ORIGINAL ARTICLE

EFFECTS OF WORKPLACE NOISE ON HEARING AND CARDIOVASCULAR SYSTEM

Berendra Yadav[1], Sangeeta Singhal[2], SF Hashmi[3], Mohammad Muzammil[4], Ajay K Singh[5]

[1] Assistant Professor, Department of Physiology, Govt.Medical College, Ambedkarnagar (UP) India, [2] Associate Professor , Department of Physiology, J.N. Medical College, A.M.U., Aligarh (UP), India [3] Professor, Department of Otorhinolaryngology, J.N. Medical College, A.M.U., Aligarh (UP), India [4] Department of Mechanical Engg. Z.H. Engineering College, A.M.U., Aligarh (UP), India, [5]Lecturer, Department of Biochemistry, Govt. Medical College, Ambedkarnagar (UP), India

Correspondence:dr.vky@rediffmail.com

Abstract

Environmental noise is a known stress, which induces alterations of various physiological responses in individuals exposed to it. The aim of the present study was to assess the effects of industrial noise on the cardiovascular system of workers exposed to industrial noise in lock factories. The study group included 114 workers of both sex having age group 18-58 years with mean age 35.74±9.14, employed in different sections of lock factories exposed to industrial noise levels exceeding 80 dB. The control group consisted 30 people who never lived or worked in a noisy environment. Hearing test was done by Tuning Fork test and pure tone audiometery. Cardiovascular assessment was done by heart rate and blood pressure measurement. The results of this study showed significant changes ($p<0.05$) in systolic blood pressure, diastolic blood pressure, mean arterial pressure, pulse pressure and heart rate in the workers of lock factories. So this study indicates that industrial noise could be possible contributing factor in the development of arterial hypertension.

Key words: Industrial noise, systolic blood pressure, diastolic blood pressure, heart rate.

Introduction

The term noise is commonly used to describe sounds that are disagreeable or unpleasant produced by acoustic waves of random intensities and frequencies[1]. Some authors define noise as any audible acoustic energy that adversely affects the physiological or psychological well being of the people[2]. Noise pollution is becoming increasingly more severe in industrial countries and the cost of alleviating it in future years is expected to be insurmountable.

Prevalence of noise is implicated in various illness of human and it is responsible for increased morbidity associated with modern life style. Immediate and serious attention must be given to control this mushrooming problem, since the overall loudness of environmental noise is doubling every ten years[3]. This has encouraged scientists to discuss and study the effects of noise pollution on human's health. The Federal Occupational safety and Health Act (OSHA) administrated by the U.S. Department of Labour, requires that specified noise exposures not be exceeded. Excessive noise pollution has been blamed not only for hearing damage and community annoyance but also for hypertension, fatigue, heart trouble, disturbed serum lipid, triglycerides, platelet count, plasma viscosity, glucose and reduced motor efficiency[4,5]. Many studies have shown that noise influences the cardiovascular, endocrine, metabolic, gastrointestinal and neurological systems[6]. The cardiovascular system is considered to be the most involved and therefore has received the most

attention, where as few specific studies have been performed concerning the relationship between noise and myocardial disease. There is evidence that noise presents a significant factor in the genesis of arterial hypertension[7], coronary disease[8], and disorders of peripheral arterial circulation[9].

Evidence that links noise exposure to chronic changes in blood pressure and heart rate can be found in both animal and human studies[10]. Some noise experts have investigated the acute affects of short term loud noise on blood pressure and other cardiovascular parameters. Most of the studies have shown a rise in systolic and/or diastolic blood pressure[11,12], while some of the research scientists observed negative (decreased or non-significantly increased) association between blood pressure and noise[13,14].

As no work has been done on the effects of noise on the cardiovascular system of workers of lock factories, therefore, the present study was intended to evaluate the influence of noise exposure on blood pressure and heart rate of the workers worked in lock factories of Aligarh. There is evidence that by the use of appropriate preventive measures, the harmful effects of noise could be moderated and even eliminated7. The aim of the present study was to evaluate the effect of industrial noise on hearing and cardiovascular system.

Material & Method:

The present study was conducted on 114 subjects in which 101 cases were male and 13 were female with age group of 18-58 years from various lock factories in Aligarh during the year 2006 to 2007. The study was conducted in the Department of Otorhinolaryngology of Jawaharlal Nehru Medical College, Aligarh Muslim University, Aligarh, and in the different sections of the lock factories of Aligarh.

Selection of Cases: Criteria for selection of the subjects in this study were:

1. Subjects having ears free from disease.
2. No history of ototoxic drugs.
3. Subjects having no history of hypertension.
4. Subjects having no history of myocardial infarction.
5. Subjects having no history of head injury with unconsciousness.

Control Cases:

The control group consisted of 30 subjects of both sexes were taken from the outdoor patient Department of Otorhinolaryngology, students and staff of Physiology Department of Jawaharlal Nehru Medical College, A.M.U., Aligarh and from the general population of Aligarh who were not exposed to any noisy environment. All the control cases were within the age group of 18-55 years with mean age 33.40±10.41 years. Their mean height was 159.97±6.15 cms and their mean weight was 57.87±8.91 kg.

Test Cases:

The test group included 114 workers of both sexes employed in different lock factories of Aligarh, exposed to industrial noise. The age of the subjects was in the range of 18-58 years with mean age 35.74±9.14 years. Their mean height was 162.16±6.09 cm. and their mean weight was 54.78±8.68 kg. The hearing tests were carried out in a sound treated room in the different lock factories. Selections of cases were randomly done. The subjects were thoroughly examined and investigated.

Assessment of hearing loss had done by Tuning fork test and Pure tone Audiometry. Tuning fork test was carried out by stainless steel 512 Hz. Tuning fork. Routine Rinne's test, Weber test and Absolute bone conduction test were done in each case.

Measurement of heart rate:

The subjects were allowed to relax so that any tachycardia due to nervousness in the subjects was subsided. The forearm of the subject was slightly pronated and the wrist slightly flexed. The radial pulse was felt with the tips of the fingers compressing the vessel against the head of the radius. The rate of the pulse rate was noted in beats per minute.

Recording of systemic arterial blood pressure:

Blood pressure was measured in supine position by using mercury sphygmomanometer. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) of all the subjects were recorded. Mean arterial pressure and pulse pressure was calculated from the above data.

Mean arterial pressure=Diastolic BP+1/3 Pulse pressure

Pulse pressure = Systolic BP – Diastolic BP.

Noise survey:

Noise level in the different units of different lock factories was measured by LUTRON SL-4001 digital sound level meter.

Results:

Table 1 shows the age composition of the subjects working in different lock-factories. It shows that the maximum number of workers were in the age group of 31-40 years. The subjects were screened from different places of different lock factories in Aligarh. The distribution of workers in different units of lock factories is shown in Table 2.

Table 1: Age Composition of Cases

Age (in years)	No. of persons	Percentage
18-20	7	6.14%
21-30	24	21.05%
31-40	51	44.74%
41-50	26	22.80%
51-60	06	5.27%
Total	114	

Table 2: Distribution of Subjects in Different Units of Lock Factories

Place of work	No of persons	Percentage
Control	30	
Power press	27	23.68%
Lathe Machine	29	25.44%
Grinder	30	26.32%
Hand Press	28	24.56%
Total	114	

The measurement of noise pollution level and its nature at different locations represented by different sections of lock factories are given in Table 3. The maximum level of noise was in Power Press unit, subsequently followed by Lathe Machine, Grinder and Hand Press unit.

Table 4 shows the Rinne's test of both cases and control. Among the control subjects, Rinne's test was positive 96.67% in right ear and 96.67% in left ear. In the test cases Rinne's test was positive in 96.29% cases in power press unit, 89.65% in Lathe machine unit, 86.67% in Grinder unit and 82.14% in hand press unit, in right ear while in left ear 85.18% cases were positive in power press unit, 93.10% in lathe machine unit , 90% in grinder unit and 89.28% in hand press unit.

Table 3: Noise Level in The Different Units of Lock Factories

Source of noise production	Noise level (in decible)	Type of noise
General noise level	90 decibels	Continuous
Power press (P.P)	104 decibels	Intermittent
Lathe machine (L.M.)	96 decibels	Continuous
Grinder	90 decibels	Continuous
Hand press (H.P.)	82 decibels	Intermittent

Table 4: Rinne's Test

Place of work	Right Ear				Left Ear			
	+	%	-	%	+	%	-	%
Control (n=30)	29	96.67	1	03.33	29	96.67	1	03.33
Power press (n=27)	26	96.29	1	03.70	23	85.18	4	14.81
Lathe machine(n=29)	26	89.65	3	10.34	27	93.10	2	06.89
Grinder (n=30)	26	86.67	4	13.33	27	90.00	3	10.00
Hand press(n=28)	23	82.14	5	17.86	25	89.28	3	10.71

Table 5 shows the Weber's test of the subjects. The test was central in 93.33%, lateral to right and lateral to left in 3.33% subject of control cases. Among test cases it was lateral to right in 11.11% cases in power point unit, 17.24% in lathe machine unit, 16.67% in grinder unit and 14.29% in hand press unit. The Weber' test was lateral to left in 14.81% cases in power point unit,13.79% in lathe machine unit,3.33% in grinder unit and 3.57% in hand press unit. The test was central in 66.67% in power press unit, 65.52% in lathe machine unit,76.67% in grinder unit and 82.14% in hand press unit. The Weber' test was confusing and could not be judged in 7.40% cases in power point unit, 3.45% in lathe machine unit and 3.33% in grinder unit.

Table 6 depicts the absolute bone conduction test of both control cases and test cases. The test was bilateral normal in 100% control cases. Among test

cases it was reduced in right ear of 7.40% subjects in power point unit, 3.45% in lathe machine unit, 3.33% in grinder unit, which reduced in left ear of 3.70% in power point unit, 3.45% in lathe machine unit, 3.33% in grinder unit and 3.57% in hand press unit. The ABC test reduced bilateral in 51.85% in power press unit, 48.27% in lathe machine unit, 43.33% inn grinder unit and 28.57% in hand press unit. It was normal in 37.04% in power press unit, 44.83% in lathe machine unit,50.00% in grinder unit and 67.83% cases in hand press unit.

Table 5: Weber's Test

Place of work	Lateral				Central		No result	
	Rt	%	Lt	%	No	%	No	%
Control (n=30)	1	3.33	1	3.33	28	93.33	0	0
Power press (n=27)	3	11.11	4	14.81	18	66.67	2	7.40
Lathe machine(n=29)	5	17.24	4	13.79	19	65.52	1	3.45
Grinder (n=30)	5	16.67	1	3.33	23	76.67	1	3.33
Hand press(n=28)	4	14.29	1	3.57	23	82.14	0	0

Table 6: ABC Test

Place of work	Reduced				Reduced B/L		Normal B/L	
	Rt	%	Lt	%	No	%	No	%
Control (n=30)	0	0	0	0	0	0	30	100
Power press (n=27)	2	7.40	1	3.70	14	51.85	10	37.04
Lathe machine(n=29)	1	3.45	1	3.45	14	48.27	13	44.83
Grinder (n=30)	1	3.33	1	3.33	13	43.33	15	50.00
Hand press(n=28)	0	0	1	3.57	8	25.57	19	67.86

Table 7 shows the audiometry test done for permanent threshold shift (PTS) of the subjects. In the control cases 93.33% were normal. There was hearing loss in 3.33% subjects, in the range of 15-30 dB, and 3.33% subject in the range of 46-60 dB. Among the test cases of power point unit 1 subject had hearing loss in the range of 15-30 dB, 4 subjects had hearing in the range of 31-45 dB, 8 cases in the range of 46-60 dB and 3 subjects in range of >60 dB. There was no hearing loss in 11 cases of power point unit. In the lathe machine unit, 3 cases had hearing loss in the range of 15-30 dB, 7 cases in the range of 31-45dB, 4 cases in the range of 46-60 dB and 1 cases had hearing loss in the range of > 60 dB. 14 cases were normal in lathe machine unit. In the grinder unit, 4 cases had hearing loss in the range of 15-30 dB, 7 subjects in the range of 31-45 dB, 4 subjects in the range of 46-60 dB and 1 cases had hearing loss in the range of >60 dB. 14 cases were normal in the grinder unit. In the hand press unit, 1 subject had hearing loss in the range of 15-30 dB, 9 subjects in the range of 31-45 dB and 18 subjects were normal in hand press unit.

When the blood pressure was analyzed in the subjects, the statistical analysis of the data showed that the systolic blood pressure (SBP), diastolic blood pressure (DBP), Pulse pressure (PP), and mean pressure (MP) increased in 63.15%, 57.02%, 48.24% and 40.35% of total subjects respectively and the above parameters decreased in 2.63%, 0%, 19.29% and 38.59% subjects respectively. No effect on SBP, DBP, PP and MP was observed in 34.21%, 42.98%, 32.45% and 21.05% subjects respectively. The heart rate was increased in 17.54% of all subjects. The numbers of subjects in whom the blood pressure increased, decreased or was not affected is shown in Table 8.

Table 9 shows the average values expressed as group mean±standard deviation (SD) of various parameters like heart rate, SBP, DBP, PP and mean arterial pressure in various sections of lock factories. The data were analyzed using the SPSS program. Analysis of significance by student t test was used to compare the different parameters of the workers in Power Press, Lathe Machine, Grinder, Hand Press units with the control subjects. The values were significant for systolic BP and heart rate in all the units of lock factories and it was significant for diastolic BP and mean arterial pressure in all units except Hand Press but the values were significant for pulse pressure in Power Press and Hand Press units only.

Table 7: Hearing loss in the control and test cases.

Place of work	Hearing loss (in dB)								Normal	
	15-30		31-45		46-60		<60			
	No	%	No	%	No	%	No	%	No	%
Control (n=30)	1	3.33	0	00.00	1	3.33	0	00.00	28	93.33
Power press (n=27)	1	3.70	4	14.81	8	29.63	3	11.11	11	40.74
Lathe machine(n=29)	3	10.34	7	24.14	4	13.79	1	3.45	14	48.27
Grinder (n=30)	4	13.33	7	23.33	4	13.33	1	3.33	14	46.67
Hand press(n=28)	1	3.57	9	32.14	0	0	0	00.00	18	64.29

Table 8: Effect of Noise on SBP, DBP, PP, MAP and Heart Rate.

Parameters	Increase	Decrease	No effect
Systolic Blood Pressure (SBP)	72 (63.15%)	3 (2.63%)	39 (34.21%)
Diastolic Blood Pressure (DBP)	65 (57.02%)	00.00	49 (42.98%)
Pulse pressure (PP)	55 (48.24%)	22 (19.29%)	37 (32.45%)
Mean arterial Pressure (MAP)	46 (40.35%)	44 (38.59%)	24 (21.05%)
Heart rate (HR)	20 (17.54%)	00.00	94 (82.45%)

.

Table 9:Mean HR, SBP, DBP, Pulse Pressure and Mean Arterial Pressure in Different Units of Lock Factories.

Parameter	Control	Power press	Lathe Machine	Grinder	Hand press
Num	30	27	29	30	28
Hear	77.13	94.81	90.76	86.46	85.00
SBP	116.7	130.7	126.2	122.7	122.2
DBP	77.00	85.19	84.28	82.67	77.71
Puls	39.73	45.56	42.17	39.73	44.43
Mea	90.07	100.3	98.24	95.77	92.36

Values expressed as mean±SD NSNon Significant *(p<0.05) Significant

Discussion:

Noise pollution is increasingly being recognized as a physical factor in the environment that is injurious to many aspects of health. Noise is an environmental problem in industrialized societies. Occupational noise is a widespread risk factor, with a strong evidence base linking it to an important health outcome so that (hearing loss). It is also distinct from environmental noise, in that it is by definition associated with the workplace. Many research scientists in the world have observed a significant rise in blood pressure in response to noise[15-17].

It was observed from both table no. 3 and 7, as the noise level in different sections of lock factories increases, percentage of noise-induced hearing loss and average hearing loss increases. So it is seen that higher is the noise level, higher is the percentage of noise-induced hearing loss[18-20]. This is also consisted with the study of Willett KM who had conducted study on “noise-induced hearing loss” in Orthopaedic staff [21]. Issam RA et al found there was strong positive correlation between noise level in dB (A) and dependent variables like hearing threshold[22].

In an ear with a normal conduction mechanism (i.e. normal hearing or a sensorineural hearing), the air conduction tone should be louder than the bone conduction. This is described as a positive Rinne’s test. In our study maximum cases were Rinne’s test positive so we could not distinguish between normal and sensorineural type deafness. The Weber’ test lateralized to better ear in case of sensorineural deafness and lateralized to poor ear in case of conductive deafness. In case of bilateral

hearing impairment, it is difficult to predict on theoretical grounds in which ear the patient should hear the tone louder; interpretation in practice is impossible and the Weber test should be reserved for cases of unilateral hearing impairment. In sensorineural deafness, the ABC test is reduced [23]. Noise-induced hearing loss is always bilateral [24]. In our study more number of cases shows bilaterally reduced ABC test. It indicates about noise-induced hearing loss.

In Audiometry 52 cases had notch at different frequencies. In which 27 cases had bilateral notch at the 4 KHz, and 14 cases had bilateral notch at 6 KHz. Unilateral notch were seen in 7 cases at 4 KHz and 2 cases at 6 KHz. There was bilateral notch at 3 KHz in 1 cases and unilateral at 3 KHz in 1 case. So it is seen that, in our study maximum bilateral notch were present at 4 KHz. Our study is consistent with the study of Gelfand, they found noise-induced impairments are usually associated with a notch-shaped high-frequency sensorineural loss that is worst at 4 KHz, although the notch often occurs at 3 KHz or 6 KHz, as well[25]. Burns W and Robinson also showed in their study that mostly the notches were seen for 4 KHz[26].

Coles RR et al gave three main criteria for detection of noise-induced hearing loss in medicolegal cases[27]. That was:

R-1 Early hearing impairment of high frequencies.
R-2 Potential hazardous amount of noise exposure
R-3 Identifiable high frequency audiometric notch.

The findings in our study conform to that of the Coles criteria.

Some of the scientists observed a rise only in systolic B.P.[28,11] while many others found a significant increase in both systolic and diastolic B.P. in response to noise. Babisch et al could not see any association of noise and blood pressure[29], whereas Elise et al observed insignificant increase in blood pressure[30].

Our result showed a significant increase in systolic blood pressure, diastolic blood pressure and heart rate in all the different units of lock factories (Table 8). The actual mechanism for increase in blood pressure is not yet completely understood but some data taken from the literature point to the following mechanism: The catecholamines released from adrenal medulla as a result of activation of adrenergic system, the effect of suprarenal glands steroids, angiotensin and also the direct effect of noise on arterial wall tension influences the blood pressure and heart rate[31]. Stimulation by noise, through sympathetic nervous system, causes an elevation of blood pressure by an increase in total peripheral resistance and myocardial contractility[32]. The repeated stimulation with noise could then accelerate the development of structural vascular changes in the peripheral resistance vessels and by this mechanism create a permanent blood pressure elevation to hypertensive levels[12].

Table No. 8 shows systolic B.P., diastolic B.P., pulse pressure, mean arterial pressure and heart rate significantly increased in power press unit with 104 dB noise level, whereas systolic B.P., diastolic B.P., mean arterial pressure and heart rate increased significantly in Lathe Machine unit with 96 dB noise level. Systolic B.P., diastolic B.P., mean arterial pressure and heart rate increased significantly in Grinder unit with 90 dB noise level and only systolic B.P., pulse pressure and heart rate increased significantly in Hand Press unit with 82 dB noise. So it is seen that all the parameters are significant in Power Press unit which has maximum noise level while only 3 parameters are significant in Hand Press unit which has minimum noise level. So it is concluded that higher is the noise level, higher is the number of workers with hypertension which is consistent with the study of Uday W. et al [33].

These results show that industrial noise cause disturbance of cardiovascular system of the exposed workers so effective actions should be taken to prevent or minimize the effects of noise at workplaces. Efforts should be made to control the noise at the source, to control the transmission of noise and to protect the exposed persons. There should be permanent arrangements for regular measurements of noise levels at different locations in cities and factories and health education regarding noise control should be given due importance.

Conclusion:

From the above study we concluded that 36.84% of the subjects showed noise-induced hearing loss. Maximum average of hearing loss is recorded in power press unit (48.84 dB) and minimum in hand press unit (35.00 dB). There was significant increase in heart rate, systolic blood pressure, diastolic blood pressure, pulse pressure and mean arterial pressure. Subjects exposed to noised workplace they must be protected by ear plugs or ear muffs and hearing assessment should be carried out time to time. To decrease noise at workplace, all machines should be properly oiled and lubricated and promote good maintenance. Knowledge and

education to the subjects working in noisy environment is provided to minimize the effect of hearing loss and related disabilities.

Competing Interest: None declared

Funding: Nil

References

1. Akhtar HN. Noise-induced hearing loss in traffic police constables. J Coll Physicianse Surg Pak. 1996; 6(5): 265-8.
2. Kryter KD. The effect of noise on Man. New York. Academic Press. 1985; 389-393.
3. Chedd G. Sound from communication to noise pollution. Science. 1970; 211 (4489): 1450-52.
4. Lord HW, Williams SG, Harold AE. Noise Control for Engineers. 1980.
5. Regecova V, Kellerova E. Effects of Urban noise pollution on blood pressure and heart rate in preschool children. J Hypertension. 1995; 13: 405-412.
6. Anticaglia J, Cohen A. Extra-auditory effects of noise as a health hazard. Am Ind Hyg Assoc J. 1970; 31: 277-281.
7. Jovanovic J. Effects of constant industrial noise on cardiovascular system of industrial workers. Doctoral thesis, Univ of Nis. 1990.
8. Cuesden L, Teganeann S, Tutus, Raiciu M, Sarp C, Coatu S. Study of cardiovascular and auditory pathophysiological implications in a group of operatives working in noisy industrial surrounding. Physiologie. 1977; 14: 53-61.
9. Borg E. Physiological and Pathogenic effects of sound. Acta Otolaryngol. 1981; 5 (Suppl 381): 1-68.
10. Peterson EA, Angenstein JS, Tomis DC. Noise raises blood pressure without impairing auditory sensitivity. Science. 1981; 211 (4489): 1450-52.
11. Germano G, Damiani S, Milito U, Giarrizzo C, Santucci A. Noise stimulus in normal subjects: time dependent blood pressure pattern assessment. Clin Cardiol. 1991; 14(4): 321-5.
12. Smookler HH, Geobel KH, Siegel MI,Clarke OE. Hypertensive effects of prolonged auditory, visual and mution stimulation. Fed Proc. 1973; 32: 2105-2110.
13. Green MS, Schwartz K, Harari G, Najenson T. Industrial noise exposure and ambulatory blood pressure and heart rate. J Occupt Med. 1991; 33(8): 879-83.
14. Kristal-Boneh E. Acute and chronic effects of noise exposure on blood pressure and heart rate among industrial employees. Arch Environ Health. 1995; 50(4): 298-304.
15. Herbold M, Hense HW, Keil U. Effects of road traffic noise on prevalence of hypertension in men. Soz Praventivmed. 1989; 34(1): 19-23.
16. Mahmood R, Ghulam JH, Alam S, Safi AJ, Salahuddin, Amin-ul-Haq. Effect of 90 decibel noise of 4000 Hertz on blood pressure in young adults. Noise Pollution. 2007; 4: 1-4.
17. Mollar AR. Noise as a health hazard. In: Maxy Rossenau Public health and preventive medicine. 11th ed. New York, Appleton Century Crofts. 1980; 790-9.
18. Jha D, Sinha A, Deka RC. Diwali & Noise pollution India. Journal of otology. 2000; 6 (3) :74-76.

19. Taneja MK. Diwali-fire crackers & deafness. Indian journal of otology. 2004; 10:3-5.
20. Pathak RD. Industrial noise pollution & conservation of hearing-A study of mine worker. Indian journal of otolaryngology &Head & Neck surgery. 2001; 53(2):116- 122.
21. Willett KM. Noise-induced hearing loss in orthpaedic staff. The journal of bone & joint surgery (Br). 1991; 73-B: 113-15.
22. Issam RA, Mohammad S. Ali-Shtayeh, Hassan RA. Effects of Noise Pollution on Blood Pressure, Heart Rate and Hearing Threshold in School Children. Pakistan Journal of Applied Sciences. 2003; 3(10-12): 717-723.
23. Khurana I. "Textbook of medical physiology" 1st edition, published by Elsevier Indian private limited. 2006; p 1186-1203.
24. Robert A, Dobie MD. Prevention of noise-induced hearing loss. Arch otolaryngol Head Neck Surg. 1995; 121(4):385-391.
25. Gelfand S. Auditory system & related disorders .Essentials of Audiology: 2nd edition. New York: Thieme. 2001; p-202.
26. Burn W and Robinson DW. Hearing & noise in industry. Londan: HMSO. 1970.
27. Coles RR, Lutman ME, Buffin JT. Guideline on the diagnosis of noise for medico legal purpose. Clinical otolaryngology & allied science. 2000; 25(4): 264-73.
28. Evans GW, lerchar P, Meis M, Ising H, Kofler WW. Community noise exposure and stress in children. J Acoust Am. 2001; 109(3): 1023-7.
29. Babisch W, Ising H, Gallacher JE, Sharp DS, Baker IA. Traffic noise and cardiovascular risk, first phase. Arch Environ Health. 1993; 48(6): 401-5.
30. Elise EMM, Kempen V, Kruize H, Hendrick C, Boshuizen, Caroline B et al. The association between noise exposure and blood pressure and ischaemic heart disease, Environ Health prospect. 2002; 110: 307-17.
31. Andren L, Hanson L, Bjorkman M, Jonsson A. Noise as a contributing factor in the development of elevated arterial pressure. Acta Med Scand. 1980; 207: 493-498.
32. Andren L. Cardiovascular effects of noise. Acta Med Scand. 1983; 5 (Suppl 657): 1- 45.
33. Uday W. Narlawar, Bhooshan G, Surjase, Sushama S. Thakre. Hypertension and hearing impairment in workers of iron and steel industry. Indian J Physiol Pharmacol. 2006; 50(1): 60-66.