1.486	0.137	-0.043	0.314	No
HP45	Occupation > Q8	0.017	0.986	-0.188	0.183	No
HP46	Occupation > Q9	1.703	0.089	-0.03	0.312	No
HP47	Occupation > Q10	1.022	0.307	-0.268	0.089	No
HP48	Occupation > Q11	0.63	0.529	-0.119	0.233	No
HP49	Occupation > Q12	1.278	0.201	-0.309	0.066	No
HP50	Occupation > Q13	0.544	0.587	-0.133	0.227	No
HP51	Occupation > Q14	0.335	0.738	-0.152	0.214	No
HP52	Occupation > Q15	0.016	0.987	-0.184	0.187	No
HP53	Occupation > Q16	0.618	0.537	-0.234	0.123	No
HP54	Occupation > Q17	0.814	0.416	-0.105	0.269	No
HP55	**Q1 > Q3**	**2.999**	**0.003**	**0.078**	**0.38**	**Yes**
HP56	**Q1 > Q4**	**3.656**	**0**	**0.108**	**0.35**	**Yes**
HP57	**Q1 > Q5**	**2.218**	**0.027**	**-0.328**	**-0.017**	**Yes**
HP58	Q1 > Q6	0.982	0.326	-0.267	0.091	No
HP59	Q1 > Q7	0.116	0.908	-0.169	0.183	No
HP60	Q1 > Q8	0.534	0.593	-0.143	0.239	No
HP61	Q1 > Q9	1.091	0.276	-0.079	0.281	No
HP62	Q1 > Q10	0.139	0.89	-0.179	0.155	No
HP63	Q1 > Q11	0.357	0.721	-0.198	0.124	No
HP64	Q1 > Q12	0.175	0.861	-0.144	0.166	No
HP65	**Q1 > Q13**	**2.663**	**0.008**	**-0.377**	**-0.055**	**Yes**
HP66	Q1 > Q14	0.108	0.914	-0.158	0.182	No
HP67	Q1 > Q15	0.335	0.738	-0.198	0.136	No
HP68	Q1 > Q16	0.85	0.395	-0.238	0.095	No
HP69	Q1 > Q17	0.238	0.812	-0.186	0.146	No

Table Cont....

Hypothesis		T statistics	P values	Confidence interval		Supported
				2.50%	97.50%	
HP70	Q2 > Q5	0.616	0.538	-0.112	0.221	No
HP71	Q2 > Q6	1.262	0.207	-0.069	0.292	No
HP72	Q2 > Q7	1.917	0.055	-0.011	0.354	No
HP73	Q2 > Q8	0.032	0.974	-0.181	0.176	No
HP74	Q2 > Q9	0.25	0.802	-0.144	0.195	No
HP75	**Q2 > Q10**	**2.177**	**0.029**	**0.014**	**0.338**	**Yes**
HP76	Q2 > Q11	0.723	0.47	-0.218	0.101	No
HP77	Q2 > Q12	0.241	0.81	-0.181	0.145	No
HP78	Q2 > Q13	0.144	0.886	-0.154	0.172	No
HP79	Q2 > Q14	1.252	0.211	-0.061	0.261	No
HP80	Q2 > Q15	1.3	0.194	-0.055	0.262	No
HP81	Q2 > Q16	0.093	0.926	-0.186	0.161	No
HP82	Q2 > Q17	0.272	0.785	-0.147	0.192	No
HP83	**Q3 > Q5**	**2.164**	**0.031**	**0.016**	**0.323**	**Yes**
HP84	**Q3 > Q6**	**2.358**	**0.018**	**0.029**	**0.359**	**Yes**
HP85	Q3 > Q7	0.741	0.459	-0.103	0.238	No
HP86	Q3 > Q8	0.795	0.427	-0.1	0.233	No
HP87	**Q3 > Q9**	**2.456**	**0.014**	**0.035**	**0.364**	**Yes**
HP88	**Q3 > Q10**	**3.33**	**0.001**	**0.097**	**0.364**	**Yes**
HP89	Q3 > Q11	1.502	0.133	-0.279	0.034	No
HP90	Q3 > Q12	0.602	0.547	-0.108	0.2	No
HP91	Q3 > Q13	1.823	0.068	-0.011	0.282	No
HP92	**Q3 > Q14**	**2.043**	**0.041**	**0.008**	**0.312**	**Yes**
HP93	Q3 > Q15	0.489	0.625	-0.106	0.179	No
HP94	Q3 > Q16	1.361	0.174	-0.043	0.234	No
HP95	Q3 > Q17	0.696	0.487	-0.21	0.099	No
HP96	**Q4 > Q3**	**2.095**	**0.036**	**0.007**	**0.323**	**Yes**
HP97	Q4 > Q5	0.334	0.739	-0.197	0.139	No
HP98	Q4 > Q6	0.84	0.401	-0.24	0.095	No
HP99	Q4 > Q7	0.172	0.863	-0.188	0.154	No
HP100	Q4 > Q8	0.757	0.449	-0.242	0.106	No
HP101	Q4 > Q9	1.511	0.131	-0.299	0.04	No
HP102	Q4 > Q10	1.517	0.129	-0.257	0.039	No
HP103	Q4 > Q11	1.631	0.103	-0.302	0.029	No
HP104	Q4 > Q12	0.077	0.939	-0.155	0.167	No
HP105	Q4 > Q13	1.139	0.255	-0.07	0.264	No
HP106	Q4 > Q14	1.127	0.26	-0.069	0.258	No
HP107	Q4 > Q15	1.425	0.154	-0.289	0.047	No
HP108	Q4 > Q16	1.179	0.238	-0.249	0.06	No
HP109	Q4 > Q17	1.263	0.206	-0.28	0.067	No

Martin et al. (2006), and Kjellberg et al. (1998) found that headache and fatigue are the two most commonly reported health issues by the respondents. According to Ismaila & Odusote (2014), multiple articles have reported health issues related to traffic noise exposure and blood pressure. Higher-paid people are less exposed to noise pollution than the lower-paid (Kjellberg et al. 1996); hence strong significance is found in our study between "occupation and 4 other questions". Thus this study reveals that the population of Raipur City faces the above-mentioned health issues due to high noise levels. The population exposed to traffic noise is mostly affected by noise and faces the health issues mentioned above.

CONCLUSIONS

Noise pollution monitoring and mapping in the current study revealed that all 18 locations recorded higher noise levels and breached the ambient noise standard of CPCB. Hence the governing bodies must implement mitigating approaches for controlling it as higher levels cause different health problems among the exposed population of the city. From the survey study, it is found that most of the respondents are exposed to higher noise levels and are facing health issues of "pain in the ear," "rise in blood pressure," "loss of sleep," "whistling and buzzing" in their ear, "headache," "heaviness" and "efficiency problem." It can be concluded that the exposed population of the city is highly affected by noise pollution. SEM analysis reveals an interrelation between noise pollution and health effects. The association between exposure time and noise affecting health is significant in this study. The study gives ample evidence that higher noise levels in the study area are present and the population is highly affected; hence study supports the importance of making guidelines in context to mitigating approaches. The study recommends making strict regulations near the most sensitive areas like hospitals, schools, and residential areas to ensure a good and healthy environment in the city. Environment and health agencies must conduct awareness drives on a large scale and keep enlightening the city's population regarding noise effects and various measures for controlling the higher noise levels in the ambient environment.

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