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NOISE INDUCED HEARING LOSS AMONG DRIVERS OF COMPRESSED NATURAL GAS (CNG) RUN THREE-WHEELER AUTO RICKSHAWS IN DHAKA METROPOLITAN CITY, BANGLADESH

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ABSTRACT

Background: Noise is an occupational hazard that affects worker safety as well as health. Prolonged exposure to noisy environment results in loss of hearing of the affected individuals. Compressed Natural Gas (CNG) run three-wheeler auto rickshaw drivers in Dhaka Metropolitan City are frequently exposed to heavy traffic and are more vulnerable to noise exposure.They have to work in excessive sound levels and being exposed to noise daily could result in noise induced hearing loss (NIHL). However, the hearing status in CNG run three-wheeler auto rickshaw drivers is unknown as this issue has not been addressed in previous studies. **Aim:** Assessment of the hearing threshold level of the auto rickshaw drivers of CNG run three-wheeler in Dhaka Metropolitan City of Bangladesh. **Materials and Method:** This research was a cross sectional study and conducted in the Department of Physiology, Dhaka Medical College, Dhaka, from January 2020 to December 2020. After fulfilling the ethical aspect, a total number of 305 drivers of CNG run 4-stroke three-wheeler auto rickshaws were chosen from various vehicles stands of Dhaka Metropolitan City. In addition, 100 apparently healthy office workers were taken as control group for comparison. Pure tone air and bone conduction tests were done and the data was collected in pre-designed structured questionnaire form. **Results:** NIHL was suffered by 31.47% (95% CI 11.8%-22.5%) of these CNG drivers. Audiometric results showed moderate degree of loss of have higher rate (62.50%) than mild or severe degree of loss of hearing. The mean hearing thresholds displayed a fall at 4000 to 6000 Hz which is typically noted. **Conclusion:** The occupational hazards of auto rickshaw driving significantly increased the threshold values of hearing. It is found that the mean values for the threshold of hearing for autorickshaw drivers increase at higher frequencies with increase in driving experience. Therefore, drivers must be educated about the hearing conservation during driving and should be periodically evaluated to detect audiological damge.

Keywards: Noise, Noise incuded hearing loss, CNG run auto rickshaw, Dhaka Metropolitan City.

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INTRODUCTION

Noise is an undesirable or unwanted sound that is perceived as loud or unpleasant[1].It is a companion of our day to day life but when it surpasses the acceptable limit, it becomes pollution[2].

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Exposure to excessive noise is the most common preventable cause of hearing loss. Noise is considered as the third leading pollutant in major cities[3]; the other two pollutions are air and water. Noise pollution due to road traffic is the most significant cause of urban noise and is the principal cause of occupational hearing loss[4]. It is an inevitable nuisance in urban life due to rapid population growth and urbanization. This problem is further exacerbated by the increasing numbers of motor vehicles on the roads[5].

Sound level up to 70 decibels (dB) is considered as safe level for hearing[6]. According to National Institute of Occupational Safety and Health (NIOSH), a branch of US Centers for disease control and prevention, the permitted level of noise for an 8-hour working day is 85 decibels. When sound level exceeds 85 dB, it acts as a stress stimulus and causes stress on the auditory system [7]. Initially it causes temporary dullness of hearing (temporary threshold shift) which usually recovers within 24 hours of exposure; whereas if there is repeated sustained exposure, the threshold shift becomes permanent (permanent threshold shift) due to nerve fiber degeneration. Health effects of high intensity noise include both auditory effects as well as non-auditory effects [8, 9]. Auditory effects include hearing loss and non-auditory disturbances include hypertension, sleep disturbances, impulsive behavior, and inability to concentrate on tasks[10].

Persistent and unprotected exposure to noise over 85dB NIHL is the primary cause for permanent increase in auditory threshold[11]. Continuous exposure to loud noise initially damages cochlea's outer hair cells resulting in buzzing in ears and tinnitus[12].

The audiological profile of NIHL is most pronounced by observing changes in the high-frequency region between 3,000 Hz and 6,000 Hz of the audiogram. However, the greatest amount of hearing loss is typically around the 4,000-Hz region [13]. In some studies, the most affected frequency suggestive of NIHL may also be found at 6,000-Hz region[14].

In the present study the CNG run three-wheeler auto rickshaw means a motorized, three-wheeled light vehicle for public transport purposes. It is one of the convenient modes of public transport system in Dhaka Metropolitan City. Auto rickshaws are cheaper compared toTaxi-cabs and easily available form of public transport. The drivers of CNG driven auto rickshaws spend most of their time in the small sized cabin[15].

The engines produce sound through the process of internal combustion which occurs inside of the cylinders and alsothrough the rapid piston movement inside the cylinders. Thus, vehicles are moving source of traffic or environmental noise and the reason for occupational hazard for drivers which can affect their hearing. Noise production from vehicles is directly proportional to the age of the engine[16].

The auto rickshaws produce noise level up to 92 dB, trucks and buses up to 94 dB, private cars up to 70 dB, whereas, motorcycles produce noise level up to 110 dB and contribute most part of traffic noise[17]. The highest noise level in busy roads in Dhaka Metropolitan City ranges from 90 dB to 104 dB[18,19]. As the noise level is over 90 dB inside cabin of auto rickshaws which is above the permissible limits for 8 hours daily, this definitely induce changes in threshold shift[20]. If the noise level is above 105 dB then exposure should not be more than 1-hour. If the noise level is above 110 dB then exposure should not be more than 30 minutes as exposure to longer duration at this level leads to gradual hearing loss.

Study rationale

The drivers of CNG run auto rickshaw are continuously being exposed to constant noise from their own vehicles and noise from all other vehicles due to heavy traffic during their working hours. In the previous studies hearing threshold assessment has been done on traffic polices, shopkeepers, hawkers, bus and truck drivers. The results showed heterogeneous pattern of hearing loss among different occupational groups.

As a distinct professional group, the drivers of CNG run auto rickshaw have never been addressed earlier to assess their occupational hazard. No available data is found on noise induced hearing threshold status of auto rickshaw drivers in Dhaka Metropolitan city. To generate the baseline data on the hearing loss prevalence this particular professional group needs to be investigated.

Data on prevalence is needed in order to develop evidence-based strategies and policies by the policy makers. Without adequate data it is difficult for the policy makers to assume the extent of the issue and to take decision for resource allocation. This study will contribute implications for the policy makers to adopt strategy on hearing conservation program.

MATERIALS AND METHOD

This cross-sectional study was conducted in the Department of Physiology, Dhaka Medical College, Dhaka from January 2020 to December 2020. Before initializing this study the approval of the protocol was obtained from the Research Review Committee (RRC) of the Dhaka Medical College Physiologydepartment and then ethical clearance was taken from the Ethical Review Committee (ERC) of the college. It was performed in accordance with ethical standards of the Helsinki Declaration (1964, later on amended in 1975 and 1983). All recruits gave written informed consent.

Participants

The current research was done among 305 drivers of CNG run 4-stroke three-wheeler auto rickshaws. Study populations were purposively chosen from various areas of Dhaka Metropolitan City, Bangladesh.One hundred office workers (age, body mass index, socio-cultural background matched)working in offices in Dhaka Metropolitan City were recruited as controls for matching with the study population. Unlike the study group, the controls were not exposed to occupational noise. Office staffs, office assistants and clerks exposed to 60-65 dB noise levels of at their workplace premises were included in control group. An informed consent in written format was collected from all the participants in the study. The demographic profile was recorded including age, education, the years of service in office, and details of their past medical conditions affecting hearing.

The subjects with no history of systemic diseases like diabetes mellitus, hypertension, otitis media, ear surgery, meningitis, head injury, using ototoxic drug were recruited. The subjects above the age of 50 years were not included both in the study and control group to avoid the outcome being affected by the influence of aging changes in hearing.

Measurement of hearing status

All the recruits were subjected to undergo pure tone audiometric testing in a standardized manner in a soundproofed room in audiometry section of Ear Nose and Throat (ENT) and Head, Neck Cancer hospital and Institute, Dhaka.

The recruits underwent routine auroscopic examination of the external ear canals and eardrums and pure tone audiometry to identify detectable hearing loss. They had normal hearing on recruitment. Pure tone air conduction hearing thresholds at different frequencies were measured. The octave frequencies of 250, 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz were noted incase of both the ears to record the thresholds of hearing of the recruits.. Madsen audiometer (Orbiter 922, Denmark) was used for performing the audiometric diagnostic test at the Audiology department of ENT and Head, Neck Cancer hospital and Institute, Dhaka.

Pure tone audiometry

Trained clinical audiologists performed the tests (air conduction and bone conduction thresholds). Masking was performed when applicable. The vibrator was placed on the mastoid bone for recording audiometric findings (bone conduction values) as per the methodology explained by the British Society of Audiology, and hearing threshold values obtained were at 500, 1,000, 2,000, 3,000, and 4,000 Hz of octave frequencies in 5-dB steps. As per need, the ear not under examination was masked.The masking was also done when the air-bone gap was more than 10 dB of the affected ear under test.

Hearing handicap is usually denoted as an average hearing threshold level of greater than 25 dB (Hearing Level) for both ears at selected frequencies[21].The hearing threshold level of 25dB is considered the cut off point for normal hearing sense in each frequency.

Statistical Analysis

Mean ± SD (standard deviation) was used for expressing the results pertaining to the study parameters.Unpaired Students t-test was applied for comparing the body mass index (BMI), age, and blood pressure between the 2 groups of recruits.P value of <0.05 were considered to be statistically significant. Chi Square test was performed for obtaining the association between the variables. A computer based statistical program SPSS (Statistical Package for Social Sciences) version 23 was used for the performance of the statistical analysis.

Ethical considerations

Approval for the research was received from the Research Review Committee (RRC) of the Physiology department and Ethical Review Committee (ERC) of Dhaka Medical College.Data privacy and confidentiality were kept in agreement with the Declaration of Helsinki on ethical principles for medical research that involve human subjects.

RESULTS

This research had included 405 male recruits.Out of these 305 recruits(age between 20-50 years) were selected as study group. Another 100 apparently healthy subjects with age ranging from 20-50 years were chosen as controls.

General demographic profile of both study group and control group are displayed in Table 1. Educational level was noted to be significantly higher in the control group than that of the study group.

Table 2 showed the baseline characteristics of the study group andcontrol group. Unpaired student's "t" test was used for comparison between the groups and the difference noted was not significant.

Table 1 : Demographic profile of study group and control group

Variable		Study group (N_S=305)		Control group (N_C=100)		*p* value
		Number	**(%)**	**Number**	**(%)**	
Age	18-27 years	55	18.03	24	24	
	28-37 years	141	46.23	61	61	0.512
	38-47 years	101	33.11	13	13	
	> 48 years	08	02.62	2	2	
Educational level	No formal education	95	31.14	0	0	
	Primary	176	57.70	19	19	0.013***
	Secondary	15	4.92	24	24	
	Bachelor	09	2.95	43	43	
	Graduate and above	03	0.98	14	14	
Marital status	Married	195	63.93%	71	71	
	Un married	108	35.40%	28	28	0.663
	Divorced /single	2	0.66%	1	1	
BMI Kg/m^2	underweight (< 18.5)	25	8.20%	04	04	
	Normal (18.51- 24.99)	197	64.60%	73	73	0.115
	Overweight (25-29.99)	69	22.62%	26	26	
	Obese (>30-34.99)	04	1.31%	01	01	
Smoking	Current smoker	204	66.27%	46	46%	0.3123
	Ex-smoker	31	10.71%	15	15%	
	Never smoked	70	23.02%	39	39%	

Results were expressed as frequency and percentage. Chi square test wasused to compare between the groups N= number of subjects in each group; Ns=number of subjects in study group; Nc=number of subjects in the control group *** s = significant, ns = not significant.

Table 2 : Baseline characteristics of the study group (N_S=305) and Control group (N_C=100)

Variables	**Study group (Mean ± SD) (N_S=305)**	**Control group (Mean ± SD) (N_C=100)**	***P*-value**
Age (incompleted years)	34.71 ± 0.91	34.91 ± 1.66	0.828
Systolic BP (mm Hg)	120.00 ± 3.82	115.74 ± 2.33	0.033***
Diastolic BP (mm Hg)	76.55 ± 2.08	80.74 ±1.55	0.099
BMI (kg/m^2)	22.63 ± 3.80	25.00 ±2.75	0.000***
Random blood Glucose (RBG)(mmol/L)	5.99 ± 0.09	6.03 ± 0.19	0.403

Results were expressed as mean ± SD. Unpaired students "t" test was performed to compare between the groups. n= number of subjects in each group; BP=Blood pressure; Ns=number of subjects in study group; Nc=number of subjects in the control group. *** s = significant, ns = not significant.

The current research tested the hearing profile of noise exposed audiometrically. Table 3 and 4 compared the threshold frequencies of the ears between the groups. In all frequencies the study group had significantly higher value for hearing threshold in both ear each (p value <0.01).Table 5 shows the grading of hearing loss in right and left ear among the study subjects in which right ear exhibited moderate hearing loss in 20% of the study group and 10% of the study group showed hearing loss of moderate nature. Table 6 displays the degree of hearing loss in study and control group in which the degree of hearing loss (mild, moderate and severe) were significantly higher in study group when compared to the controls (p<0.001).Table 7 exhibits Prevalence of audiometric notches at various frequencies among study group (N_S=305) and Control group where 63 (65.63%) of the study group had audiometric notch at frequency of 4 kHz.

Table 3 : Comparison of frequency thresholds of right ear among study group (N_S=305) and control group (N_C=100)

Freq. (in Hz)	Right Ear		
	Study group (Mean± SD)	Control Group (Mean± SD)	*p* value
250	10.13±6.62	8.70 ±5.77	<0.01
500	10.47 ±6.24	9.20±5.99	<0.01
1000	11.62 ±5.37	10.66 ±5.62	<0.01
2000	11.62 ±5.51	9.20 ±5.32	<0.01
3000	15.28 ±8.95	10.90 ±5.16	<0.01
4000	21.79 ±16.74	13.45 ±6.62	<0.01
6000	18.65 ±13.77	11.30 ±5.77	<0.01
8000	13.08 ±10.39	8.40 ±4.79	<0.01

Freq. = Frequency, P values were calculated by paired t test (Evaluated by paired t test in all frequencies) <0.01

Table 4 : Comparison of frequency thresholds of left ear among study group (N_S=305) and control group (N_C=100)

Freq. (in Hz)	Left Ear		
	Study group (Mean± SD)	Control Group (Mean± SD)	*P* value
250	8.95±5.11	8.96±4.75	<0.01
500	10.79±6.14	8.95±5.11	<0.01
1000	11.37±6.72	9.10±5.58	<0.01
2000	11.80±5.51	9.25±4.71	<0.01
3000	15.72±8.70	10.40±4.72	<0.01
4000	21.47±14.90	13.05±6.67	<0.01
6000	18.17±12.69	12.10±5.66	<0.01
8000	12.79±10.06	9.30 ±5.75	<0.01

** Freq. = Frequency, ** P values were calculated by paired t test (Evaluated by paired t test in all frequencies)

Table 5: Grading of hearing loss in Right and Left ear among subjects of Study group (N_S=305)

Hearing loss (HL)	Right ear		Left ear	
	Frequency	Percentage	Frequency	Percentage
None (0-25 dB)	212	69.51	232	76.06
Mild (26-40 dB)	27	8.85	38	12.46
Moderate (41-60 dB)	61	20.00	31	10.16
Severe (61-80 dB)	05	1.64	04	01.31
Profound (>81 dB)	00	00	00	00

Results were expressed as frequency and percentage, HL = Hearing Loss, dB = Decibel,
Mild HL =26-40 dB, Moderate HL =41-60 dB, Severe HL = 61-80 dB,
Profound HL = 81 dB or greater

Table 6: Degree of hearing loss in Study group (N_S=305) and Control group (N_C=100)

Degree of hearing loss	Study group Number (Percentage)	Control Group Number (Percentage)	*P* value
0-25 dB (None)	209(68.52)	95(95)	<0.01
26-40 dB (Mild)	24(7.87)	3(3)	<0.01
41-60 dB (Moderate)	60(19.67)	2(2)	<0.01
61-80 dB (Severe)	12(3.93)	0 (0)	<0.01
>81 dB (Profound)	0 (0)	0 (0)	

** P values were calculated by Chi square test
(Differences observed is statistically significant)

Table 7: Prevalence of audiometric notches at various frequencies among Study group (N_S=305) and Control group(N_C=100)

Notch frequency	3kHz Number (%)	4kHz Number (%)	6kHz Number (%)	8kHz Number (%)
Study group (N_S=305)	0	63 (65.63)	21 (21.87)	12 (12.50)
Control group (N_C=100)	0	1 (20)	3 (60)	1 (20)
P value				

Results were expressed as frequency and percentage

DISCUSSION

This research was carried out among the drivers of CNG run autorickshaw to explore the occupational hearing lossby audiometric testing. The CNG run auto rickshaw drivers are extremely prone to NIHL as they are constantly exposed to loud noises from their own vehicles and noise from other vehicles for sustained periods. The results exhibited a typical picture of NIHL and were significant when compared with properly matched controls.

The mean age of the study group and control group were 34.71 years with SD (+0.91) and 34.91years with SD (±1.66) years respectively, the study populations were matched. In a previous study Khadatkar et al. also worked with the population where mean age of study group and the controls was 40.1 10.9 years and 40.8 ± 11.4 years respectively[22]. Among the study subjects 46.23% were between 28 to 37 years and 33.11% were between 38 years and 47 years.

In this research the overall prevalence of the NIHL among drivers of CNG was 31.47%. In a recent study Pourabdian et al. noted 26.8% prevalence rate of NIHL in Isfahan, Iran[23]. The bus drivers had to be exposed in road traffic noise for longer duration, so they could be comparable with auto rickshaw drivers for discussion. Comparison among other studies is difficult due to the scarcity of previous studies of CNG run auto rickshaw drivers. However, noise exposure levels and its effects can be comparable to that of road traffic settings.

Bilateral hearing loss is a characteristic finding in NIHL. In earlier studies by Janghorbaniet al., Ansari et al. and Pourabdian et al. reported the prevalence of bilateral hearing loss of 18.1%, 23.8% and 14.6% respectively[23, 24, 25.] The reason behind this increased rate of NIHL is rapid urbanization and increased number of vehicles. In our study the prevalence of bilateral hearing loss was 19.67%, which was more than the study of Pourabdian et al. of 14.6%. The difference may be due to different vehicle related entity. CNG auto rickshaw drivers were more likely to be exposed to noisier environment. They had to encounter noise from both inside and outside of the vehicle, In CNG run auto rickshaw the driver's cabin is opened in both sides.

However, greater number of hearing loss was observed in left (7.8%) ear than right ear (4.4%) in a study by Pourabdian et al.[23]. Earlier study by Ansari et al. [25] also found the left (6.5%) sided preponderance of hearing loss than right (3.0%). This outcome matched with that of Hong, Ross et al., Marvel et al., Pirila et al., and Simpson et al., although the exact mechanism of higher involvement of left ear is not understood yet[26, 27, 28, 29, 30]. It was assumed that in Iran almost all of the vehicles are left hand driven and so the left window of the vehicles remains opened for most of the time. Left ear is more exposed to noise. This is a possible explanation why left ear is affected most.

In the current research we found that both left ear 19 (6.23%) and right ear 17 (5.57%) were equally affected by hearing loss due to noise exposure. The hearing thresholds for left and right ears were compared by Student's t-test at each test frequency. No significant difference was determined ($p > 0.05$). There was symmetrical involvement of hearing loss in both the ears. This may have resulted from the fact that the cabin of CNG vehicle is an open cabin, both the windows in CNG auto rickshaw has no window shield like other vehicles. So, noise enters equally from both sides of the open cabin of CNG auto rickshaw.

For control group we took the office workers who work in quiet office environment. The office was the quieter place where the average noise intensity level ranges from 35dB to 50 dB. In another study by Sadia et al. in

Chattagram, Bangladesh reported that the average sound level of the administration section ranges from 50-70 dB[31]. In reality the control group as for comparison for occupational studies does have some noise exposure. So, they may in fact develop some hearing threshold change.

Unpaired t test was performed to detect the significance of hearing loss in study group over control group. CNG drivers had a significantly high NIHL when compared to the controls at the different frequencies. Previous studies concluded a positive association of hearing loss with exposure time to high noise exposure [32].

Prior research has reported that NIHL tends to affect higher frequencies more than lower ones. The most significant hearing loss is usually observed around the 4 kHz or 6 kHz range. In thisresearch, the maximum hearing threshold change is found at 4kHz frequency 63 (65.63%) which matches the classic indicator of NIHL. However, threshold shift at 6kHz frequency is seen in 21 (21.87 %) and at 8kHz frequency is seen in 12 (12.50%) cases. This finding is consistent with the other published studies[26]. This poor audiometric status of CNG drivers might have resulted from damage to hair cells by high pitched sound of road vehicles.

In a study Nelson et al. mentioned that with continued noise exposure the notch grows deeper and wider[33.] The 6000 Hz and 3000 Hz were the second and third frequencies affected which is typical for NIHL. It is consistent with the findings of previously reported study by Leensen et al. [34].

Sharif et al. in a research on traffic police of Dhaka Metropolitan City found that the hearing threshold change in frequencies at 4000 and 6000 Hz[35] which is in line with previous study by Hong[26]. The first sign of NIHL can be identified by observing a typical 4000 Hz "notch" in audiograms. It indicates the loss of hearing ability of human voices in middle frequency range. The mean of hearing loss in high frequency (4000 to 8000 Hz) was more than the low frequency in our research.

The significant difference ($p< 0.001$) in audiometric pattern between study group and control group was noted here. This difference is due to exposure to noise. CNG drivers encounter engine and road traffic noise during professional hours. In contrast, in the control group comprising of office workers only 5 subjects had a hearing threshold shift towards noise induced hearing loss. This is because they work in low sound intensity levels of between 35dB to 50 dB.

It has been noted that about 62.5% of the affected CNG drivers were graded to have moderate degree hearing loss; 25% had mild and 12.5% had severe hearing loss. In comparison, 60% of the control group (office workers) had mild degree of hearing loss and 40% had moderate hearing loss. Furthermore, in the present study bilateral thresholds shifts were observed in both ears of 62.5% of the CNG drivers. We did not measure the noise levels by ourselves because in several studies the noise level of Dhaka Metropolitan City has been estimated which ranges from 60 dB to 100 dB [36]and we have used that range as our baseline data. Bilateral hearing loss develops due to long-term exposure to noisy environment throughout the day in the work place.

CONCLUSION

The outcomes of this research show a significant association between road traffic noise exposure and noise induced hearing loss among drivers of compressed natural gas run auto rickshaw .It is found that the mean hearing threshold levels at higher frequencies for the left and right ears are higher for more driving experienced drivers. The estimated prevalence of noise induced hearing loss is 31.47% and it clearly poses a health threat to drivers of

CNG run auto rickshaws. The study highlights the need for interventions to reduce the harmful effect of road traffic noise by improvising the altered silencers for CNG run auto rickshaws and by improvising the traffic regulations. Periodic audiological evaluation and comprehensive hearing conservation programs should be introduced as a priority.

AUTHORS CONTRIBUTIONS

Rahman MM, Begum D, Orpa TR: conceived and designed the work. Rahman MM: performed the work Khanom S, Chakraborty S, Rahman MM': analyzed the data and interpretated the results Rahman MM: wrote the manuscript Begum D, Rahman AFSMS, Chakraborty S.: revised the manuscript

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CONFLICT OF INTEREST

There is no conflict of interest.

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