Original Article

Analysis of the Non-Acoustic Effects of Traffic Noise on Drivers' Physical and Psychological Health

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Abstract

Background: Over the past few decades, rapid urbanization has led to noise pollution emerging as a major pollutant, with urban traffic noise being a major component of it. Understanding the effects of activities that do not have a direct impact on our health is complex. The present study is an attempt to gain insights into the nonaudiometric effects of noise on humans. **Methods:** Two groups of driver types were formed to assess the nonaudiometric effects on humans: (1) driver of three-wheeler tempos (exposed group); (2) drivers of noncommercial light motor vehicles (LMVs) (unexposed group). In the present research, 300 drivers (150 tempo drivers and 150 LMV drivers) were examined using various questionnaire tools, such as the Perceived Stress Scale-4, the Generalized Anxiety Disorder Questionnaire, and the Patient Health Questionnaire-9. Medical examinations were also performed to evaluate the physiological effects. **Results:** In the exposed group, 39.3% had moderate anxiety, and 12.0% had minimal anxiety. In the unexposed group, the majority (58.0%) had minimal anxiety, and 12.0% had moderate anxiety. A total of 42.0% of the tempo drivers had moderate depression, and 12.0% had severe depression. Among the LMV drivers, the majority (51.3%) had no depression, and none had severe depression. Furthermore, statical significance was only noticed for systolic blood pressure ($P = 0.026$), whereas no significant difference was observed for diastolic blood pressure ($P = 0.27$). **Conclusion:** The exposed group suffered more compared with the unexposed group, except for when considering annoyance.

Keywords: noise pollution, human health, anxiety, depression, blood pressure

Key messages:

(1) The present research focused on the nonaudiometric effect of noise on humans
(2) A total of 300 drivers (150 tempo drivers and 150 light motor vehicle drivers) were examined using various questionnaire tools.
(3) Among all psychological nonaudiometric effects of noise, the exposed group suffered more, except for when considering annoyance.
(4) No significant difference was observed in the diastolic blood pressure between the two groups.

Introduction

Noise pollution has emerged as one of the main forms of urban pollution, dominating major cities of the world. It is believed to be responsible for several harmful effects on humans and leads to the deterioration of the quality of life (QOL) and public health.[1] Noise pollution results from changes in pressure, usually in air medium, due to turbulence or vibrations.[2,3] Human ears exhibit very subtle sensitivity to noise frequencies ranging from 500 to 4000 Hz but are much less sensitive to lower frequencies.

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This sound frequency range of human audibility coincides with the frequency range of verbal communication.[4,5]

With the manifold expansion of urbanization, noise pollution has also increased and become a major environmental concern worldwide.[6] Many studies have been conducted globally to evaluate and record the adverse effects of noise exposure.[7,8] Comprehensive examinations of noise exposure in relation to human health have revealed various undesirable effects, such as annoyance, hearing loss, poor sleep, increased blood pressure, and mental instability.[9] The World Health Organization consideres noise exposure a harmful pollutant responsible for several adverse health effects on exposed populations.[10] Welch *et al*.[11] indicated that stress may be directly related to noise. Long-term exposure to noise may also lead to cardiovascular disease and mental health problems. Traffic noise also severely affects sensory modalities related to memory.[12] Furthermore, psychophysiological stress occurs both directly in response to transport noise exposure and indirectly as a result of other responses to noise.[13]

In the current urban scenario, road traffic plays a major role in noise pollution compared with other modes of transport. Road traffic noise accounts for approximately 78% of the total noise in the urban environment.[14,15] In the present study, Lucknow, an emerging capital city in India, was considered. As an emerging capital city, the road network of Lucknow is expected to experience an exponential growth. As a result, vehicular traffic will also increase rapidly, which will ultimately account for urban noise pollution. Those who spend most of their time beside the road, such as roadside inhabitants, shopkeepers, traffic personnel, drivers etc., are the most affected by road traffic noise.[16,17] Vehicle drivers are the most road noise-imperiled people due to their work profile; for most hours, they find themselves in the purlieu of traffic flow.[18,19]

Most people perceive noise pollution as harmful only to the ears, but it also has a crucial nonaudiometric effects. Considering these facts, the present study evaluated nonaudiometric effects of traffic noise to understand the health problems of individuals exposed to occupational noise. The findings will be useful for policymakers to form new and improved policies for the welfare of individuals exposed to occupational noise.

Materials and Methods

Study Area and Design

Three busy routes in old Lucknow city were selected for noise measurement. The noise level was measured for both stationary vehicles in the waiting area and those in motion. To investigate the effect of different types of vehicles, 30 vehicles of each type, i.e., diesel-driven tempo, compressed natural gas (CNG)-driven tempos, and light motor vehicles (LMVs), were considered in the noise investigation. For the health effect assessment, 300 drivers were considered. These numbers were derived using the following formulae[8]:

$$N = \frac{4pq}{d^2} \qquad \text{Equation1}$$

where N is the number of samples required, p is the prevalence, q is equal to $1–p$, and d is the precision.

(Considering significance level of 5% with a precision of 0.07)

A total of 300 drivers, comprising 150 tempo drivers as the exposed group and 150 LMV drivers as the unexposed group, were investigated in the study.

For ethical approval of the present study, written approval was obtained from our university council (reference number: 2061/Ethics/R.Cell-17 dated November 20, 2017). In addition, informed consent was obtained from all the participants.

Cumulative noise exposure (CNE): The CNE was calculated by multiplying daily noise exposure energy by the number of years worked as a driver (years) and the number of days a driver works in a year.

$\text{CNE}= E \times (\text{Years of working}) \times (\text{Days/year})$

where E = Total daily noise exposure, in PASQUES and Days/year = Total days in year − total nondriving days in a year.

The unit of CNE is pascals squared per second (Pa^2-s) or PASQUES.

Classification Criteria

Specific inclusion and exclusion criteria were adopted for the exposed and unexposed groups. For the inclusion criteria of both groups, consent to participate, along with at least 1 year of driving experience, was considered. The following parameters were evaluated for the inclusion criteria:

(1) Tempo drivers who consented to participating in the study
(2) Tempo drivers who have been working for at least 1 year

In addition to the above inclusion criteria, one additional inclusion criterion i.e., the driver should have never worked as a commercial driver, was imposed for the unexposed group.

For the exclusion criteria, the following parameters were evaluated:

(1) Drivers who did not consent to participating in the study
(2) Drivers aged less than 18 years or more than 50 years
(3) Drivers with diabetes mellitus.
(4) Drivers with a perforated tympanic membrane.
(5) Drivers prescribed ototoxic drugs

In addition to the above criteria, one additional exclusion criterion was applied to the unexposed group: the driver should never have worked as a commercial driver.

Sampling Process

In this work, multistage random sampling was used to select tempo drivers for health assessment and the collection of relevant information. A list of tempo drivers for the three routes was obtained from the respective contractors of tempo stands. This list contained basic information, including the drivers' age, the type of fuel used in their tempo, and their contact numbers. A total of 250, 378, and 452 tempo drivers were sorted out for routes 1, 2, and 3, respectively. After maximum effort, 231 out of 250, 319 out of 378, and 421 out of 452 tempo drivers for routes 1, 2, and 3, respectively, could be traced. Each tempo driver was contacted and informed about the purpose of the study. Out of these tempo drivers, 221, 301, and 411 allotted for routes 1, 2, and 3, respectively, gave consent to participate in this research.

In the second stage for route 1, the 221 drivers were contacted again and informed about the purpose of the study. Only 211 out of 221 tempo drivers gave consent to participate. The same procedure was adopted for routes 2 and 3. Finally, 211, 248, and 351 drivers for routes 1, 2, and 3, respectively, consented to participate in the study.

The total sample size calculated for the tempo drivers was 150. This number was divided into 45, 50, and 55, based on the tempo drivers' population proportions for routes 1, 2, and 3, respectively. At the third stage for route 1, every third subject from the list of 211 drivers was selected using a systematic random sampling technique, and this process was continued until 45 subjects were chosen in accordance with the exclusion and inclusion criteria. In this context, we examined 57 subjects for route 1.

The same technique was applied to routes 2 and 3. Thus, instead of 50 subjects for route 2 and 55 subjects for route 3, 58 and 63 subjects were examined, respectively. For the investigation of drivers' health and the collection of other relevant information, a multistage random sampling technique was applied [Figure 1]. The detailed methodology for vehicle selection for noise measurement, determination of the exposed and nonexposed groups, noise exposure assessment, and related procedures were presented in the work of Manar *et al*.[8]

Nonaudiometric Effect of Noise

In this work, efforts were made to comprehend the nonaudiometric effects of traffic noise on the exposed and unexposed groups. Nonaudiometric effects were further categorized as psychological and physiological.

Psychological Effects

Questionnaires were adopted to assess the nonaudiometric psychological effects of traffic noise on the drivers. These

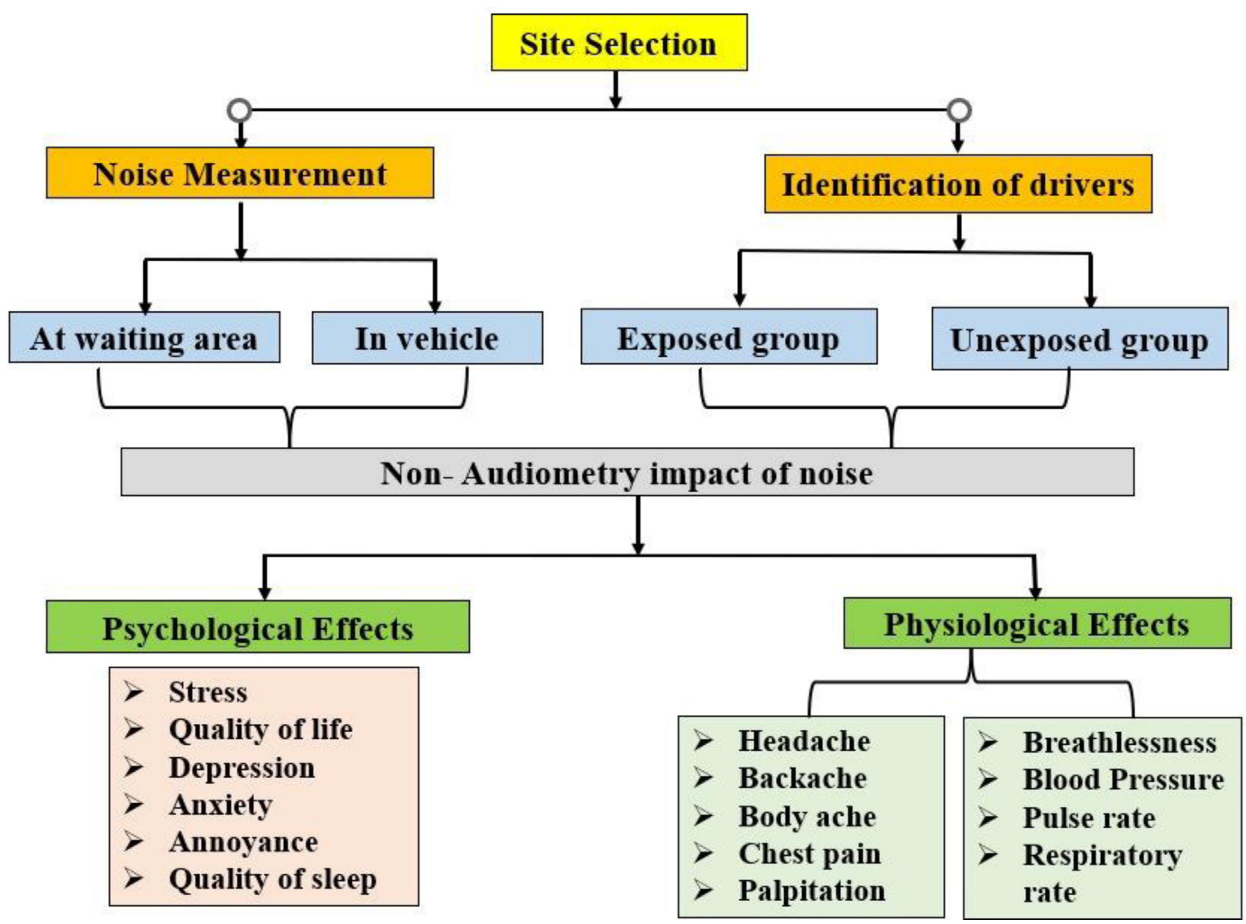

Figure 1: Methodology adopted in the present study.

tools were designed to assess the nonaudiometric effects of traffic noise on the QOL, anxiety disorder, stress, and depression in the exposed and unexposed groups. The details of the data collection tools are as follows:

Perceived Stress *Scale 4*

The Perceived Stress Scale 4 (PSS-4) consists of four questions on 5-point Likert scale, ranging from 0 = "never" to 4 = "very often," and assesses the feelings and thoughts of the respondents during the last month.[20] It encapsulates various aspects of the respondents' lives, such as unpredictability, uncontrollability, and feelings of being overloaded over the last month. The PSS comprises 10 items, and respondents must evaluate them on a 0 to 4 scale, where 0 corresponds to "never" and 4 to "very often" (questions 1 and 4), and vice versa for questions 2 and 3. The final score can range from 0 to 16, with higher scores indicating more stress.

World Health Organization Quality of Life: Brief Version

The World Health Organization Quality of Life: Brief Version (WHOQOL-BREF) is used to assess the QOL of individuals. In the present study, the Hindi version was used. It comprises 26 questions distributed across four sectors and includes two general questions regarding the QOL.[21] The scores of all four domains were converted into Sten scores [Figure 2a]. The score ranged from 0 to 100, with higher scores indicating better perceived QOL. The ultimate QOL was calculated by summing up the Sten scores obtained across various domains, i.e., physical, psychological, social relationships, and environmental, and then converting into a scale of 0 to 100. The obtained Sten scores (0–100) were further categorized into five categories to evaluate the QOL across different domains [Figure 2a].

Patient Health Questionnaire-9

This questionnaire is a 9-item depression screening tool used to identify the frequency and presence of the nine core depressive symptoms identified in the Diagnostic and Statistical Manual of Mental Disorders-IV over the last 2 weeks.[22] Each response is evaluated on a 4-point Likert scale from 0 to 3, where 0 stands for "Not at all," 1 for "Several days," 2 for "More than half the days," and 3 for "Nearly every day." All the responses are then summed to obtain a severity score for each participant [Figure 2b].

Generalized Anxiety Disorder Scale

This scale consists of seven items and assesses the extent to which an individual has been bothered by anxiety symptoms over the past 2 weeks (e.g., "Feeling anxious, nervous, or on edge"). The responses are then rated on a 4-point Likert scale

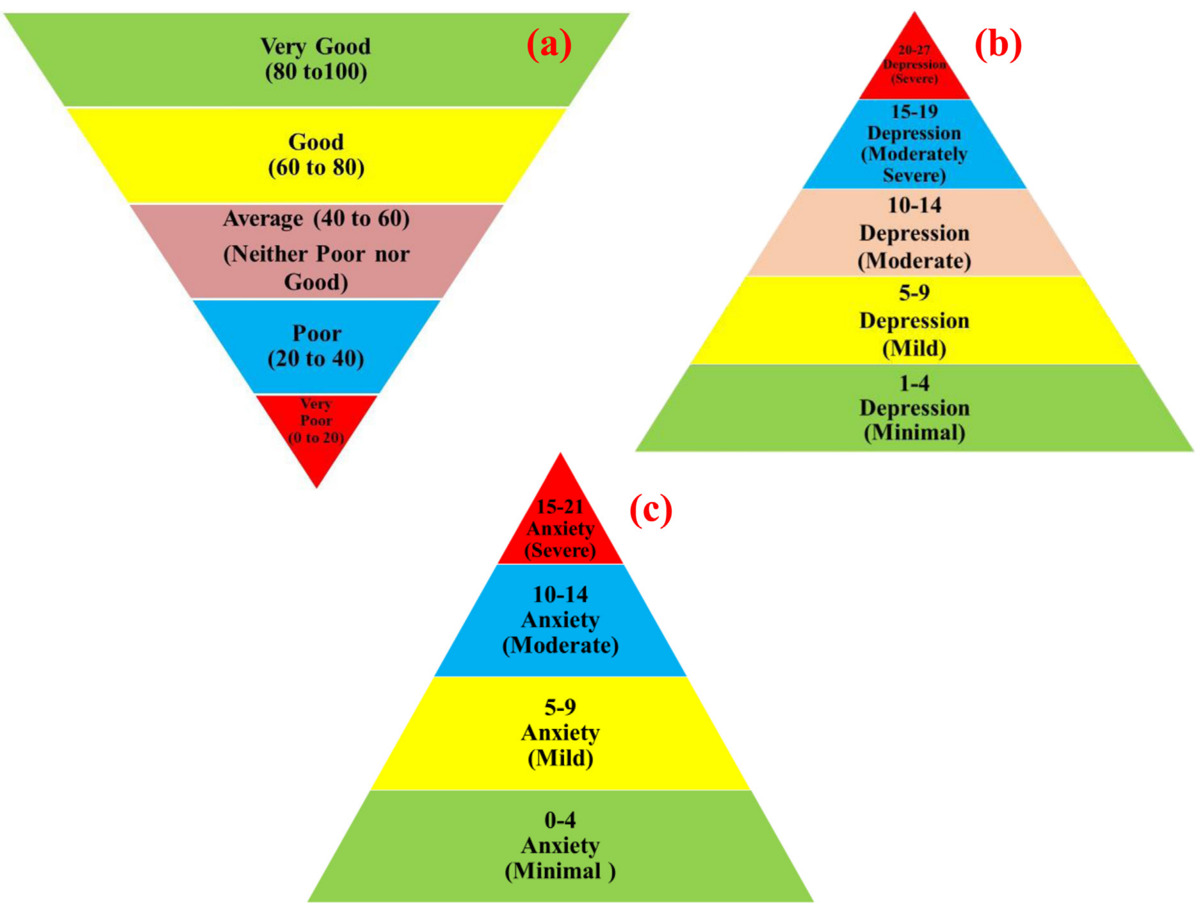

Figure 2: (a) Sten score versus level of the QOL, (b) total score versus depression severity, and (c) total score versus generalized anxiety severity.

(0 = "Not at all," 1 = "Several days," 2 = "More than half of the days," and 3 = "Nearly every day").[23,24] The total score (after the addition of all the numbers) provides a possible score in the range of 0 to 21 [Figure 2c]. A total score of 10 or higher indicates that further evaluation is required. The interpretation of the total score is shown in Figure 2c:

Physiological Effects

Several questionnaires were administered, and medical examinations were performed to further investigate the nonaudiometric physiological effect of noise on the exposed and unexposed groups. The questionnaire methodology was adopted to assess the physical symptoms, such as headache, backache, body ache, chest pain, palpitation, and breathlessness, while physical examination was performed to identify the physical parameters, including blood pressure (systolic and diastolic), respiration, and pulse rate.

Statistical Analysis

For comprehension of the correlation between nonaudiometric effects and the exposed and unexposed groups, various statistical analyses were performed. Moreover, the Chi-square test was performed. SPSS version 24 was used for data analysis. In the present study, 95% confidence interval was used to investigate the level of statistical significance. Therefore, at a 95% confidence interval, a P-value of <0.05 was considered statistically significant. Cramer's V was used to strengthen the significance of data. For graphical representation of data, Origin 9.2 version was used. Licenses for both software programs were obtained from our mother institute.

Results

Demographic Profile

Table 1 provides the sociodemographic profile distribution of the tempo and LMV drivers. Except for education, the

Table 1: Sociodemographic profile distribution of tempo and LMV drivers

Sociodemographic Variable		Driver Type					
		Tempo (n = 150)		LMV (n = 150)		Total (n = 300)	
Age (years)	Mean ± SD	35.09 ± 9.24		35.37 ± 8.41		35.28 ± 8.82	
		N	%	*N*	%	*N*	%
Gender	Male	150	100.0	150	100.0	300	100.0
Religion	Hindu	99	66.0	119	79.3	218	72.7
	Muslim	48	32.0	31	20.7	79	26.3
	Sikh	3	2.0	0	0.0	03	1.0
Social group	Unreserved	39	26.0	55	36.7	94	31.3
	Scheduled Caste	15	10.0	18	12.0	33	11.0
	Scheduled Tribes	0	0.0	2	1.3	2	0.7
	Other Backward Caste	96	64.0	75	50.0	171	57.0
Socioeconomic survey*	I	6	4.0	5	3.4	11	3.7
	II	19	12.7	11	7.3	30	10.0
	III	47	31.3	63	42.0	110	36.7
	IV	57	38.0	51	34.0	108	36.0
	V	21	14.0	20	13.3	41	13.7
Marital status	Single	35	23.3	35	23.3	70	23.3
	Married	112	74.7	115	76.7	227	75.7
	Divorce/separated	2	1.3	0	0.0	2	0.7
	Widower	1	0.7	0	0.0	1	0.3
Type of family	Nuclear	53	35.3	48	32.0	101	33.7
	Joint	97	64.7	102	68.0	199	66.3
Residence	Urban	123	82.2	124	82.7	247	82.3
	Rural	23	15.3	23	15.3	46	15.3
	Urban slum	4	2.7	3	2.0	7	2.3
Education	Illiterate	46	30.7	12	8.0	58	19.3
	Primary school	61	40.7	40	26.7	101	33.7
	Secondary school	36	24.0	76	50.7	112	37.3
	Graduate and above	7	4.7	22	14.7	29	9.7
Years since driving	<10	72	48.0	62	41.3	134	44.7
	10–20	57	38.0	70	46.7	127	42.3
	>20	21	14.0	18	12.0	39	13.0
Work hours per day	Mean ± SD	9.93±1.64		10.20±1.19		10.07±1.42	

Note: LMV, light motor vehicle, SD, standard deviation; * Modified BG Prasad classification for Consumer Price Index of 2018 sociodemographic profiles of the exposed and unexposed groups were almost similar. In the exposed group, 30.7% of people were illiterate, whereas in the unexposed group, the value observed was 8.0%.

Noise Quality Data

Among the three identified routes, both diesel- and CNG-driven tempos passed on route 1, whereas only the CNG-driven tempos were observed on route 2 and only diesel-driven tempos on route 3, respectively. The in-vehicle time-weighted average equivalent noise levels (LA_{eq}) for diesel- and CNG-driven tempos were 86.26 and 83.99 dB(A), respectively. Likewise, for the waiting area, the equivalent time-weighted average noise level was calculated for all the routes, and no substantial variation was observed among the different tempo stands, i.e., the tempo stands having diesel, CNG, and both diesel and CNG tempos, with values reaching 84.13, 83.78, and 84.32 dB(A), respectively.

However, a higher variance was witnessed in the unexposed group (i.e., LMV drivers) compared with the exposed group (i.e., tempo drivers). The in-vehicle time-weighted average equivalent noise level in LMVs reached 74.63 dB(A), which was lower compared with those of other tempos.

Cumulative Noise Exposure

CNE was assessed for the exposed and unexposed groups. To examine the association between CNE and the age of the exposed and unexposed groups, an unpaired *t*-test was conducted for the tempo and LMV drivers. For all ages groups in both categories, CNE showed a significant difference at $P < 0.01$.

Nonauditory Effects of Noise Exposure

In the present study, the Generalized Anxiety Disorder scale was used to assess the anxiety among the exposed and unexposed groups. In the exposed group, the majority (39.3%) had moderate anxiety, while 12.0% had minimal anxiety. Meanwhile, in the unexposed group, the majority (58.0%) had minimal anxiety, and 12.0% had moderate anxiety [Table 2]. The association between the severity of anxiety and driver type was statistically significant ($P < 0.01$).

Similarly, the Patient Health Questionnaire-9 scale was used to gain insights into depression in the exposed and unexposed groups. The majority (42.0%) of tempo drivers had moderate depression, while 12.0% had severe depression. Meanwhile, the majority of the LMV drivers (51.3%) had no depression, and none had severe depression. The association between the severity of depression and type of driver showed statistical significance ($P < 0.01$) [Table 3].

The mean ± standard deviation (SD) scores of the QOL in the physical, psychological, environmental, and social relationship domains and the overall QOL of the tempo drivers were 66.38 ± 13.11, 64.16 ± 14.09, 52.12 ± 12.25, 68.05 ± 15.72, and 62.16 ± 17.96, respectively. The mean ± SD scores obtained in the physical, psychological, environmental, and social relationship domains, and the overall QOL score of LMV drivers were 73.35 ± 11.21, 72.16 ± 14.05, 58.97 ± 11.21, 68.11 ± 13.71, and 69.41 ± 16.98, respectively. The overall QOL and scores in various domains were higher in LMV drivers, and the difference between the mean score of the LMV and tempo drivers in the different domains of the QOL indicated statistical

Table 2: Association of anxiety level by driver type*

Variable GAD-7	Driver type						*P*-Value
	Tempo ($n = 150$)		LMV ($n = 150$)		Total ($n = 300$)		
	N	%	*N*	%	*N*	%	
Minimal	18	12.0	87	58.0	105	35.0	<0.01
Mild anxiety	53	35.3	43	28.7	96	32.0	
Moderate anxiety	59	39.3	18	12.0	77	25.7	
Severe anxiety	20	13.3	2	1.3	22	7.3	

Note: LMV, light motor vehicle; * χ^2=74.72, df=3, Cramer's *V*=0.50 (moderate association).

Table 3: Association of depression by driver type*

Variable- PHQ-9	Driver Type						*P*-Value
	Tempo ($n = 150$)		LMV ($n = 150$)		Total ($n = 300$)		
	N	%	*N*	%	*N*	%	
No depression	20	13.3	77	51.3	97	32.3	<0.01
Mild depression	25	16.7	37	24.7	62	20.7	
Moderate depression	63	42.0	26	17.3	89	29.7	
Moderate-severe depression	24	16.0	10	6.7	34	11.3	
Severe depression	18	12.0	0	0.0	18	6.0	

Note: LMV, light motor vehicle, PHQ-9, Patient Health Questionnaire-9; * χ^2=65.46, df=4, Cramer's *V*=0.47 (moderate association).

Table 4: Association of annoyance due to occupational noise by type of drivers*

Annoyance	Driver Type						*P*-Value
	Tempo (n = 150)		LMV (n = 150)		Total (n = 300)		
	N	%	*N*	%	*N*	%	
Not at all	36	24.0	16	10.7	52	17.3	<0.01
Slightly	33	22.0	7	4.7	40	13.3	
Moderate	63	42.0	66	44.0	129	43.0	
Very	14	9.3	57	38.0	71	23.7	
Extremely	4	2.7	4	2.7	8	2.7	

Note: LMV, light motor vehicle; *χ^2=50.70, df=4, Cramer's V=0.41 (moderate association).

significance ($P < 0.05$), except for the social relationship domain.

In the present study, more than one-third of tempo (42.0%) and LMV drivers (44.0%) were moderately disturbed, bothered, or annoyed by occupational noise. Meanwhile, 9.3% of the tempo drivers and 38.0% of the LMV drivers were very annoyed. A statistically significant ($P < 0.01$) difference was observed between the type of driver and annoyance due to occupational noise [Table 4].

QOL was also assessed using WHOQOL-BREF, with statistically higher significance ($P < 0.05$) observed in the LMV drivers compared with tempo drivers across all domains and the overall score. An exception was noted in the social domain, where the score was higher, but the results were not statistically significant.

In addition to psychological effects, physiological effects were studied in the exposed group. Backache was the major problem in 18.0% of the drivers (possibly due to their sitting or working style), followed by headache (11.3%). Meanwhile, backache was observed in 2.0% in the unexposed group, and no complaint of headache was recorded. Among the tempo drivers, the majority (62.8%) had backache, and 9.3% had chest pain. Among car drivers, the majority (30.0%) had backache and chest pain, and 20.0% experienced palpitation and breathlessness. Table 5 presents the association between substance abuse and driver type.

Systolic blood pressure among the tempo and LMV drivers reached 119.41 ± 16.79 and 115.98 ± 8.32 mm Hg, respectively. Further, this difference between the two groups was statistically significant ($P = 0.027$). This variation may be due to the inclusion of office workers in the control group. In the tempo and LMV drivers, the average diastolic blood pressures were 80.52 ± 12.80 and 79.24 ± 6.30 mm Hg, respectively, and the pulse rates were 74.13 ± 8.03 and 76.32 ± 9.01, respectively. The difference between the two groups was statistically significant ($P = 0.026$). The respiratory rate of the tempo drivers was 17.63 ± 2.22, and that of the LMV drivers was 18 ± 1.55.

Discussion

The scores for overall QOL and its various domains were higher in the LMV drivers, and the difference between the mean score of the LMV and tempo drivers in various domains of QOL was statistically significant ($P < 0.05$), except for the social relationship domain. In the present study, more than one-third of the tempo (42.0%) and LMV drivers (44.0%)

Table 5: Association of substance abuse with driver type

Substance Abuse		Driver Type						*P*-Value	Chi-square (χ^2)	Cramer's *V*
		Tempo (n = 150)		LMV (n = 150)		Total (n = 300)				
		N	%	*N*	%	*N*	%			
Alcohol	Absent	46	30.7	61	40.7	107	35.7	0.071	2.85	0.10
	Present	104	69.3	89	59.3	193	64.3			
Smoked tobacco	Absent	57	38.0	69	46.0	126	42.0	0.160	0.22	0.03
	Present	93	62.0	81	54.0	174	58.0			
Pan masala	Absent	34	22.7	82	54.7	116	38.7	<0.01	16.18	0.23
	Present	116	77.3	68	45.3	184	61.3			
Chew tobacco	Absent	82	54.7	125	83.3	207	69.0	<0.01	25.24	0.29
	Present	68	45.3	25	16.7	93	31.0			
Sleeping pills	Absent	142	94.7	147	98.0	289	96.3	0.218	1.51	0.07
	Present	8	5.3	3	2.0	11	3.7			
Marijuana/bhang	Absent	130	86.7	148	98.7	278	92.7	<0.01	14.18	0.22
	Present	20	13.3	2	1.3	22	7.3			

Note: LMV, light motor vehicle

were moderately disturbed, bothered, or annoyed by occupational noise. Meanwhile, 9.3% of the tempo drivers and 38.0% of the LMV drivers were highly annoyed. Further, the majority of the tempo (64.7%) and LMV drivers (76.7%) had a good quality of sleep [Table 4]. Beutel *et al*.[25] showed that road traffic noise annoyed 43.5% of people, and annoyance was extreme in 1.7% of the individuals they observed. Stansfeld *et al*.[26] reported that annoyance was statistically significant ($P < 0.05$) in the exposed group than in the unexposed group [Table 4]. These results were similar to those of our study. However, 10.7% of the tempo drivers and 10.0% of the LMV drivers had very good quality of sleep. A statistically significant ($P < 0.01$) difference was observed between the quality of sleep and type of driver. In the present study, the majority of tempo and LMV drivers consumed alcohol and smoked tobacco. Among the tempo drivers, 77.3%, 45.3%, 5.3%, and 13.3% consumed pan masala, chewed tobacco, took sleeping pills, and used marijuana/bhang, respectively. Meanwhile, among the LMV drivers, 45.3%, 16.7%, 2.0%, and 1.3% consumed pan masala, chewed tobacco, took sleeping pills, and used marijuana/bhang, respectively. A statistically significant ($P < 0.001$) difference was noted in the consumption of pan masala, chewing tobacco, and marijuana/bhang between LMV and tempo drivers. Manglam *et al*.[27] revealed that 74.0% of drivers were abusing some substance, which is similar to our results.

Systolic blood pressure was higher among the tempo drivers than among the LMV drivers. The difference between the two groups was statistically significant ($P = 0.027$). This variation may be due to the inclusion of office workers in the control group. The average diastolic blood pressure was observed again, but the pulse rate in the tempo drivers was lower compared with the LMV drivers. The difference between the two groups was statistically significant ($P = 0.026$). In a similar study conducted by Balaji *et al*.[28] in Puducherry on male bus drivers as the exposed group and office workers as the unexposed group, the mean systolic blood pressures were 132.34 ± 18.07 and 118.00 ± 14.65 mm Hg, respectively, and this difference was statistically significant.

Limitations and Future Research Directions

Notably, best efforts were exerted, and utmost care was taken to avoid methodological, instrumental, and human errors during the planning, execution, and finalization phase. However, this study still encountered some limitations:

(1) Noise is everywhere in this noisy world and an integral part of daily life. In this study, only occupational noise was considered, but the subjects (drivers) have been exposed to several nonoccupational noises throughout their lifetime. Quantification of such exposures was excluded in this study, as it was practically not feasible. Hence, our study may have underestimated the CNE.

(2) During the in-vehicle noise monitoring period, the drivers were requested not to play music. In this way. the study may have underestimated the CNE for those who are fond of music.

(3) In this work, the age-corrected values for hearing loss of tempo drivers due to aging were also calculated using recommendations made for and from the United States population. These age-related corrections in hearing loss may not be suitable for the Indian populations.

(4) Tempo drivers were exposed to noise levels of approximately 86 dB, and the CNE of most of these drivers clustered within a certain range of CNE. Inclusion of groups exposed to higher noise levels may be incorporated in future studies to improve the study strength.

Conclusion

For the noise levels between diesel and CNG tempos, no significant difference was noticed, whereas a significant noise level difference around 10 dB was observed between the exposed and unexposed groups. Similarly, for CNE, a significant difference ($P < 0.001$) was observed in stress, annoyance, and the quality of sleep across all age groups of the exposed and unexposed drivers. Higher perceived stress was noticed among tempo drivers [median: 8 (7.0–9.25)] compared with LMV drivers [median: 7 (4.75–8.0)]. In terms of all psychological nonaudiometric effects of noise, the exposed group suffered more compared with the unexposed group, except when considering annoyance. In the case of annoyance due to occupational noise, 9.3% of the tempo drivers were very annoyed compared with 38.0% of their counter parts, i.e., LMV drivers. This result was possibly observed because tempo drivers are more accustomed to occupational noise and do not feel very annoyed. Physiological effects, such as headache, backache, body ache, chest pain, palpitation, and breathlessness, were low, i.e., a maximum of 18.0%, in the exposed group, and notably less, i.e., a maximum of 2.0%, in the unexposed group. The unexposed group had no complaint of headache, whereas body ache was noticed in the exposed group (17.0% and 16.0%, respectively). Further, a significant between-group difference was observed only for systolic blood pressure, with a P value of 0.026. For diastolic blood pressure, no statistical significance was observed, with a P value of 0.27. This difference in systolic blood pressure may be due to the significant differences in the CNE between the two groups.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

The main investigator was Manish Kumar Manar, who designed the manuscript. The drafting and writing of the manuscript were done by Markandeya and Neeraj Kumar

Singh. Moreover, Prashant Kumar Bajpay, S.K. Singh, Veerendra Verma, Shailza Verma, and Sheo Prasad Shukla were advisors of the present research. All the authors have read and approved the manuscript.

Ethics Approval and Consent to Participate

We have taken ethical approval for this study by the council of KGMU Lucknow reference number 2061/Ethics/R.Cell-17 dated November 20, 2017. All authors have read, understood, and are aware that, with minor exceptions, no changes can be made to authorship once the paper is submitted.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

1. WHO. WHO: Burden of Disease from Environmental Noise 2011; World Health Organization.
2. Singh NK, Markandeya Manar MK, Shukla SP, Mohan D. Statistical and spatio-temporal analysis of noise pollution level and its health impact. Environ Sci Poll Res 2023; 30: 82951–63.
3. Ang LYL, Cui F. Remote work: aircraft noise implications, prediction, and management in the built environment. Applied Acoustics 2022; 198: 108978.
4. Li S, Lu L, Yang J, Duan M. Advanced management of hearing loss: a comprehensive review of the special issue. J Clin Med 2024; 13:7409.
5. Eckert MA, Teubner-Rhodes S, Vaden KIJr, Ahlstrom JB, McClaskey CM, Dubno JR. Unique patterns of hearing loss and cognition in older adults' neural responses to cues for speech recognition difficulty. Brain Str Funct 2022; 227: 203–18.
6. Nath H, Adhikary SK, Alsulamy S, *et al.* Assessment of index-based traffic noise annoyance level at major road intersections in a tourist city: a case study towards environmental sustainability. Heliyon 2024; 10:e40005.
7. Quader MA, Rahman MM, Chisty MA, *et al.* Evaluation of noise pollution impact on health in Dhaka city, Bangladesh. Front Public Health 2024;12:1477684.
8. Manar MK, Singh SK, Bajpai PK, *et al.* Statistical estimation of noise induced hearing loss among the drivers in one of the most polluted cities of India. Sci Rep 2024; 14: 7058.
9. Radun J, Maula H, Saarinen P, Keränen J, Alakoivu R, Hongisto V. Health effects of wind turbine noise and road traffic noise on people living near wind turbines. Renew Sustain Energy Rev 2022; 157: 112040.
10. Minkin M, Woodland L, Williams OA, *et al.* Revisiting the association between transportation noise and heart disease reported in the World Health Organization Environmental Noise Guidelines for the European Region: a systematic review and meta-analysis. Environ Int 2025; 202: 109667.
11. Welch D, Shepherd D, Dirks KN, Reddy R. Health effects of transport noise. Transport Rev 2023; 43: 1190–210.
12. Zhu Y, Chen Y. A study of noise exposure of traffic-type pocket parks in old urban districts based on audio-visual interaction. Applied Acoustics 2023; 213: 109628.
13. Voss S, Schneider A, Huth C, *et al.* Long-term exposure to air pollution, road traffic noise, residential greenness, and prevalent and incident metabolic syndrome: results from the population-based KORA F4/FF4 cohort in Augsburg, Germany. Environ Int 2021; 147: 106364.
14. Soni AR, Makde K, Amrit K, Vijay R, Kumar R. Noise prediction and environmental noise capacity for urban traffic of Mumbai. Applied Acoustics 2022; 188: 108516.
15. Carter L, Black D, Bundy A, Williams W. An estimation of the whole-of-life noise exposure of adolescent and young adult Australians with hearing impairment. J Am Acad Audiol 2016; 27: 750–63.
16. Pérez-Crespo L, López-Vicente M, Valentín A, *et al.* Association between residential exposure to road traffic noise and cognitive and motor function outcomes in children and preadolescents. Environ Int 2024; 183: 108414.
17. Thompson R, Smith RB, Karim YB, *et al.* Noise pollution and human cognition: an updated systematic review and meta-analysis of recent evidence. Environ Int 2022; 158: 106905.
18. Radun J, Maula H, Saarinen P, Keränen J, Alakoivu R, Hongisto V. Health effects of wind turbine noise and road traffic noise on people living near wind turbines. Renew Sustain Energy Rev 2022; 157: 112040.
19. Peer MY, Mir MS, Mohanty B. Evaluation of the spatiotemporal variations of road traffic noise pollution and public cognizance of associated health hazards within urban environments. Int J Sustain Transp 2025; 1–21.
20. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav 1983; 24385–96.
21. Orley J. WHOQOL-BREF: Introduction, Administration and Generic Version [Internet]. World Health Organization; 1996.
22. Kroenke K, Spitzer RL, Williams JBW. The Patient Health Questionnaire-9: validity of a brief depression severity measure. J Gen Intern Med 2001; 16: 606–13.
23. Wang X, Wu Y, Chen Y, Xu J, Gao Q, Zang S. Traffic-related pollution and symptoms of depression and anxiety among Chinese adults: a population-based study. J Affect Disord 2024; 352: 101–9.
24. Spitzer RL, Kroenke K, Williams JBW, Lowe B. A brief measure for assessing generalized anxiety disorder. Arch Intern Med 2006; 166: 1092–107.
25. Beutel ME, Jünger C, Klein EM, *et al.* Noise annoyance is associated with depression and anxiety in the general population-the contribution of aircraft noise. PLoS One 2016; 11: 1–13.
26. Stansfeld S, Clark C, Smuk M, Gallacher J, Babisch W. Road traffic noise, noise sensitivity, noise annoyance, psychological and physical health and mortality. Environ Health 2021; 20: 1–15.
27. Manglam MK, Sinha VK, Praharaj SK, Bhattacharjee D, Das A. Personality correlates of accident-proneness in auto-rickshaw drivers in India. Int J Occup Saf Ergon 2013; 19: 159–65.
28. Balaji R, Rajasegaran R, John NA, Venkatappa US. Hearing impairment and high blood pressure among bus drivers in Puducherry. J Clin Diagn Res 2016; 10:CC08–10.