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TRAFFIC NOISE AND ITS EFFECTS ON HUMAN HEALTH AND BEHAVIOR IN SOME SELECTED INTERSECTIONS OF KHULNA CITY

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ABSTRACT

Traffic noise has reached in an unacceptable level with the growing number of vehicles in urban areas. Exposure to traffic noise causes significant health and behavioral risks for the people who are vending or working along the roadside. This research explores the traffic noise levels at six selected intersections of Khulna City and identifies its effects on human health. So, noise level (in dB unit) was measured by Sound Meter, an android application which supports calibration to achieve actual reading. Using a cluster random sampling technique, a total of 120 respondents were surveyed through questionnaire together with collecting noise levels' data of different times at all selected intersections. Questionnaire of this study included issues related to demographics, health and exposure to noise. Then appropriate statistical analysis was carried out by using Statistical Package for the Social Sciences (SPSS) and R Studio. Among the six intersections, highest (111 dB) level of traffic noise was found in Dakbangla and lowest (51 dB) in Moilapota. In fact, noise levels at all the intersections are greater than expected level. Intersections with inadequate carriageway width to accommodate all traffic flow along with low level traffic management can be considered as one of the major causes of high traffic noise levels at the intersections. High noise levels have been found to be correlated with rising risk of noise related physical and mental health issues. Most of the people got affected by several health related problems simultaneously such as hearing impairment, communication problem, sleeping disturbance, cardiovascular and psychophysiological issues, mental health problems and performance related problems. Among them, some people were found with diabetes mellitus who were affected by traffic noise while working along the roadside of these intersections. It is also observed that age is moderately correlated with noise related health problems. Although the study didn't withstand effects of other factors on health related problems, but it has explored something on this aforementioned issuse that creates an enormous scopes for clinical research and upgrading relevant policy.

Keywords: *Traffic Noise, Noise Effect, Human Health, Human Behavior, Khulna City.*

1. INTRODUCTION

Noise can be defined as unwanted sound which is perceived as stressor or disturbance to the adjacent community (Stansfeld & Matheson, 2003). It is very regular for a person experiencing sound at levels that can cause unfavourable wellbeing impacts except people from very countryside area. People living in a typical urban environment hear a broad range of sounds in many places during a single day, including stations, road intersections, markets, shopping malls, classrooms, office, recreation canters and home. The most pervasive noise related issue refers to road traffic in most cities around the world. World Health Organisation (WHO) described noise as one of the most important health threats for the working-class population (Hansen, 2018). Noise-induced hearing impairment has been marked as the most prevalent irreversible occupational hazard.

Modern world is facing severe noise pollution due to over urbanization during the 21-century. Booming population growth, depletion of rural land area and rapidly growing transit infrastructure are of the main reasons behind the issue of noise pollution. It is a matter of concern for both developed and developing countries worldwide (Hoque, Basak, Rokanuzzaman & Roy, 2014). As a developed country, about 22 million U.S. workers are exposed to hazardous noise levels at work every year (Tak, Davis & Calvert, 2009). In Bangladesh, millions of people are exposed to a number of health risks due to noise pollution. Around 11.7% of the population in Bangladesh have lost their hearing due to noise pollution by 2017, according to the Department of Environment (DoE) study. It is also found that sound levels are far beyond the acceptable threshold for the human ear in all divisional cities of Bangladesh where Dhaka and Khulna are in the same position (Mamun, 2018).

Traffic noise is the principle source that is making Khulna city increasingly objectionable every day. Traffic noise exposure is responsible for a range of effects on human health and behavior including interference with communication, noise-induced hearing impairment, sleep disturbance effects, cardiovascular and psychophysiological effects, mental health effects, effects on performance, annoyance responses and effects on social behaviour (Berglund, Lindvall & Schwela, 1999). According to the Noise Pollution (Control) Rules 2006, the acceptable sound level for the Bangladesh is 50dB for daytime and 40dB for night in silent areas; 50dB for daytime and 45dB for night in residential areas; 60dB for daytime and 50dB for night in mixed areas (residential, commercial and industrial localities); 70dB for daytime and 60dB for night in commercial areas, and 75dB for daytime and 70dB for night in industrial areas (Bangladesh Department of Environment [BDE], 2006). Khulna city is going to deal with huge number of traffic after completing the Padma bridge in near future. So, Khulna may face shocking level of traffic noise soon. In fact, no recent research on traffic noise and related health issues is found for Khulna city which suggests the importance of this work.

In response to the alarming degree of traffic noise, this research attempted to find out the current traffic noise condition and its impact on human health and behaviour at some selected intersections in Khulna city. For this, available handheld mobile device was used in a systematic way to measure the noise level. Adjacent people around the intersections who works along the roadside were surveyed to extract information about traffic noise and their health based on perception.

2. METHODOLOGY

2.1 Study Area

Six intersections were selected to conduct this research in Khulna City Corporation (KCC) area, the main city of Khulna division. Geographically, it is linear shaped and lies at 22"49'north latitude and 89"34'east longitudes. Its area is 59.57 km^2. Khulna is Bangladesh's third-largest economic centre. It is a hub of Bangladeshi industry hosting many national companies. Khulna is served by the Port of Mongla (the second-largest seaport in the country). Its population density is about 19,000 inhabitants per square kilometre (49,000/sq. mi). The selected intersections for this research are Dakbangla, Shibbari, Sonadanga, Gollamari, Nirala and Moilapota which are shown through Figure 1. These are the major working along the roadside, well-known and important intersections in Khulna City.

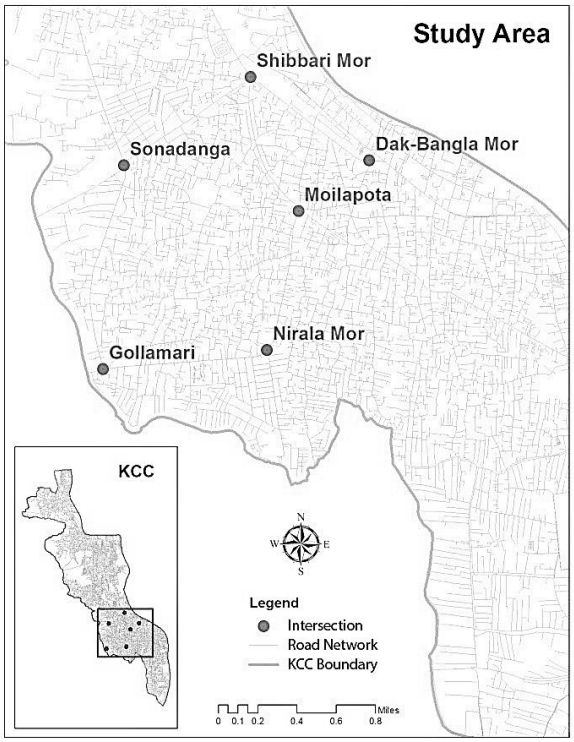

Figure 1: Study area

Source: Authors, 2019.

2.2 Sampling, Data Collection Tools and Techniques

2.2.1 Questionnaire Survey Data

Questionnaire survey data comprised demographic and health related data of every respondent. The sample size was calculated using the simplified equation provided by Taro Yamane where the confidence level was taken as 91 percent (Yamane, 1967). The resulted sample size was 120. So, total 120 respondents were surveyed through cluster random sampling technique for six selected intersections. 20 respondents were selected randomly for each of the intersections. A questionnaire was developed considering all necessary related aspects to collect data from the respondents. All respondents were picked in a way that their working place is situated within 50 meters buffer zone of the corresponding intersection (noise measuring point).

2.2.2 Noise Data

Using an application called Sound Meter (Version: 3.2.6, Abc Apps), noise data was collected through android mobile device. It has calibration functionality which is very useful to get noise data in decibel (dB) unit as same as sound level meter. Calibration was done using UT353 Mini Sound Meter (UNI-T) where the error was around 17dB. Noise data was collected from all six intersections for three times a day covering peak (9AM to 10AM, 5PM to 6PM) and off-peak (3PM to 4PM) hours. This process was followed for three days at each of the intersections. Noise was measured (Maximum, Average and Minimum) for ten minutes duration every time.

2.3 Analytical Procedure

Several analytical tools and techniques have been applied to analyse traffic noise along with its impact on human well-being and behaviour. An overall and time-wise estimation of noise level (dB) has been made for all of the intersections and then, descriptive and inferential statistics have been used to analyse noise level (dB) along with data collected through questionnaire survey. Statistical Package for Social

Sciences (SPSS) and R Studio have been used to perform those. Firstly, association between noise level and health issues were assessed through Pearson's Chi-square test while both were taken as categorical variable. Then, Univariate Binary Logistic Regression (UBLR) analysis was used to examine the impact of traffic noise on human health and behaviour. Finally, appropriate descriptive statistical analysis was used to clarify and justify the circumstances on the basis of the UBLR's result.

Univariate Binary Logistic Regression (UBLR) is used to characterize information and to illustrate the relationships between one dependent binary variable and one or more independent nominal, ordinal, interval or ratio-level independent variables (Schüppert, 2009). Here, noise related health problem (Two category: Yes or No) has been taken as dependent variable and the noise data in dB unit has been taken as independent variable to conduct UBLR. Here, equation (1) shows the UBLR with proper depiction (Figure 2).

$$P(Y) = \frac{1}{1+e^{-(b_0+b_1X_1)}} \quad (1)$$

P: probability of *Y* occurring
e: natural logarithm base (= 2.7182818284…)
b_0: interception at y-axis
b_1: line gradient
X_1 predicts the probability of *Y*.
Here, Figure 2 shows that *P(Y)* ranges from *0* to *1*, the logit ranges from -∞ to +∞.

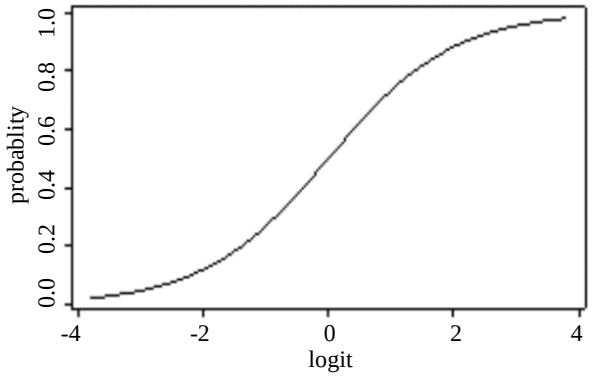

Figure 2: Logit transformation

Source: Rodríguez, 2019.

The regression model is acceptable when the p-value is below 0.05 and a high R^2 value means a better model fit. However, Figure 3 illustrates the analytical procedure of this study below.

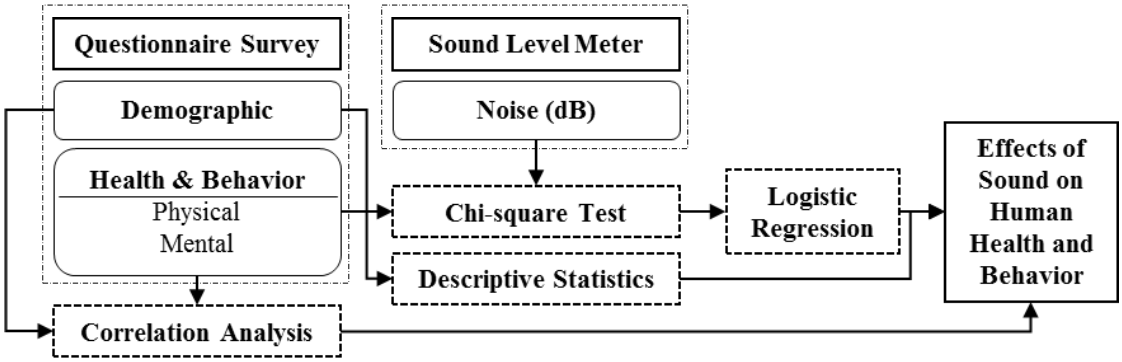

Figure 3: Analytical framework

3. RESULTS AND DISCUSSIONS

3.1 Traffic Noise Condition at Six Intersections

This study found the average, minimum and maximum noise level of three times a day for all six intersections. An overall estimation has been conducted from the daily three times' data to see the simplified scenario of the intersections. Table 1 shows that the minimum sound is 51 dB (Moilapota) and the maximum sound is 111 dB (Dakbangla). Because, Moilapota intersection has a roundabout which is quite spacious. Here, the traffic management is relatively better as well. On the other hand, Dakbangla intersection is the most overcrowded and busy place in Khulna city. It is the main commercial zone next to the railway station and launch terminal in the city boundary. It is also observed from the overall average noise levels of these two locations. Overall average noise at Shibbari (76 dB) shows the second lowest level. Shibbari connects northern and western part of Khulna with the central part. It has to deal with huge number of vehicles but its large spacious roundabout contributes to keep noise level comparatively lower. The second highest overall average noise level has been found at Gollamari (82 dB). It is the entrance intersection towards Khulna city centre with relatively narrow street. As a result, traffic jam is very common in this intersection during peak hour and noise measurement during off-peak hour shows high level of noise as well. From the overall noise data, it is seen that Dakbangla, Gollamari and Sonadanga (overall average noise level is 81 dB) are nearly placed. Sonadanga is the main bus terminal in Khulna city. It is another entrance to Khulna city via Sonadanga bypass road with heavy traffic. Nirala is a well-known residential area in Khulna city. Nirala intersection has to carry traffic with its narrow street and intersection from Gollamari to Moilapota and vice-versa. So, it's usual to see Nirala's overall average noise level (78 dB) in moderate level comparing to the other intersections. However, all of these intersections' noise is higher than the accepted normal noise level (70dB for daytime and 60dB for night in commercial areas) defined by appropriate authority (BDE, 2006).

Table 1: Noise levels in all intersections

Location	Overall (Sound in dB)			Morning (Sound in dB)**			Noon (Sound in dB)*			Evening (Sound in dB)**		
	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max	Min	Avg.	Max
Sonadanga	66	81	107	69	79	106	66	82	107	69	82	107
Gollamari	58	82	110	58	79	106	63	85	107	65	83	110
Nirala	58	78	110	58	77	106	60	81	110	60	77	110
Dakbangla	61	83	111	61	81	109	64	84	111	69	85	110
Moilapota	51	73	110	51	73	103	57	75	110	56	73	109
Shibbari	59	76	110	60	75	109	59	75	110	65	77	107

**Peak hour, *Off-peak hour

Source: Field Survey, 2019.

3.2 Respondents' Demographic Information

This study found that the majority of respondents were male. They were primarily involved in various types of business such as tea stall, fruit shop, departmental store, stationary shop, electronics shop, medicine store, restaurant and various small scale road side business. Table 2 shows the respondents' age range from 22 years to 60 years where the average age is 38 years old.

Table 2: Respondents' demographic information

	Age (Years)	Service Time (Hours Per day)	Monthly Income (BDT)
Mean	38.27	13.56	35275
Median	38	13	25000

	Age (Years)	Service Time (Hours Per day)	Monthly Income (BDT)
Mode	38	13	25000
Standard Deviation	8.47	1.91	25590.49
Minimum	22	7	8000
Maximum	60	17	120000

Source: Questionnaire Survey, 2019.

All of them are adult and there is a necessary variation in ages as well. Standard deviation refers to majority's age range is from 30 years to 46 years. Every day, they spend about 13 hours on an average in their own working place. Their monthly earning ranges from 8000 BDT to 120000 BDT where the average earning is 35275 BDT. Here, the standard deviation of monthly income indicates heterogeneity among the respondents.

3.3 Traffic Noise and Related Issues

Association between traffic noise level and noise related health issues has been tested through Pearson's Chi-square test. Noise level is divided into six categories in a level of 1 to 6 based on their noise intensity. On the other hand, noise related health issue has been considered as binary variable with YES=1 or NO=0 value. The result is shown through Table 3.

Table 3: Chi-square test's result from health effects of traffic noise and noise level

Number of Valid Cases	Pearson Chi-Square			Cramer's V	
	Value	Asymptotic Significance (2-sided)	df	Value	Approximate Significance
120	21.052632	0.001	5	0.418854	0.001

Source: Questionnaire Survey, 2019.

The null hypothesis of the Chi-Square test is that no relationship exists on the categorical variables in the population; they are independent. Here (Table 3), the Chi-square result can be expressed as $X^2(5) = 21.05$, $p = 0.001$ which indicates that Chi-square value is greater than the critical value (11.07) at df=5 and $p \leq 0.01$. So, the null hypothesis is rejected and there is a significant association between traffic noise level and noise related health issues. Cramer's V is a number between 0 and 1 that indicates how strongly two categorical variables are associated. Here (Table 3), the resulted value (0.42) shows a significant moderate association between the variables.

As the association has been found through appropriate statistical analysis, it is important to find out how traffic noise affect human health and behavior. Univariate Binary Logistic Regression (UBLR) has been used to do so with the aforementioned two variables (2.3.2). Table 3 shows the result of UBLR.

Table 4: Univariate Binary Logistic Regression (UBLR)'s result

Independent Variable (N=120)	B (Beta Coefficient)	S.E. (Standard Error)	Wald Chi-Square	Sig.	Exp(B) Odds Ratio
Traffic Noise Data in dB Unit	0.940	0.443	4.505	0.034*	2.560

Dependent Variable: If Any Noise Related Health Problem (*YES=1, NO=0*).
$X^2(1) = 17.008$, $p \leq 0.01$
Nagelkerke R Square = 0.403
* Significant at $p \leq 0.05$.

Source: Questionnaire Survey, 2019.

Here, Univariate Binary Logistic Regression (UBLR) was performed to ascertain the effects of traffic noise on the likelihood that participants have noise related health problems. Table 4 indicates that UBLR model is statistically significant, $X^2(1) = 17.008$, $p < 0.01$. The model can explain 40.3% (Nagelkerke R^2) of the variance in noise related health problems and correctly classify 95.0% of cases. Table 4 also shows that increasing traffic noise (dB) is associated with an increased likelihood of exhibiting noise related health problems in Khulna city.

Due to traffic noise, people of the adjacent intersection are suffering from various health and behavioural problems. This study found (Table 5) about 94 percent of the respondents who were suffering from mental health related problems like mental stress as well as bad headache. Noise-induced hearing impairment affected 90 percent of the respondents. 88 percent respondents belong to groups sensitive to interference with communication. Noise tends to interfere with auditory communication, where the most important signal is speech (Berglund, Lindvall & Schwela, 1999). Around 53 percent of the respondents are suffering from sleeping problem. Cardiovascular and psychophysiological effects due to traffic noise seem very lower in percentage. Also, impact of traffic noise on performance is very low among the respondents. There are many people having multiple problems simultaneously.

Table 5: Noise related health and behavioral problems

Name of the Problems	**Percentage of Affected People* (Individual Percentage, N=120)**
Noise-induced hearing impairment	90.00%
Interference with communication	88.33%
Sleep disturbance effects	53.33%
Cardiovascular and psychophysiological effects	25.00%
Mental health effects	94.17%
Effects on performance	10.00%

*People have multiple problems simultaneously.

Source: Questionnaire Survey, 2019.

Generally, aging is a strong risk factor for many types of diseases (Atella et al., 2019). Figure 4 shows similar scenario from the perspective of traffic noise related health problems. Plotting between number of noise related health problems and corresponding respondent's age gives an upward trend line. Considering these two factors, a Pearson Correlation was conducted where a positive moderate correlation coefficient value as 0.413 was found that is significant at 0.01 ($p < 0.01$).

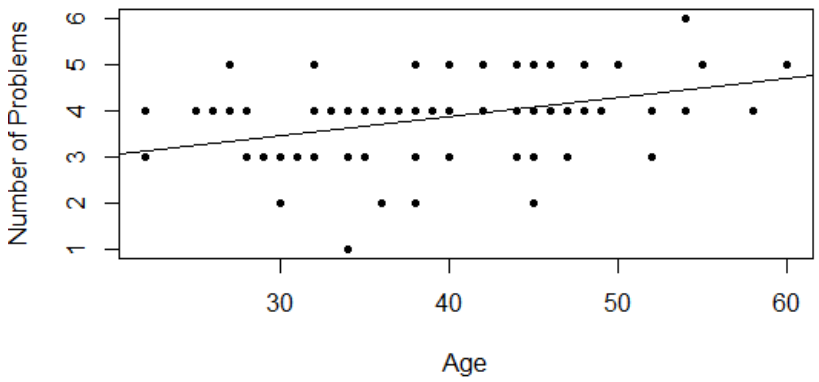

Figure 4: Plotting age with number of problems due to traffic noise.

Source: Questionnaire Survey, 2019.

Again, number of health problems are shown through boxplot according to each of the intersections which shows that number of health problems is the highest at Gollamari and the lowest is at Shibbari (as shown in Figure 5). Here, larger interquartile range (Shibbari and Gollamari) indicates large variation in number of problems among respondents in the corresponding intersection. Also, Shibbari

holds the lowest median which indicates that most of the respondents at Shibbari have lower number of problems. In contrast, narrow interquartile range (Sonadanga) indicates smaller variation in number of problems among respondents in the corresponding intersection. While considering the medians, boxplots of all intersections except Dakbangla are skewed. Dakbangla holds a symmetric (roughly the same on each side when cut down the middle) data set that indicates the median roughly in the middle of the box. So, almost half of respondents from Dakbangla have 3 problems and the rest half have 4 problems. Nonetheless, the average number of problems is 3.80 where both median and mode value is 4 and standard deviation is 0.85. This scenario is similar to the boxplot's (Figure 5) scenario for all intersections.

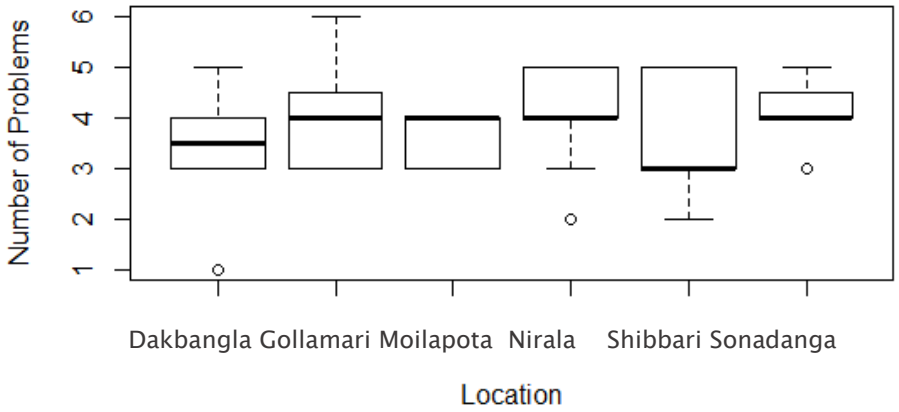

Figure 5: Boxplot of the six intersections considering number of problems due to traffic noise.
Source: Questionnaire Survey, 2019.

It is also found that people (appx. 7%) are suffering from other health related problem like diabetes and their age range is from 44 years to 60 years. This study shows that all of them got affected by diabetes mellitus (DM) after coming to their present workplace. Several researchers also found that an increase in traffic noise of 5 dB was associated with an increase in DM risk of 7 percent (Sakhvidi, 2018). They are also suffering from 3 to 6 traffic noise related health problems simultaneously. Their very common noise related health problem is mental health effects.

3.4 Overall Discussion

Traffic noise levels at all six intersections were found comparatively higher than the normal accepted noise level (70 dB) specified by Department of Environment. Highest average level was observed at Dakbangla where the lowest was observed at Moilapota. Considering the other intersections' noise levels, it can be said that intersections with inadequate carriageway width having efficient traffic management generates higher level of traffic noise. Respondents' age range is from 30 years to 46 years (nearly) who works 13 hours on an average daily. Analysis shows that people are suffering from various types of health and behavioral problems due to higher level of traffic noise at all six intersection in Khulna. It is expected that scenario of other well-known and important intersections in Khulna may be same as those selected intersections.

Here, most of the people are suffering from hearing, communication and mental health related problems. Others problems are also found but not as higher percentage as those while majority people are affected by multiple problems. Most of the people are affected by 3 to 4 noise related problems and people at Gollamari intersection are affected by the highest number of noise related problems. A significant association has been found between age and respondents' number of noise related problems. Some of the respondents were found with diabetes mellitus while working at their present working place beside the corresponding intersection. Here, traffic noise can be considered as potential cause of diabetes mellitus.

4. CONCLUSIONS

This research was conducted to find out the present condition of traffic noise and its effect on human health and behavior in Khulna. It included a wide range of people who works around 13 hours a day in noisy environment continuously. As a consequence of higher noise level, their mental health is affected more than their physical health. Often, issues in mental health lead to physical health problems. There are scopes of in-depth clinical research regarding this aspect as soon as possible. Nonetheless, in Khulna, intersections with inadequate carriageway to accommodate all traffic flow having low level traffic management, lead to higher traffic noise which is above the normal and acceptable level. So, it is urgent to impose strict traffic regulations in related options that can help noise reduction. Appropriate authority has wide scopes to review the rules and regulations relating to noise, taking into account from a range of related perspectives.

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