

Environmental noise assessment and its effect on human health in an urban area

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ABSTRACT

Traffic noise is a major environmental source of pollution in the whole planet, both in developed and in developing nations. The present study focuses on the traffic noise assessment and its negative health effect on road side residents. Five different locations were selected along a National Highway of Burdwan having a day time L_{eq} level of 60 to 89.5 dBA. Evaluation of various noise descriptors such as L_{10} , L_{50} , L_{90} , L_{eq} , L_{NP} and TNI showed that people of the study area got suffered from slight uncomfortable feeling to a position of noise annoyance. Assessment of health effects among the 52 peoples of 10 families residing in the study areas for long time was conducted through a questionnaire based survey. Responses from the people were collected for analysis and the outcome revealed that 53%, 36%, 40% of people were suffered from headache, anxiety and high blood pressure whereas 36%, 15%, 67% and 61% of people were suffered from hearing disability, cardiovascular diseases, irritability and insomnia respectively. Chi-Square test was conducted among the different physiological and psychological effects and it was found that noise has a significant ($\alpha = 0.05$) effect on hearing loss, sleep disturbances, abnormal heart beat and speech communication problem.

Keywords: Traffic noise, Noise descriptors, Social survey, physiological effects, psychological effects.

1. Introduction

Noise can be defined as an unwanted or undesired sound whereas environmental noise is any unwanted or harmful outdoor sound created by human activities that is detrimental to the quality of life of the individuals. Noise pollution is by now recognized worldwide as a major problem for the quality of life in any urban area (Piccolo et al., 2005). In most developed countries, standards for air pollution and noise exposures are important part of environmental policy to improve local environmental quality.

Numerous noise surveys treating the problem of noise pollution in many cities throughout the world have been conducted (Peter et al., 2008; Rehman and Maddison, 2008; Tang et al., 2007; Driussi and Jansz, 2006; Gündoğdu et al., 2005; Rao et al., 2004; Guasch et al., 2002; Sadan, 1986; Schultz, 1978). Most of this research has been concerned with the impact of noise on the auditory system (Pachpande et al., 2005), and it is now well established that exposure to noise levels of relatively high degrees can lead to direct hearing loss and /or hearing impairment (Prasher, 2003). Various works have also been done on the relationship between the extent of reaction of people and exposure to traffic noise in different cities (Chakraborty et al., 1998; Zannin et al., 2003; Gorai et al., 2006). However, more recent research has concentrated on the relationship between noise and non-auditory effects (Stansfeld, 2003). Social survey data has shown that annoyance, sleep disturbance and

cardiovascular problems are considered to be the most important environmental noise effects (Ouis, 1982; Langdon, 1976). Several noise factors that influence sleeping are the level of noise, fluctuations, number of exposures, type, time and information content. Individual factors are also important for the effect of noise on sleep. In a noise and sleep research, it was recommended that the night time average sound level ought to be kept below 45 dB in a sleeper's quarters (Griefahn, 1990). Noise also has been implicated in the development or exacerbation of a variety of health problems, ranging from hypertension to psychosis in human beings. It is reported that half of twelve field studies showed a positive correlation between noise exposure and blood pressure, while the rest indicated no significant effects (Van Dijk, 1990).

Burdwan (23.25° N, 87.85° E), located in the state of West Bengal, is situated at a distance of 100km from northwest of Kolkata and is a district head quarter. Burdwan is a developing town with good facilities for education, medical, market for grain and other commercial commodities. Population according to 2001 census is around 2, 86,058. In city noise mainly arises from the transportation system. Various types of vehicle, automobile, cycle, rickshaw etc. create tremendous noise at various points of this city. Previously noise level assessment of this town was performed by Datta et al., 2006, but so far no work has been done in the aspect of health effects. With this backdrop, the present research deals with the assessment of environmental noise by using various noise descriptor and its associated auditory and non-auditory health effects among different age group of people.

2. Methodology

2.1 Equipment Used

The equipments used for the present research work consist of sound level meter (Model LUTREN, SL-4001) which is an instrument responds to sound in approximately same way as human ear and which gives reproducible measurements of sound level (Mato and Mufuruki, 1999). Physiological parameters viz. hearing impairment, blood pressure and heartbeat were measured by using audiometer (Arphy, Model No. 500 MKIIS); mercury sphygmomanometer (msi, CM/L 08961725) and stethoscope (Diamond) respectively. Other physiological parameters were surveyed through personal interview and past record.

2.2 Noise Descriptors

Noise descriptor such as L_{10} , L_{50} , L_{90} , L_{eq} , L_{NP} and TNI were recorded. Baseline sound levels were monitored for three different periods of the day, namely: morning, afternoon and evening time readings. Definition for the noise descriptors are presented as follows:

L_{10} : Defined as the level in dB (A) exceeded over 10% of the time, during every hour period of 18hours from 6a.m to midnight on a typical working day.

L_{50} : Defined as the level in dB (A) exceeded for 50% of time.

L_{90} : It is the level exceeded for 90% of the time; it is often referred to background noise level.

L_{eq} : The constant level that would produce the same amount of energy at the measuring point as the actual fluctuating level during the measuring period.

L_{NP} : It takes account the variations in the sound signal and hence it should serve as a better

indicator of pollution in the environment for both physical and psychological disturbances of people. TNI: The traffic noise index (TNI) is a method used to estimate annoyance responses due to traffic noise (Griffiths et al., 1968).

2.3. Social survey

Altogether, 52 questionnaires were taken for the survey. Within this study area ten (10) families consisting of 52 members who are continuously exposed to traffic noise were taken as a subject for this research work. Entire survey was conducted directly through household visits assessing the physiological and psychological effects of noise among subjects. Among the participants in the survey, 32.7% were male and 67.3% were female, and their age was between 8 to >50 years. Out of them 15.38% were in the age group of 1-15 years, 38.46% of 16-35 years, 32.69% of 36-50 years, and 13.46% of 50 years. Out of total respondents, 9.61% had shown ignorance on health effect due to noise exposure.

2.4. Statistical analysis

In order to determine whether the effects of noise on road side peoples are significant or not, data was analyzed through a statistical test of significance. The most common type of test used to carry out bivariate analysis in practice is Chi-square test. The Chi-square test may be used to find whether the two variables are dependent or independent. However, it does not tell anything about the nature of relationship between the two variables.

Generally, the null hypothesis (H_0) suggests that two variables are independent of each other. The alternative hypothesis (H_1) suggests that they are not independent of each other i.e. there is a relationship between the two variables. In the present study, one variable is represented by the kind of location or site while the second variable is indicated by the presence or absence of effect of noise on the people. The observed (O) and expected (E) frequency values were calculated. The null hypothesis was tested at a confidence level of 95%, confidence coefficient (α) is 0.05 and accuracy $\pm 5\%$. Chi-square value was calculated using the following equation [Montgomery et al., 2003].

$$\text{Chi-square value} = (O-E)^2/E$$

Expected value was calculated using the probability. When observed value is significantly greater than the expected value, then a relationship is said to exist between two variables, otherwise the relationship does not exist.

3. Results and discussion

3.1 Assessment of environmental noise

Assessment of noise are done through various noise indices viz., L_{10} , L_{50} , L_{90} , L_{eq} , L_{NP} and TNI (Table 1) which are also compared with noise level pertaining to the dissatisfaction parameters scores (Table 2) (Rao and Rao, 1992). According to Rao and Rao 1992 dissatisfaction score 2, 3 and 5 represents slight uncomfortable feeling, mild disturbance and a position of noise annoyance respectively. Results of 5 specific sites of study area in respects to dissatisfaction score of various noise parameters are represented in Table 3. Most of the monitoring sites have the value of L_{10} , L_{50} , L_{90} , L_{eq} , L_{NP} exceeding the dissatisfaction score of 3, while some monitoring sites have L_{NP} exceeding dissatisfaction score 2. Only site 5 has L_{50}

value exceeding the dissatisfaction score 5. So peoples of the study area are overall suffering from slight uncomfortable feeling to a position of noise annoyance.

Table 1: Noise descriptors in the study area

Location No.	L ₁₀	L ₅₀	L ₉₀	L _{eq}	L _{NP}	TNI
Site 1	78.52	77.36	76.7	75.52	77.34	53.98
Site 2	72.55	72.44	72.35	69.55	69.95	43.15
Site 3	74.77	74.13	74.07	71.77	72.47	46.87
Site 4	72.95	72.05	71.97	69.95	70.93	45.89
Site 5	87.01	86.88	86.54	84.01	84.14	57.06

Table 2: Prohibited levels of Environmental Traffic Noise indices (Rao and Rao, 1992)

Noise index	Upper limits for Noise levels in dBA		
	<i>Desirable Prohibitive</i>		
	Dissatisfaction	Dissatisfaction	Dissatisfaction
	Score 2	Score 3	Score 5
L ₁₀	64	74	93
L ₅₀	58	67	85
L ₉₀	52	61	79
L _{Aeq}	58	68	89
L _{NP}	69	82	111

Table 3: Dissatisfaction score with respect to noise descriptors

Location No.	L ₁₀	L ₅₀	L ₉₀	L _{eq}	L _{NP}
Site 1	>Score3	>Score3	>Score3	>Score3	>Score2
Site 2	>Score3	>Score3	>Score3	>Score3	>Score2
Site 3	>Score3	>Score3	>Score3	>Score3	>Score2
Site 4	>Score2	>Score3	>Score3	>Score3	>Score2
Site 5	>Score3	>Score5	>Score5	>Score3	>Score3

3.2. Physiological and psychological assessment

Age wise distribution of effect of noise is graphically represented in Figure1 and Figure 2.

3.3. Physiological effect

Exposure to noise can induce disturbance of sleep in terms of difficulty to fall asleep, alternation of sleep pattern of depth and awakenings (Eberhardt, 1987; Griefahn, 1989, 1990). Due to high intensity of traffic noise peoples not only in day but also in night could not sleep properly. As a result awakening from sleep is very common factor which leads to decrease their working efficiency and health status decreases. Other primary physiological effects that can be induced by noise during sleep are vegetative reactions such as increased blood pressure (Muzet et.al., 1980), and increased heart rate (Öhrström, 1989). This particular effect of noise is also supported by the study of Xin et al. 2000. In the present survey 32 people out of 52 people of different age group are sufferer of insomnia. Maximum cases are found among 50+ aged people and minimum one among 16 to 35 years old people. Particularly poor people whose houses are not designed to prevent noise are more sufferers. Noise makes the blood vessels narrower and resulting significant reduction in blood supply leading to

brain and therefore headaches results from listening to persistence noise (Bhatia, 2007). Present survey indicates that 28 people out of 52 people respond to causing headache due to noise. Maximum effects are found between 16 to 35 years age group whereas minimum one is found between 1 to 15 years. The elevated sound levels cause trauma to the cochlear structure in the inner ear, which gives rise to irreversible hearing loss (Rosen et al., 1965). Hearing deficiency also found to be varying with occupations and age (Rosenhall et al., 1990). Present study reveals that 21 people out of 52 people have more or less affected by hearing problem. Maximum sufferer are restricted to 50+ years old people and minimum occurrences found in 16 to 35 years old people. Similar kind of effect has also been reported by (Broste et al., 1989).

Like headache, blood pressure and cardiovascular diseases have a relationship with noise exposure. It is found that typical roadway noise levels are sufficient to constrict arterial blood flow and lead to elevated blood pressure and thereby increase cardiovascular risk as well as hypertension (Babisch, 2000; Lundberg, 1999; Belojevic et al., 2008). Apart from these, sufficient evidences are also found in the literature for the relationship between traffic noise and heart diseases like myocardial infarction and ischemic heart diseases (Griefahn, 1990; Babisch, 2006; Babisch et al., 2005). Present survey reveals that 21 and 8 people out of 52 people are the sufferer from blood pressure and has irregular heart beat respectively. Maximum effects in both the cases are restricted to 50+ age group people. These kinds of observations are very much corroborated to other research works (Bodin et al., 2009; Babisch et al., 1988).

Other physiological effects of noise exposure are elevated blood sugar and stomach disorder. Some studies shows that stress hormones like epinephrine is one of their major functions is to raise blood sugar to help boost energy when it's needed most (Nelson, 2010), and it is also found that high noise levels have increased frequency of headaches, fatigue, stomach ulcers and vertigo (USEPA, 1978). In study area, out of 52 people 6 people are suffering from blood sugar and 5 people are suffering from ulcer. But the relationship between stomach ulcer and blood sugar with noise level are statistically not significant.

3.3 Psychological effect

Noise creates very much problem in speech communication among the people living in road side of the study area. Present survey reveals that 31 people among 52 people in that area facing speech communication problem, of which 50+ years old people are maximum sufferer and minimum cases restricted to 16 to 35 years old people. Similar work has been reported in a school, where survey done for student and their speech reorganization performance was measured (Neuman et al., 2010).

Exposure to high levels of occupational noise has been associated with development of neurosis and irritability and also environmental noise with mental health (Evans, 1982; Cohen et al., 1986). Noise pollution is not believed to be a cause of mental illness, but it is assumed to accelerate and intensify the development of latent mental disorders. It has been found that maximum peoples are very much irritated due to traffic noise of their locality. It has an effect on their personal life and they feel very angry even in very small reason. It also has an effect on their performance. Present survey reveals that 35 people among 52 people are very much sufferer due to this particular effect of noise. From which maximum cases found in 50+ years old people and minimum cases found in between 36 to 50 years old people.

Like speech interference and irritation another psychological effects of noise is anxiety. Anxiety is a psychological and physiological state characterized by cognitive, somatic, emotional, and behavioral components (Seligman, 2001). Present survey reveals that 19 people out of 52 people are the sufferer from anxiety. Maximum effects are found in 50+ years' age group people and minimum in 16-35 age group people. Similar kind of effect is also reported by Stansfeld et al., (1996).

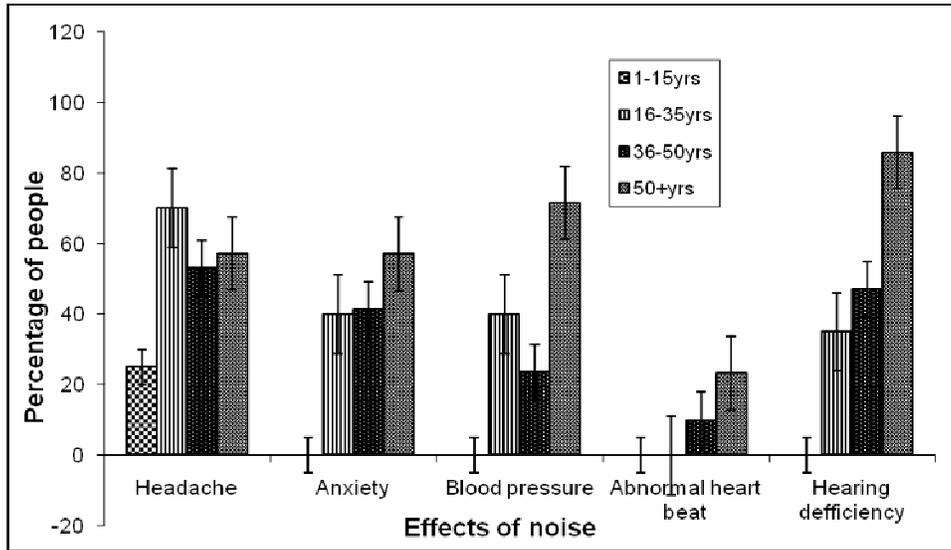


Figure 1: Age wise distribution of effect of noise

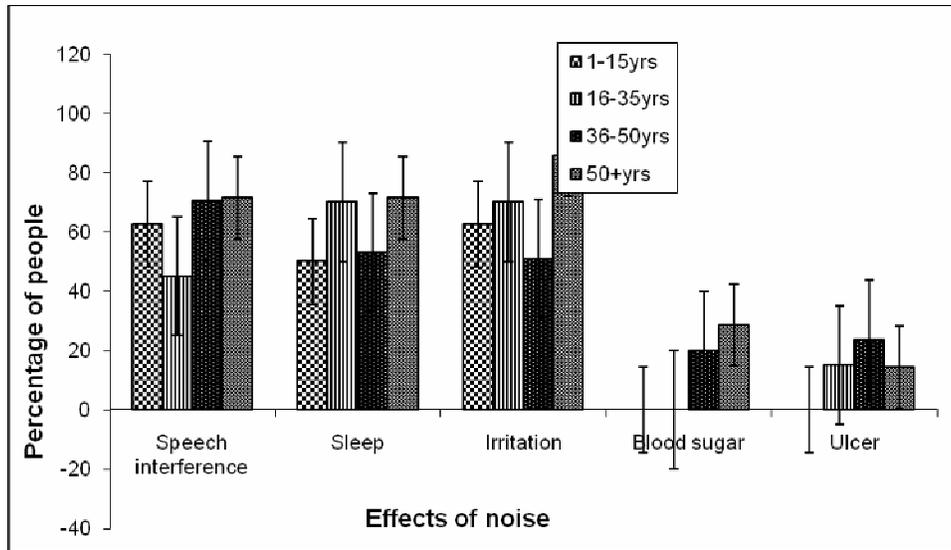


Figure 2: Age wise distribution of effect of noise

3.4 Statistical interpretations

H_0 : Effects of noise on road side people are independent of types of location.

H_1 : Effects of noise road side people depend on the types of location.

Table 4 shows the total Chi-square value obtained from different sites. From Chi-Square distribution table (Montgomery et al., 2003), for the level of significance, $\alpha = 0.05$ and the degree of freedom (dof) = 4, the critical value of Chi-square obtained is 9.49. It is shown in Table 4 that the computed test statistics for the effect of noise on hearing loss, sleep disturbances, abnormal heart beat and speech communication exceeds the critical value, hence the null hypothesis is rejected. This means that at the level of significance $\alpha = 0.05$, there exists a significant relationship between this type of effects of noise on people and the types of location (Table 5).

Table 4 also reveals that the computed test statistics for other effect are less than the critical value and hence, the null hypothesis is accepted. The data show that there is no significant relationship between these effects of noise on roadside people and the types of locations (Table5).

Table 4: Total Chi-Square value of different types of effect of noise obtained from five locations

Noise related complaints of the respondents	Total chi square value obtained from five locations
1. Headache	6.63
2. Anxiety	1.31
3. Elevated blood pressure	2.60
4. Abnormal heart beat rate	20.91
5. Hearing deficiency	9.62
6. Blood sugar	2.11
7. Problem in speech communication	13.69
8. Interference with sleep	13.25
9. Irritation	4.04
10. Disturb stomach or ulcer	4.99

Table 5: Relationship between the types of effect at different proposed sites

Types of effect	Relationship between the type of effect at different proposed sites $\alpha = 0.05$
1. Headache	Not significant
2. Anxiety	Not significant
3. Elevated blood pressure	Not significant
4. Abnormal heart beat rate	Significant
5. Hearing deficiency	Significant
6. Blood sugar	Not significant
7. Problem in speech communication	Significant
8. Interference with sleep	Significant
9. Irritation	Not significant
10. Disturb stomach or ulcer	Not significant

4. Conclusion

Present study reveals important information pertaining to the effect of noise among residents having continuous exposure to traffic noise for long time. A questionnaire based survey was carried out to get responses from fifty two (52) people of ten (10) different families. The primary data, thus collected, was analyzed and it was found that except psychological behavior, the physiology viz. hearing capability, auditory communication and sleep of the

residents were significantly affected by the existing noise levels. Thus there is a need for an immediate intervention of the management and the system designers to make and implement effective plans to curb the adverse effects of noise in order to ensure health, safety and to enhance efficiency and comfort of the residents of the area.

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