STUDY OF THE ASSOCIATION BETWEEN TRAFFIC NOISE LEVEL AT ROAD INTERSECTIONS OF DHAKA AND PERCEIVED ANNOYANCE

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ABSTRACT

This study attempted to find the correlation between traffic noise and perceived annoyance levels in people exposed to high noise levels for prolonged periods, such as traffic police, street vendors, and shopkeepers adjacent to road intersections. Both acoustic parameters, such as noise level and duration of exposure, and individual factors, such as age, job experience, shift length, and smoking habit, were considered in this study. Socio-acoustic surveys were conducted near different intersections of Dhaka city . At each intersection, the noise levels were recorded continuously with a sound level meter for one hour. All noise level readings were taken during peak hours (9 am to 5 pm) on weekdays. A questionnaire survey was done to collect information on socio-demography, noise-related health impacts, and exposure. Perceived noise annoyance was recorded using a self-reported annoyance scale. Various indices, such as L_{10}, L_{Aeq}, and Traffic Noise Index (TNI), were calculated and compared with standards. The L_{eq} values of every intersection exceeded the permissible limit for mixed areas, which is 60 dB. About 51% of respondents reported annoyance as "Extremely". Chi-square test of independence showed a strong association between anoonaynce and education, occupation, smoking habit, working shift lengths, and job duration. Ordinal logistic regression showed that a person working over 8 hours is about seven times more likely to be annoyed compared to working for four to eight hours(adjusted odds ratio = 7.07, 95% confidence interval: 2.20, 22.71, and p value = 0.001). Similarly, the likelihood of annoyance increases with increasing job experience. The study offers key insights regarding the relationship between annoyance and traffic noise level, exposure, and demographic factors, which can be used to take mitigating measures.

Keywords: *Road intersection, perceived annoyance, traffic noise, ordinal logistic regression*

1. INTRODUCTION

According to "Noise Pollution Control Rules 2006", noise pollution means the creation or transmission of any noise exceeding the noise standards specified, which may be harmful to the environment or contribute to its damage. In Dhaka city, traffic noise is the principal source of noise pollution. The noise levels measured at different points of Dhaka show that the noise levels exceed safe limits (Naha et al., 2020), (Quader et al., 2024). Long-term traffic noise exposure is associated with elevated blood pressure, hearing issues, annoyance, and sleep disturbances (Tabraiz et al., 2015). So, controlling noise pollution and mitigation of its adverse impacts has become a priority.

In Bangladesh, the extent of traffic noise and its impacts on health were investigated in major cities like Chittagong (Uddin et al., 2018) and Khulna (Sultana et al., 2020). Naha et al. (2020) reported that due to prolonged noise exposure among traffic police in Dhaka, 64% of the 100 participants had sensorineural hearing loss. The hearing loss was determined through specific tests. Self-reported health effects can also be used to investigate the effects of noise pollution (Quader et al., 2024).
Noise affects people differently based on demographic factors. The extent of impact also depends on exposure duration. For example, hearing loss among members of the traffic police of Dhaka city was significantly associated with increasing age and job duration (Naha et al., 2020). Similar studies were done focusing on a single occupation. In (Jamalizadeh et al., 2018), the association between traffic noise exposure and annoyance in taxi drivers was investigated. Venkatappa and Shankar (2012) examined the association between noise levels and stress among traffic policemen in Bengaluru city.

To find potential factors influencing perceived annoyance, different statistical and modeling approaches have been used. Venkatappa and Shankar (2012) used Pearson's correlation coefficient to test the significance between stress level and noise level. Pearson's correlation coefficient was also used in (Jamalizadeh et al., 2018) and (Naha et al., 2020). Klaeboe et al. (2004) used ordinal logit models to develop exposure–effect relationships and compared the likelihood of higher noise annoyance for different conditions. Naha et al., 2020 also used the chi-square test to compare the categorical variables. Advanced modeling techniques like "Structural Equation Modeling (SEM)" and "Artificial Neural Network (ANN)" have been used to find the relationship between annoyance and demographic factors like age, gender, etc. (Chauhan et al., 2024), (Das et al., 2022).

Based on previous studies, in this study, the sound levels at different intersections of Dhaka were measured. Different noise indices were used to assess the extent of noise pollution. Subsequently, a questionnaire survey was done at those intersections to assess the perceived annoyance and health impacts on people. This study focused on people who spend a significant amount of time near intersections, irrespective of occupation. Other demographic factors like age, gender, and education were also considered. Statistical analyses (chi-square test and ordinal logistic regression) were done to find the association between different demographic factors and perceived annoyance.

2. METHODOLOGY

2.1 Description of study locations

For this study, a total of 10 intersections in Dhaka were selected for noise data collection and questionnaire survey. All the intersections are controlled manually by traffic police and have shops and/or street vendors near the intersections. The locations are shown on the map in Figure 1.

2.2 Noise Data Collection

Noise data was collected using a sound level meter "LUTRON SL-4023SD". It has a wide range from 30 dB to 120 dB. The meter was calibrated before use. To simulate "human ear listening", "A weighting" and "Fast" response time were used for measuring. Following ISO 9631-1, the sound level meter was attached to a tripod and kept at a height of 1.5m above the ground and 3 to 3.5m away from any wall or barrier to avoid reflection. The setup is shown in Figure 2. The meter was placed as close to the centre of the intersection as possible. At each intersection, the sound levels were measured for one hour. This was done so that the fluctuation in traffic-induced noise can be captured and the data can be considered as representative of the whole day. All the measurements were taken during peak hour (9 am to 5 pm) on weekdays (Sunday to Thursday) in the month of June 2025.

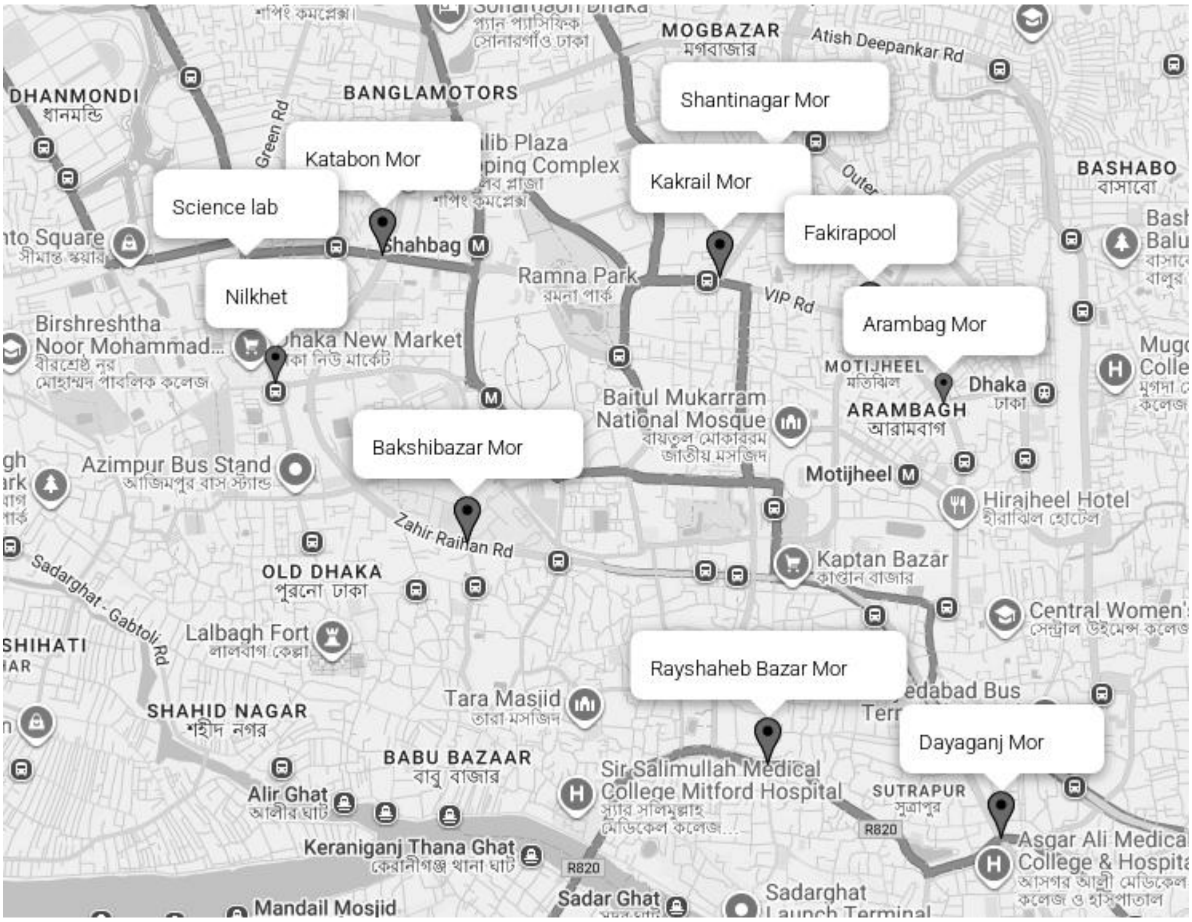

Figure 1: Map of study locations

2.3 Questionnaire Survey

To gather information about perceived annoyance, health effects related to noise pollution, and socio-demography, a questionnaire survey was conducted near the intersections where the sound levels were measured. The questions were developed following ISO/TS 15666 and reviewing previous studies (Jamalizadeh et al., 2018), (Chauhan et al., 2024), (Naha et al., 2020), (Soni et al., 2024). People who spend a long time near intersections were selected for the survey.

At first, they were informed about the objective of the survey and how the information would be used. After acquiring consent, they were asked to report their perceived annoyance on a scale of 1 to 5. Here, 1 represents “not at all” and 5 represents “extremely”. They were also asked about health effects like headache, blood pressure, etc. They were instructed to answer while “Thinking about the last (12 months or so)”. Then they were asked about their occupation, education, smoking habits, and exposure to noise. There were a total of 13 questions. All the questions were asked in Bengali. During the survey, the presence of sound-absorbing materials such as glass doors, books, curtains, etc, and the perpendicular distance of the shop from the road were recorded.

Figure 2: Sound level meter placed near the intersection

2.4 Calculation of Noise Indices

To understand the extent of traffic-induced noise pollution, various indices were calculated from the data collected using a sound level meter. The L_{eq} or equivalent continuous sound level is the constant sound level that, over a given period of time (in this case, one hour), contains the same total sound energy as the actual fluctuating sound. It is one of the most common metrics used for noise control. For continuous data, it is calculated using Equation 1.

$$L_{Aeq,T} = 10\,log_{10}\left(\frac{1}{T}\int_0^T 10^{\frac{L_A(t)}{10}}\,dt\right) \quad (1)$$

The Department of Environment (DoE) of Bangladesh has implemented the Noise Pollution Control Rules of 2006. It contains acceptable noise limits in terms of L_{eq} for different types of areas during both day and night. From 6 am to 9 pm is considered as "Day" and from 9 pm to 6 am is considered as "Night". They are shown in Table 1.

Table 1: Acceptable noise standards (L_{eq})

Category of Area	Day	Night
Sensitive Areas	50	40
Residential Areas	55	45
Mixed Areas	60	50
Commercial Areas	70	60
Industrial Areas	75	70

To measure the fluctuation in noise level, noise climate (NC) was determined using Equation 2. Here, L_{10} and L_{90} represent the sound levels exceeded 10% and 90% of the duration of measurement. L_{10} can be considered as the upper limit of the noise recorded, while L_{90} is associated with background noise. Similarly, L_{50} is the sound level exceeding 50% of the time.

$$NC = L_{10} - L_{90} \tag{2}$$

Traffic Noise Index (TNI) is a widely used indicator of noise pollution and is used to assess annoyance due to traffic noise. It incorporates both background noise levels and maximum noise levels and is calculated using Equation 3.

$$TNI = 4 \times NC + L_{90} - 30 \tag{3}$$

TNI = 74 dB (A) can be considered as a threshold for dissatisfaction due to traffic noise (Langdon & Scholes, 1968). Higher TNI indicates higher fluctuation in traffic noise that leads to higher annoyance. All the calculations are done using Excel.

2.5 Statistical Analysis

To examine the relationship between socio-demographic characteristics and perceived annoyance, statistical analyses were carried out. The chi-square test of independence was employed to test whether there are significant associations between different variables, such as age groups, gender, education, and exposure duration, with annoyance levels. This test helps to determine whether differences in annoyance responses across various demographic groups were statistically significant.

An ordinal logistic regression model was applied to evaluate the relative contribution of these factors to higher annoyance levels while controlling for other variables. The results were presented as adjusted odds ratios (aOR) with 95% confidence intervals (CI) and corresponding p-value. The odds ratio can be interpreted as the likelihood of experiencing higher annoyance relative to a selected reference category. A significance level of 0.05 was adopted for both the chi-square test and the ordinal logistic regression. All the statistical analyses were done using IBM SPSS Statistics 27.

3. RESULTS AND DISCUSSION

3.1 Noise Indices at Different Intersections

A summary of all the traffic indices for all the locations is shown in Table 2. For all the intersections, L_{eq} values exceeded the acceptable limit of 60 dB. The TNI values also crossed the threshold of 74 dB, indicating traffic-induced annoyance. "Katabon Mor" was found to be the noisiest with the highest $L_{eq,}$ NC, and TNI values. This could be due to the formation of long queues of vehicles during the red signal and the overuse of the horn. Both "Katabon Mor" and "Rayshaheb Bazar Mor" had the highest "peak level" noise. The background noise was the highest at "Shantinagar Mor" and "Rayshaheb Bazar Mor". Most fluctuation in noise level was found at both "Arambag mor" and "Katabon Mor". "Bakshi Bazar Mor" was relatively less noisy compared to other intersections.

Table 2: Summary of Noise Indices

Location	L_{eq}	L_{10}	L_{50}	L_{90}	NC	TNI
Nilkhet	86	89	80	72	16	108
Bakshibazar Mor	84	87	78	72	15	102
Shantinagar Mor	87	90	84	78	13	98
Kakrail Mor	87	90	83	77	12	97
Rayshaheb Bazar Mor	90	94	85	78	16	111
Dayaganj Mor	85	85	78	72	14	96
Katabon Mor	91	94	84	77	17	114
Arambag Mor	90	93	83	76	17	114
Fakirapool	87	89	81	75	14	100
Science lab	89	92	82	76	16	110

3.2 Summary of Survey Results

A total of 153 people participated in the survey. The survey data includes perceived annoyance and self-reported health impacts, demographic factors, and variables related to the extent of exposure. The data was thoroughly checked for erroneous entries. In some cases, the sub-categories were regrouped for statistical analyses.

3.2.1 Perceived Annoyance and Health Impacts

The survey results show that traffic noise causes annoyance (Figure 3) and adversely affects health (Figure 4). Every participant reported annoyance to some extent. Over half of the respondents (51%) were extremely annoyed by noise. More than half experienced headaches from moderate to extreme levels. Nearly two-thirds reported hearing issues to different extents. Sleep disturbance was also common. About 59% of participants reported that they experience difficulty sleeping. However, the extent of difficulty is relatively less severe. Most participants did not report having high blood pressure. Overall, traffic noise causes serious annoyance and various health issues.

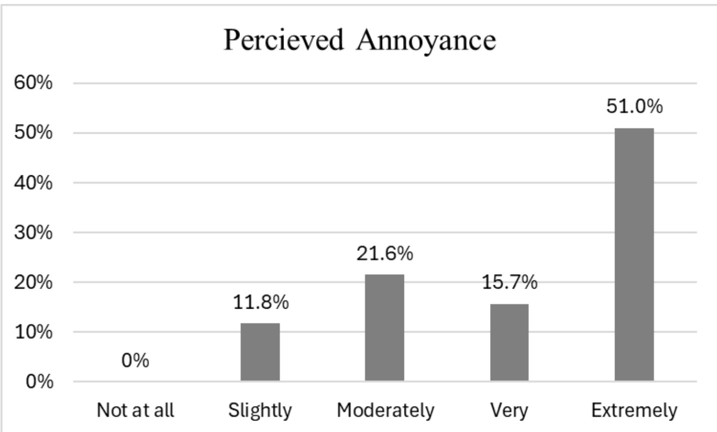

Figure 3: Distribution among different levels of perceived annoyance

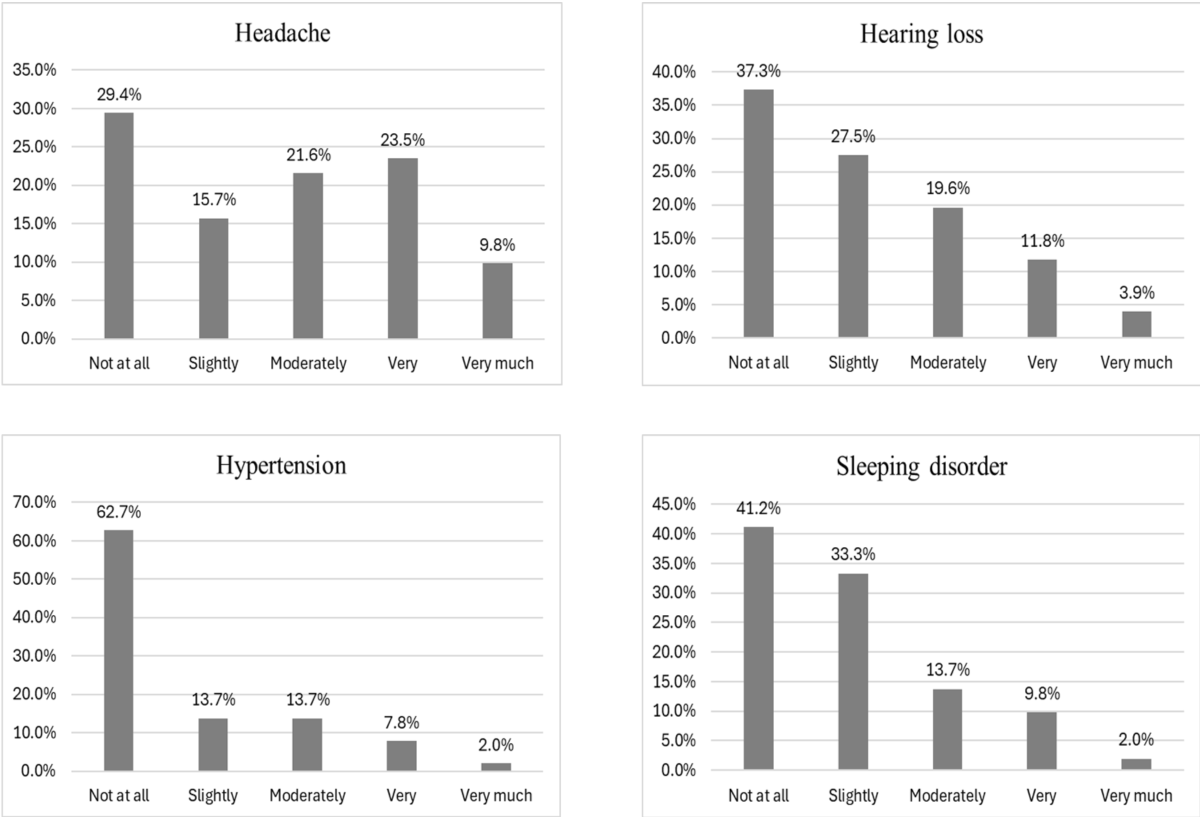

Figure 4: Distribution among different levels of health effects

3.2.2 Categorical Variables

From the survey, a total of eight categorical variables were found (Figure 5). Most of the respondents were traffic police (31.4%) and shop owners or keepers (29.4%). The other occupations were roadside vendors (17.6%), support staff such as traffic police assistants (11.8%), and security guards (9.8%). In terms of educational background, over half of the participants (51%) had completed undergraduate or higher studies. Most respondents (66.7%) were non-smokers. All the participants were put into three categories based on age. Most of them were aged between 26 and 40 years (51%). During the survey, it was observed that in around 63% cases, there were no sound-absorbing materials in their surroundings. Participants were also put into three categories based on job duration. 41.2% of the respondents had been working near the intersection for more than 15 years. A large proportion (72.5%) of the participants reported that they always work during peak traffic hours. This leads to exposure to a higher level of noise. Working hours were put into two categories: 4 to 8 hours and more than 8 hours. The participants were nearly evenly distributed in the two categories.

3.3 Results of Statistical Analyses

For statistical analysis, 8 variables were considered. The variables include socio-demographic variables like age, education, occupation, and smoking habit, and variables related to the extent of exposure like duration of shift, presence of sound-absorbing materials, etc. Since all the participants were male, the effect of gender could not have been identified. The occupations of the participants include- roadside vendor, security guard, shop owner/keeper, support staff of traffic police, and traffic police. These were put in two broad sub-categories – "traffic police & support staff' and "other".

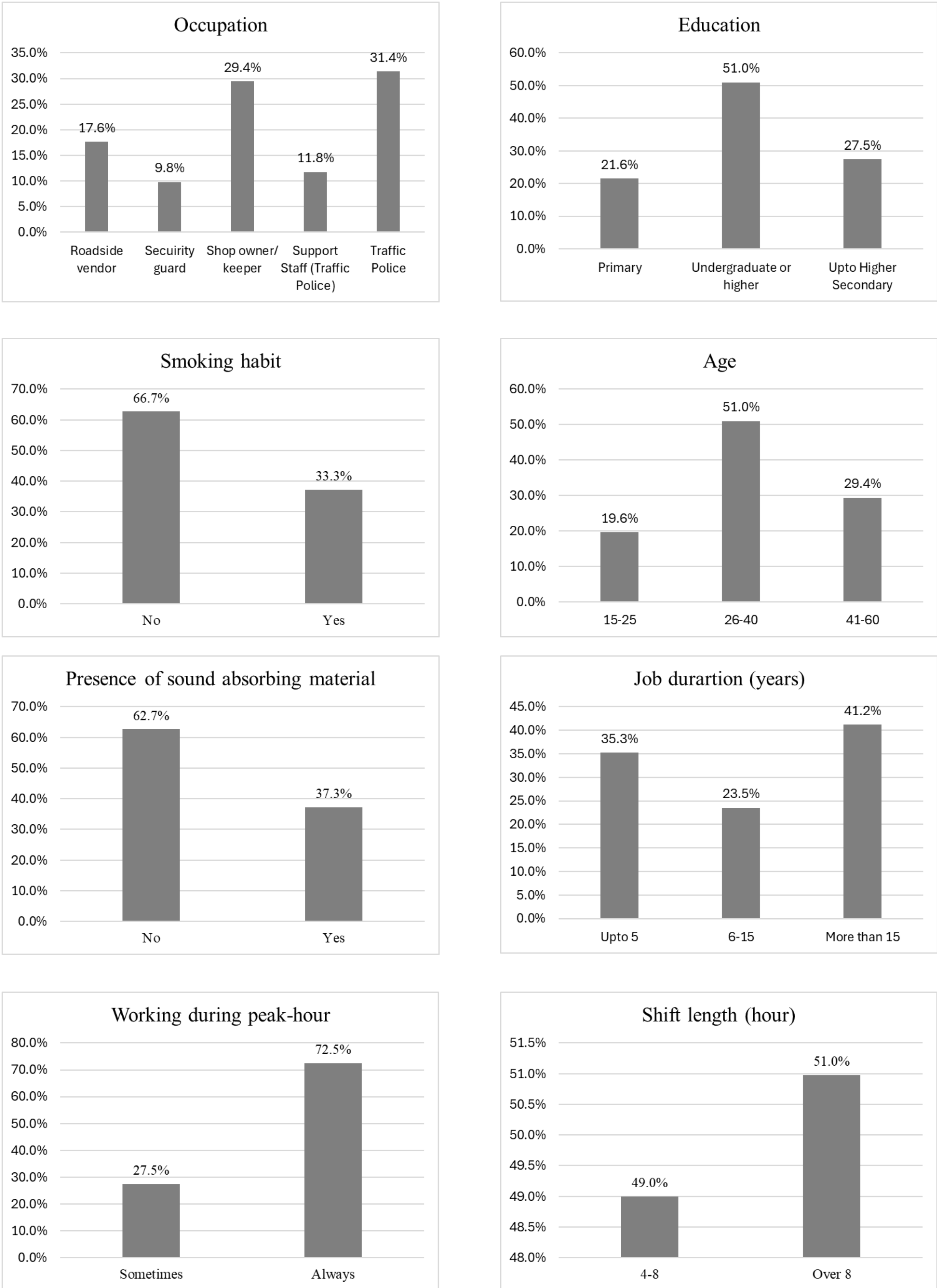

Figure 5: Distribution among different categorical variables

3.3.1 Chi-Squared Test

The results of the chi-squared test are shown in Table 3. At a significance level of 0.05, "Age" did not show a statistically significant association with perceived annoyance. Soni et al., 2024 also did not find a significant association between age and annoyance in their study. However, the job duration or how long a person has spent prolonged time at or near intersections showed a strong association. Previously, Naha et al., 2020 also found a strong association between job duration and annoyance among traffic police in Dhaka city. The other variables were also found to be strongly associated with perceived annoyance.

Table 3: Results of chi-squared test

Categorical Variable	Chi-square	p-value	Association
Age	12.061	0.061	Insignificant
Occupation	26.130	<0.001	Significant
Education	32.965	<0.001	Significant
Smoking habit	12.157	0.007	Significant
Duration of shift	11.858	0.008	Significant
Job duration	24.886	<0.001	Significant
Working during peak hour	25.371	<0.001	Significant
Presence of sound-absorbing material	14.935	0.002	Significant

3.3.2 Ordinal Logistic Regression

The result of the ordinal logistic regression is shown in Table 4. One sub-category of each categorical variable was treated as reference, and the likelihood of higher annoyance for other sub-categories of that variable is shown with a 95% confidence interval and significance. For example, a person who works more than eight hours at or near the intersection is about seven times more likely to be more annoyed compared to someone who works for four to eight hours (reference) at the same noise level. It can also be inferred that a longer duration of exposure increases the chance of being annoyed. Similarly, members of the traffic police and support staff are more likely (more than three times) to be annoyed compared to people from other occupations. However, the subcategory wasn't a statistically significant predictor ($p = 0.153 > 0.05$). Absence of sound-absorbing materials, smoking, and working during peak hours increases the likelihood of annoyance. The likelihood increases with the increase in both shift length and job duration. A higher level of education also indicated a higher possibility of annoyance. A similar trend was also observed in (Soni et al., 2024). But with increasing age, the annoyance likelihood for people aged 26-40 years and 41-60 years is about half with respect to people aged 15-25 years. In Soni et al., 2024, people from different age groups had different likelihoods without any clear trend. Still, similar to the current study, younger people (less than 20 years old) were most likely to be annoyed compared to older people (more than 60 years old).

Table 4: Results of ordinal logistic regression

Category	Sub-category	aOR	95% CI		Significance
			Lower	Upper	
Presence of sound-absorbing material	No	4.27	1.02	17.91	0.048*
	Yes	1.00	Reference		
Occupation	Traffic Police & Support staff	3.37	0.64	17.90	0.153
	Other	1.00	Reference		
Education	Primary	1.00	Reference		
	Up to Higher Secondary	5.21	1.22	22.29	0.026*
	Undergraduate or higher	7.44	1.86	29.76	0.000*
Smoking habit	No	1.00	Reference		
	Yes	3.31	1.01	10.84	0.048*
Working during peak hour	Sometimes	1.00	Reference		
	Always	2.63	0.68	10.21	0.162
Age	15-25	1.00	Reference		
	26-40	0.50	0.14	1.76	0.277
	41-60	0.53	0.10	2.91	0.467
Shift length (hours)	4-8	1.00	Reference		
	Over 8	7.07	2.20	22.71	0.001*
Job duration (years)	Upto 5	1.00	Reference		
	6-15	4.37	1.02	19.04	0.001*
	More than 15	8.18	1.88	35.583	0.000*

*predictor significance at $p < 0.05$

4. CONCLUSIONS

This study shows that the noise levels near intersections exceeded the standard set in the Noise Pollution Control Rules 2006. According to the survey, every participant reported annoyance to some extent. People from all occupations who work near the intersections are suffering from the adverse effects of noise pollution. Traffic police are the worst sufferers due to longer shifts and job duration. Statistical analyses showed that the presence of sound-absorbing material is associated with perceived annoyance. In the absence of sound-absorbing materials, a person is more likely (about four times) to be annoyed.

Conducting socio-acoustic surveys at more intersections will help to better assess the association between traffic-induced noise and perceived annoyance. This study can also be done focusing on intersections near hospitals and educational institutions. Taking noise level measurements during off-peak hours and on weekends at the same intersection will help to capture the variation in noise levels. For a bigger dataset, machine learning or artificial neural network can be used.

Declaration of Use of AI

The authors declare that Grammarly was used for spelling and grammar checking. Some suggested edits were accepted to improve clarity of the text. No other AI tools were used for content generation, data analysis, or interpretation.

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