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Noise Annoyance Due to Construction Worksites

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ABSTRACT

Background: Noise pollution can contribute to adverse health effects in humans. Noise annoyance and related problems, caused by noise emission during the progress of building construction, have become increasingly important. These problems can influence the exposed workers, as well as vicinity residents. The goal of the present study was to assess the noise annoyance due to noise from construction worksites among residents of Hamadan City (west of Iran).

Methods: In this cross-sectional study, 20 construction worksites and 140 near vicinity residents were selected. The main sources of construction worksite noise were diesel power generators, cutting and welding processes, heavy machinery (such as trucks) and transport of materials. Ambient noise levels were measured using a calibrated sound level meter, at each home of the residents included in the study. A noise annoyance questionnaire was employed for annoyance assessment.

Results: The majority of subjects had very high annoyance (87.1%). The mean and SD of ambient levels were 74.57±7.12 dB (A) which exceeded the acceptable recommended level for residential areas. The most common problems among the participants were disturbance in sleep, difficulty in reading and distraction. Results showed significant relationship between noise annoyance and some factors including residing which floors had highest annoyance ($F=13.22$, $P<0.001$) and ambient noise ($F=11.313$, $P<0.001$).

Conclusions: High levels of noise annoyance among near vicinity residents who are affected by construction activities. This means that construction activities and other noise related sources should be regarded as the major source of ambient noise leading to noise annoyance.

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Introduction

Noise, defined as any kind of undesirable sound is regarded the important cause of environmental pollution in urban societies[1]. This physical hazard propagates from numerous sources such as machinery and equipment, traffic, building construction and others[2]. Depended upon some acoustical factors (loudness and frequency), noise may lead to adverse health effects, including physiological effects and psychological impacts. Main effects caused by the environmental noise include: annoyance, sleep disturbance, cardiovascular disorders, cognitive impairment and hearing disturbs[2]. In addition, other psychological impacts such as stress, anxiety, mental health disorders, aggression and irritability, behavioral interference and noise annoyance have been studied in relation to noise exposure[3].

Noise annoyance could be defined as displeasure, unwanted, interfering consequences that has adverse effects on exposed people to noise[4]. These adverse effects of noise exposure may include sleep disturbance, irritability, stress, tension, distraction, risk of ischemic heart disease, influence on quality of life, interference with communication, health and well-being outcomes, behavioral and mental health effects and diminished performance[5,6]. Many variables could be derived from exposed humans in the noisy field for study of noise annoyance. Therefore, it is hard to weigh an “annoyance” level[7]. Moreover there is not a perfect method for estimating of annoyance

reactions according the noise exposure levels; because results from different studies show that the large variation in the relationships between them and it is impossible to predict annoyance with sufficient accuracy[7].

Background noise, normally exists in daily activities and other sources such as construction noise could exacerbate it. Ambient noise, in particular, traffic and building construction noise are some of these sources that cause annoyance in urban districts. According to WHO reports, almost 40% of the persons residing in European Union countries are exposed, in the daytime, to road traffic noise with a level higher than 55 dB[8]. Results of the studies on Tehran residents show that 46.5% of participants were experiencing high level of annoyance due to the traffic noise[9]. Construction is growing in parallel with urbanization could cause noise pollution and related problems among the exposed vicinity residents. The main sources of construction worksite noise are diesel power generator, cutting and welding processes, heavy machinery and evacuation of materials, transportation of heavy machinery trunks and cranes which may affect vicinity inhabitants[10]. A study on residents around building construction worksites indicated that vicinity residents reported various problems due to the noise including sleep disturbance, interfere with speech communication, behavioral effect, interference with usually conversation and television-watching. These problems were most prevalent among the closest residents[11]. Findings of one laboratory study also demonstrated the ability of construction noise in decreasing the reproductive efficiency of mice[3].

Despite the mentioned issues, many countries do not have particular regulations for supervision to reduce noise emission from sources at construction works[12]. The ambient noise standard of Iran determines 55 dB (A) to be the accepted Sound Pressure Level (SPL) for the daytime in residual areas, but it has not been specified for various sources such as building construction activities and machinery[1].

Recently, construction activities have increased in reconstruction areas of cities and hometowns of Iran. In these processes many various activities can cause noise pollution. However its potential influences on noise pollution and noise annoyance among vicinity inhabitants have been largely neglected. Building construction have a long term process in which some stages including excavation, metal frame construction and each stage requires special materials and processes. The construction noise sources produce high level of noise could affect near vicinity residents.

The goal of the present study was to assess the noise annoyance caused by the noise of construction worksites among residents of Hamadan City (west of Iran).

Methods

This cross-sectional study carried out in the spring of 2011 in Hamadan City (west of Iran) aimed at assessing the effect of construction worksites noise among near vicinity resident.

Study subjects and sample size

In order to determine the sample size, in a pilot study, noise level of eight construction worksites was measured. On the basis of the pilot stage of results, with a confidence level of 95% and a study power of 80%, calculations led us to select 20 construction sites and 140 residents as the sample of our main study. In the pilot study, diesel generators were found to be the main sources of noise pollution, as they generated noise more than any other construction activities such as: cutting and welding processes, heavy machinery and evacuation of materials. All investigated construction worksites were in manufacturing steel skeleton frame stage. Samples were selected from all over the Hamadan City.

Noise measurement

The ambient noise (day levels) was measured close to vicinity homes using calibrated sound level meter type TES-1358 according to the standards of ISO 9612[1]3 and BS 4142[14]. Noise measurement due construction activities was also conducted on road side near (1 m distance) the homes. Noise was measured at A – frequency weighting and slow response mode. Wind screen was used for the purpose of protecting the microphone from air turbulence and effect. The height of microphone was 140 cm and the random state. These measurements were performed during the operation of construction works, while other noise sources were at the lowest levels. Frequency analysis of noise was performed for sets which exceeded the acceptable noise standard.

Noise annoyance

Noise annoyance was measured using a modified questionnaire that was previously used to investigate noise effects of building construction on residents[11]. Although other researcher proposed questionnaire for determining the noise annoyance[3,15], but this study was based on the NG C F method[11]. Set of annoyance categories divided the range from 0 to 10 in equally spaced intervals that had 11 responses choice by interviewer in each 15 questions. Determining of annoyance range indicate in Table 1. The distribution of the annoyance scores based on 5 levels (very low, low, moderate, high and very high annoyance) according to results of ROC curve method.

Table 1: Distribution of noise annoyance among the participated residents and relation between noise annoyance and ambient noise using one-way ANOVA

Annoyance Category	Score [a]	Frequency (%)	*P* value
Very low and Low	<40	0 (0.0)	<0.001
Moderate	40-70	3 (2.1)	
High	70-90	15 (10.7)	
Very high	>90	122 (87.1)	

[a] Based on the ROC curve results

The questionnaire was translated into Persian language by a scientific expert translator then checked by authors and also then modified according to the obtained data from construction noise effect and the feedback of interviews with residents. After questionnaire modifications, for determining of reliability, collection data from 13 residents in pilot stage of study were performed. A split-half reliability coefficient was computed, from the collected data in order to test the internal consistency of the scale. The coefficient turned out to be 0.774 which was considered appropriate. The questionnaire was anonymous and included the following two parts: Part one included age, gender of the cases and residing floor (in the studied homes), and part two consisted of 15 questions about hearing the noise of the construction worksite, annoyance of this noise, interference in concentration and relaxation, difficulties in hearing the speech of family members, interference in daily conversation, interference in television watching, sleep disturbance, difficulties in telephone and bell hearing, stress, difficulties in telephone conversation hearing, difficulties in talking by telephone, distraction in reading, interferences in relaxation, rest and their senses about times of annoyance related to noise loudness. In 20 studied construction worksites for obtaining 140 interviewed samples; seven near homes around each construction worksite were selected for assessing noise annoyance among the residents. Therefore, the sexes of interviewed cases were access sample.

Data analysis

Package of SPSS 13.0 was employed for Statistical analyses. Procedure was as follows:

- Independent sample *t*-test was used to assess the association between gender and noise annoyance. 1-sample *t*-test was also used to assess the compare between noise level and acceptable of Iranian ambient noise standard[1].
- One-way ANOVA was performed to assess the mean compare between residing floor and noise annoyance, noise annoyance and ambient noise and followed by a Least Significant Difference (LSD) test for specified compare between them.
- The level of significance was set at 5%.

Results

The demographic details of the participated residents (45 male and 95 female) showed that the Mean and SD of participants' age were 29.81 and 6.64 years respectively. The majority of participants were residing in the first (42.1%) and the second floor (35.7%). Significant associations were found between annoyance and other factors including gender (P<0.002), and floor (P<0.001, F=13.22).

As the results of the LSD test in Table 2 show, significant differences were found between every two floors (P<0.05) except between the fourth and the third (P=0.494, mean difference =8.97). The highest and the lowest differences were determined between the fourth and the first floors (mean difference=27.71), and between the first and the second floors (mean difference=8.32) respectively.

Table 2: Results of Least Significant Difference (LSD) test for determination of mean difference between different annoyances of reside floors

					95% CI	
Floor (I)	**Floor (J)**	**Mean Difference (I-J)**	**SE**	***P* value**	**LL**	**UL**
First	Second	-8.32339	2.97718	0.030	-16.0673	-0.5795
	Third	-18.72513	3.80733	0.001	-28.6283	-8.8220
	Fourth	-27.70339	5.83538	0.001	-42.8817	-12.5251
Second	First	8.32339	2.97718	0.030	0.5795	16.0673
	Second	-10.40174	3.90225	0.042	-20.5518	-0.2517
	Fourth	-19.38000	5.89776	0.007	-34.7205	-4.0395
Third	First	18.72513	3.80733	0.001	8.8220	28.6283
	Second	10.40174	3.90225	0.042	0.2517	20.5518
	Fourth	-8.97826	6.35733	0.494	-25.5142	7.5577
Fourth	First	27.70339	5.83538	0.001	12.5251	42.8817
	Second	19.38000	5.89776	0.007	4.0395	34.7205
	Third	8.97826	6.35733	0.494	-7.5577	25.5142

According to Table 3 which shows the effects of construction noise on various life aspects of residents, the noise of construction workplaces was heard by the subjects (8.75±1.26) and they stated that its annoyance was due to its annoying loudness (8.23±1.59). They stated that construction works' noise annoyed them and affected different aspects of their lives. This included, among other things, makes unpleasant (8.00±1.30), disturbing daily sleep (7.76±1.90), making reading difficult and causing distraction (7.75±1.79), disturbing concentration and re-

laxation (7.70±1.30), interfering with television watching (7.40±1.30), disturbing relaxation in holidays (7.11±1.99), interfering with daily exposures and causing dissatisfaction (7.10±1.36) and causing difficulties in hearing the speech of family members at home (7.04±1.30). The response rate of questionnaire was at 100%.

Table 3: Construction noise effects stated by Interviewees

Variable	Mean±SD	Min	Max
Hearing construction worksite noise	8.75±1.26	5	10
Makes unpleasant	8.00±1.30	4	10
Disturbance of concentration and relaxation	7.70±1.30	4	10
Disturbance of speech listening inside house	7.04±1.30	4	10
Interferences with daily conversation	7.10±1.36	4	10
interference in the sound understanding of television	7.40±1.30	4	10
Disturbances in sleep	7.76±1.90	4	10
interference in the hearing of telephone and ring	6.67±1.40	4	10
Make stress	6.16±1.55	3	10
Makes difficult of hearing in telephone conversation	6.55±1.37	3	10
Makes difficult to talk with telephone conversation	6.26±1.43	3	10
Makes Decentralization in reading	7.75±1.79	3	10
Disturbance of relaxation in resting	7.11±1.99	3	10
Discomfort due to untimely Construction noise	6.95±2.26	3	10
Annoyance due to harmful noise loudness	8.23±1.59	4	10

Table 1 demonstrates the level of overall noise annoyance. The mean of annoyance among residents was 109.43 which fall within the very high level. Of participants, 10.7% had high annoyance (10.7%) and the majority (87.1%) had very high annoyance. The results of one-way ANOVA test show significant relation between annoyance and ambient noise (f=11.313, P<0.001).

Table 4 shows the results of LSD test for determination of mean difference among annoyance categories. As seen, mean differences of annoyance were found to be between moderate and high categories (P=0.008, mean difference =-10.522) as well as high and very high categories (P<0.001, mean difference =-7.36).

Table 4: Results of Least Significant Difference (LSD) test for determination of mean difference between annoyance categories

Annoyance category (I)	Annoyance category (J)	Mean Difference (I-J)	SE	*P* value	95% CI	
					LL	UL
Moderate	High	-3.16000	2.97718	0.030	-16.0673	-0.5795
	Very high	-10.52268	3.80733	0.000	-28.6283	-8.8220
High	Moderate	-3.16000	2.97718	0.030	0.5795	16.0673
	Very high	-7.36268	3.90225	0.042	-20.5518	-0.2517
Very high	Moderate	10.52268	3.80733	0.000	8.8220	28.6283
	High	7.36268	3.90225	0.042	0.2517	20.5518

The results shown in Figure 1 indicates residents of 3rd, 4th, 5th and 16th site locations reported the highest Mean and SD of annoyance level, i.e. 116.57±20.77, 118.72±17.89, 116.43±11.51, 115.57±16.31, 116.14±23.72, respectively (Figure 1). The lowest and highest annoyance levels were 56 and 150, respectively. Almost of the studied sites were categorized in high and very high annoyance levels.

As Figure 2 illustrates, the mean and the SD of ambient noise near the study homes were 74.57 and 7.12 dB (A) respectively. Further, the lowest and the highest SPL were found to be 60.2 and 92 dB (A), respectively. According to Figure 2, residents of 5th, and 6th site experienced the highest SPL of the ambient noise with M±SD 83.28±8.05 and 83.85±6.75, respectively. In the studied construction sits we found the diesel generators were the main noise sources[16]. The mean and SD of sound pressure levels near them were 97 ± 2.2 dB (A).

Discussion

The present study aimed at assessing the effects related to noise annoyance due to construction among residents of Hamadan City. No regulation exists for construction worksite noise in Iran and consequently no sufficient control and supervision. Therefore, we used noise standard of ambient noise and due to the lack of similar studies about noise annoyance in Iran, we used the results of other studies in other countries or in similar contexts.

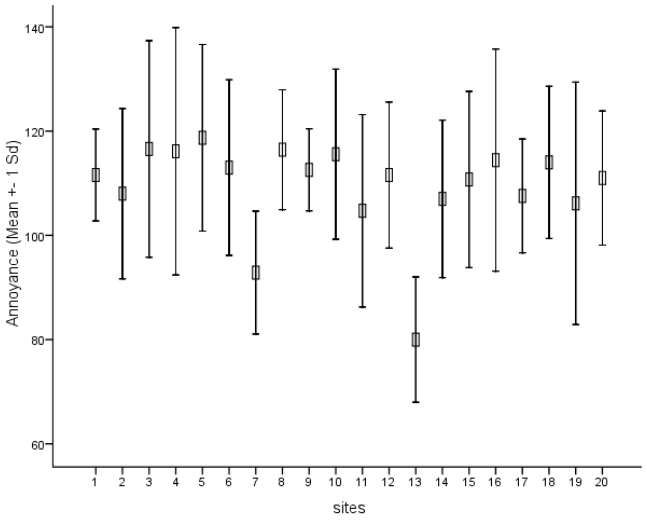

Figure 1: Noise annoyance in studied sites

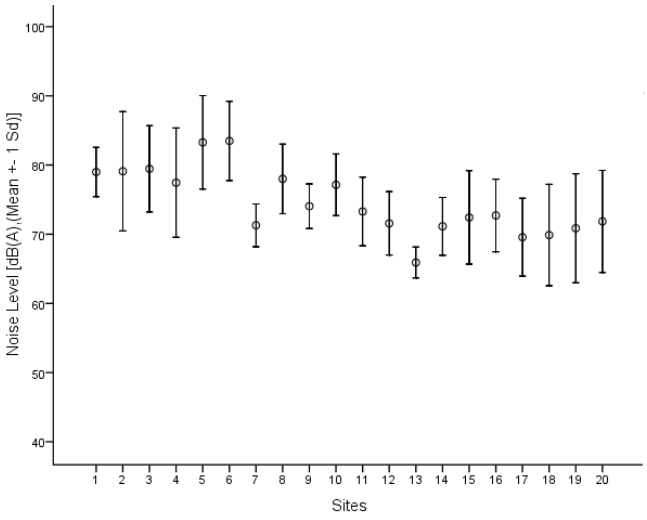

Figure 2: Details of the ambient noise level in studied sites

Results of the study show that the ambient noise of the construction worksites are higher than the acceptable standard 55 dB (A) (P<0.001) and that dominant frequency is 63 Hz. As seen, dominant frequency is low and its psychological effects have been confirmed in other studies[17]. In addition, the walls of the homes near the noise sources had a low resistance in low frequencies[1]. This factor coupled with high level of noise could affect vicinity residents and cause some disturbances in their individual lives. Construction activities are performed daily from 8.00 am to 6.00 pm, and are continuous with low interruptions. On the other hand, the walls of near-by buildings don't have appropriate acoustic characteristics for noise reduction especially in low frequencies[1]. Therefore noise could easily transmit from them and affect residents[1]. Noise, for the aforementioned reasons, could cause hearing problems and can affect different aspects of vicinity residents' lives (Table 3). Consistent with the findings of a number of previous studies, our results show that homes which are placed in close distance, receive high levels of noise and that their residents complain from the situation. In this study, annoyance has positive regression with noise levels. This is consistent with the result of previous studies[9,18,19].

The majority of participants experienced very high level of annoyance due to construction noise (87.1%). Moreover, the means of annoyance in all the cases are categorized in very high level (Tables 1 and 4). Results of LSD test show significant mean differences so that residents in the highest floor experienced the highest level of annoyance. However, higher floors had not better condition for protection. This might be attributed to the characteristics of noise emission 1. In addition, significant mean differences were found among annoyance categories and noise levels. These findings are consistent with the results of other researches that reported annoyance due to other sources consisted of construction[9,11,21,22]. The most important factors that are likely to be involved are levels of ambient noise, such as time of activities, type of emitted noise, the degree of noise sensitivity, residing floor and distance from construction sites. This leads to reduction in the amount of heard construction noise.

Most of the residents had heard the construction noise and believed that loudness was the main reason for annoyance. Regarding the mentioned issue, sleep disturbance was the main negative side effect of construction activities (Table 2). Sleep, which could be affected by environmental factors such as ambient noise, is a necessary process for the recovery of body activities to the normal state[23]. The interference due to noise is related to daily actions[6]. The negative effects of noise on sleep quality has already been reported in some studies[5,24]. Our findings show that construction worksite noise can cause difficulties in sleeping, interruption in sleep, abrupt awakening from sleep and shortening of the sleep time.

The interviewees complained from difficulties in reading, in concentration and relaxation, in TV watching, and in communication (Table 2). These are daily, routine tasks and short term noise exposure could interrupt them and make more details and more attention necessary[5]. Noise could influence it by interfering in the reception of voice messages[25]. One study among office stuff has shown that telephone conservations could take place in 55 dB without disturbance but higher noise levels could make interference[26]. Ambient noise in the present study is higher than 55 dB and is regarded as one main reason for interference in speech communication. In the study of Fan NG (2000), interference in communication was reported by residents around construction sites[11].

As mentioned above, construction activities' noise causes some disturbances among neighboring residents. Therefore, noise control program should also consider noise annoyance because of its importance in representing the probability noise adverse effects[24]. Welding and cutting are prolonging processes during building construction and especially use of diesel generator is unavoidable due to the utilization of city power net being forbidden. Diesel generator that was considered as the

main source of noise in construction worksites had high noise level which exceeded the acceptable regulations. With respect to the limitations for noise control in other options, it seems that preventive interventions could focus on noise control of diesel generators as one major option. However, discrimination of main noise sources is difficult because of the existence of other activities and high background noise in construction workplaces. This study merely focused on the effects of noise on individual life and did not paid attention to the psychological effects among residents.

Conclusion

Ambient noise and construction site noise exceeded the acceptable regulations and that dominant frequency was low. In addition, the results show that the majority of residents reported very high levels of noise annoyance. Statistical analysis also demonstrated the significant correlation between noise annoyance and some factors including ambient noise and residing floor. Daily sleep disturbance was the most frequent problem reported by participant. Therefore, we could regard the construction noise as a main source of ambient noise as well as of noise annoyance among residents. Hence, control measures such as engineering (in particular for diesel generators) along with management control are required for the purpose of reduction of construction noise and consequently noise annoyance. Realization of these targets is not possible without the supportive role of related organizations and construction employers.

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Conflict of interest statement

The authors have no conflict of interest to report.

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References

1. Golmohammadi R. *Noise and Vibration Engineering*. 4th ed. Hamadan-Iran: Daneshjoo; 2010.
2. World Health Organization. *Burden of disease from environmental noise*. Denmark: WHO; 2011.
3. Rasmussen S, Glickman G, Norinsky R, Quimby FW, Tolwani RJ. Construction noise decreases reproductive efficiency in mice. *Contemp Top Lab Anim Sci.* 2009;48(4):363-370.
4. Ouis D. Annoyance from road traffic noise: a review. *J Environ Psychol*. 2001;21:101-120.
5. Olaosun A, Ogundiran O, Tobih J. Health hazards of noise: a review article. *J Res Med Sci.* 2009;3(3):115-122.
6. Stansfeld SA, Matheson MP. Noise pollution: non-auditory effects on health. *Br Med Bull.* 2003;68:243-257.
7. Miedema HME, Oudshoorn CGM. Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. *Environ Health Perspect.* 2011;109(4):409-416.
8. World Health Organization. *Transport-related health effects with particular focus on children.* Geneva: WHO; 2004.
9. Alimohammadi I, Nassiri P, Azkhosh M, Hoseini M. Factors affecting road traffic noise annoyance among white-collar employees working in Tehran. *Iranian J Environ Health Sci Eng*. 2010;7(1):25-34.
10. Holt ASJ. *Principle of construction safety.* Malden: Blackwell Science; 2005.
11. NG CF. Effects of building construction noise on residents: a quasi-experiment. *J Environ Psychol*. 2000;20:375-385.
12. Ballesteros MJ, Ferna´ndez MD, Quintana S, Ballesteros JA, González I. Noise emission evolution on construction sites. Measurement for controlling and assessing its impact on the people and on the environment. *Build Environ.* 2010;45:711-717.
13. ISO-9612. *Acoustics - guidelines for the measurement and assessment of exposure to noise in a working environment*. International Organization for Standardization, 1997.
14. BS-4142. *Method for rating industrial noise affecting mixed residential and industrial areas*. British Standard; 1997.
15. Levy-Leboyer C, Natural V. Neighbourhood noise annoyance. *J Environ Psychol*. 1991;11:75-86.
16. Golmohammadi R, Mohammadi H, Bayat H, Soltanian A., Noise pollution assessment and control for construction diesel generators in Hamadan, Iran. *Health System Researchs*, 2011;7(6):718-726.
17. Prashanth KM, Sridhar V. The relationship between noise frequency components and physical, physiological and psychological effects of industrial workers. *Noise and Health.* 2008;10(40):90-98.
18. Nassiri P, Azkhosh M, Mahmoodi A, Alimohammadi I, Zeraati H, Jafari Shalkouhi P, et al. Assessment of noise induced psychological stresses on printery workers. *Int J Environ Sci Tech*. 2011;8(1):169-176.
19. Pierrette M, Marquis-Favre C, Morel J, Rioux L, Vallet M, Viollon S, et al. Noise annoyance from industrial and road traffic combined noises: a survey and a total annoyance model comparison. *J Environ Psychol.* 2012;32:178-186.
20. Torija AJ, Ruiz DP, Coensel BD, Botteldooren D, Berglund B, Ramos-Ridao Á. Relationship between road and railway

noise annoyance and overall indoor sound exposure. *Transportation Research Part D*. 2011;16:15-22.

21. Babisch W, Houthuijs D, Pershagen GR, Cadum E, Katsouyanni K, Velonakis M, et al. Annoyance due to aircraft noise has increased over the years - results of the HYENA study. *Environ Int*. 2009;35(8):1169-1176.

22. Muzet A. Environmental noise, sleep and health. *Sleep Med Rev*. 2007;11:135-142.

23. Firdaus G, Ahmad A. Noise pollution and human health: a case study of Municipal Corporation of Delhi. *Indoor Built Environ*. 2010;19(6):648-656.

24. Dunn BE. The noise environment of man. In: Jones HW, editors, Noise in the human environment. Alberta: Environmental Council of Alberta; 1981. pp.193-257.

25. Beranek LL. Criteria for office quieting based on questionnaire rating studies. *Journal of the Acoustical Society of America*. 1956;28:833-850.

26. Dratva J, Zemp E, Dietrich DF, Bridevaux P-O, Rochat T, Schindler C, et al. Impact of road traffic noise annoyance on health-related quality of life: results from a population-based study. *Qual Life Res*. 2010;19:37-46.