

Effect of Tractor Driving on Hearing Loss in Farmers in India

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Background Indian tractor drivers operate their tractors and other implements/equipment in an environment which can have extreme temperatures and high level of suspended particulate matter. In addition, Indian tractors do not have adequate vibration and noise attenuating designs features. This cross-sectional study compares the hearing status of tractor driving farmers (TDFs) (study group) and non-tractor driving farmers (NTDFs) (control group) matched for age, sex, generic/ethnic group, land holding, education levels, and work routines.

Method Two groups of 50 experienced tractor-driving farmers and 50 non-driving farmers were selected from 2 villages, 50 km from Delhi. All participants were interviewed for details of work routine and noise exposures. An audiogram was performed and noise measurements taken on tractors and other machines.

Results Self-reported hearing problems were similar (4 cases each) in both the groups of 50 farmers. However, audiogram analysis showed higher prevalence of abnormalities in TDFs. TDFs (24) had more often high frequency hearing loss when compared to NTDFs (14). The noise levels observed on tractors in different operations were in the range of 90–110 dB (A).

Conclusions Tractor noise levels exceeded the recommended safe limits of OSHA and NIOSH prescribed standards. TDFs had higher high frequency hearing loss than NTDFs. The mechanism of damage and prevention needs to be studied further. *Am. J. Ind. Med.* 47:341–348, 2005. © 2005 Wiley-Liss, Inc.

KEY WORDS: hearing impairment; noise induced hearing loss; farming; tractor driving

INTRODUCTION

Occupational health problems of agricultural workers have not received significant attention in low-income

countries (LICs). This is particularly true for tractor drivers who operate their tractors in an environment with extreme temperatures and high level of suspended particulate matter. Indian tractors do not have adequate vibration and noise attenuating design features. Tractor designs in high-income countries (HICs) have become more sophisticated and most have enclosed environment-controlled suspended cabins and well-designed instrumentation and controls. These designs are not likely to become common in countries like India in the near future.

The number of agricultural and household machines in rural India has increased over a period of time as shown in Figure 1 [Singh, 1997]. The energy sources of many of these machines have shifted from manual operation to internal combustion engines and electric motors. The use of tractors on Indian farms has increased from 52,000 in the 1960s to

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3.2 million in the 1990s [Motor Transport of India, 2003]. Indian agricultural output has increased but the detrimental health effects of noise have not been controlled adequately. Sources of noise in rural settings are not only tractors but also water pump sets, fodder cutting machines, flourmills, and other equipment driven by internal combustion engines. The studies on the adverse effects of noise levels of farm machines on operators have been conducted mostly in HICs. Hutchings and Vasey [1964] measured noise levels in the vicinity of 12 agricultural tractors and found the sound pressure level at the driver's ear in the range of 100–113 dB (A) at full load and rated speed. Matthews [1968] measured tractor noise and reported that operators were not adequately protected from noise exposure and hearing was at risk. The noise levels were 74–108 dB (A) with very little correlation between tractor horsepower and higher correlation with engine speed. Jones and Oser [1968] reported average overall sound pressure level for tractors of all models, types, and operator position was 103.5 dB. Similar results of exceeding 85 dB levels on tractors were also reported in later studies [Broste et al., 1989; Bean, 1995; Dennis and May, 1995].

Some hearing impairment studies have been performed on farming communities. Thelin et al. [1983] reported that farmers as compared to office workers are at risk of hearing loss at 2,000 and 4,000 Hz. The prevalence of hearing loss was greater for farmers at both frequencies in age groups from 25 to 64 years. Using screening failure at 2,000 and 4,000 Hz in both ears as a criterion for a loss, the failure rate was 16.8% for farmers and 6.2% for office workers. Karlovich et al. [1988] showed that men, who lived in rural areas, including farmers, demonstrated a high prevalence of hearing loss and associated communication problems due to excessive noise exposure. Marvel et al. [1991] in a study of randomly selected 49 dairy farmers with age and sex matched

control group of rural non-farmers, reported 65% hearing loss in higher frequency and 37% hearing loss in mid frequency among farmers as compared to 37% and 12% in non-farmers. Plakke and Dare [1992] have also reported high frequency sensorineural hearing loss among farmers.

In a recent study, Hwang et al. [2001] reported that farm noise exposure is a serious risk to the hearing of this population. In their study, 1,622 persons completed the hearing loss and noise exposure interview. Twenty-two percent of participants reported hearing loss. Significant confounders were age, gender, being from a livestock farm, and loss of consciousness due to head trauma. Significant noise exposure was more hours of lifetime exposure to noisy farm equipment or having had a noisy non-farm job.

The Occupational Safety and Health Administration [OSHA, 1983] noise exposure standards for general industry use a permissible limit of 90 dB (A) for 8-hr time weighted average (TWA) (29 CFR). National Institute for Occupational Safety and Health (NIOSH) recommended an exposure limit of 85-dB (A) for an 8 hr TWA. The exchange rate is 5 dB (A) in OSHA and 3 dB (A) in NIOSH [1998], i.e., prescribed exposure time becomes half with increase of 5 and 3 dB noise level, respectively. OSHA suggests that feasible administrative and engineering controls must be implemented whenever employee noise exposures exceed 90 dB (A) (8-hr TWA). In addition, an effective hearing conservation program (including specific requirements for monitoring noise exposure, audiometric testing, audiogram evaluation, hearing protection for employees with a standard threshold shift, training and education, and record keeping) must be made available whenever employee exposure equals or exceeds an 8-hr TWA sound level of 85 dB (A) [29CFR 1910.95]. The American Conference of Governmental Industrial Hygienists [ACGIH, 1994] have also recommended exposure limits of 85 dB (A).

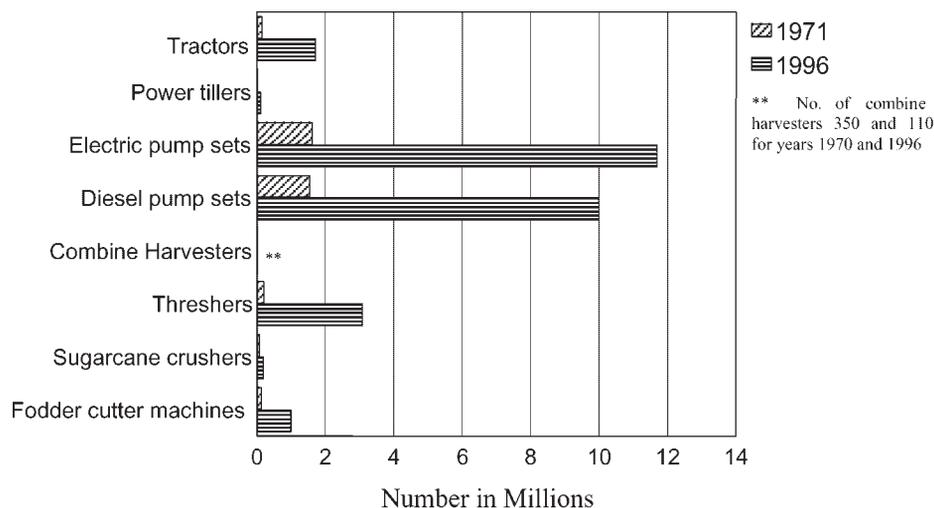


FIGURE 1. Farm mechanization levels in India in 1970 and 1996 [adapted from Singh, 1997].

OBJECTIVES

The objectives of the study were to measure and evaluate the noise transmitted by tractor and other machines to the driver in different operations; to compare the observed noise levels with international criteria for safe exposure for noise; to examine whether tractor driving farmers (TDFs) are at a greater risk of hearing impairment than non-tractor driving farmers (NTDFs).

METHODOLOGY

Noise Measurement and Comparison With Prescribed Limits

Noise measurements were performed on tractors and other machines to observe the magnitude of noise levels. The measurements were carried out on the farms and households of the farmers of both the groups. The measurements were taken on all the equipment owned by exposed and control group farmers and were done with hand held battery operated noise meter. The measured values were compared with international norms (OSHA and NIOSH) of noise level.

Study Description and Data Collection

Fifty experienced tractor drivers were selected from 2 villages, 50 km from Delhi. All the selected tractor drivers satisfied the following criteria: minimum tractor driving experience of 5 years; age group 25–45 years; minimum land holding of 2 hectares; not suffering from any other disease except musculoskeletal and/or low back pain; had no history of ear discharge; not involved in regular travel by any means of mechanized transport; and willingness to participate in the study. Information was also collected from each subject on age; education; occupation(s), including number of years of active farming and tractor driving; tractor details and hours of driving experience in a year; details of land holding; food habits; and smoking and alcohol intake. For this purpose, a form was designed in the local language and was completed by the researchers. Information was gathered from every participant. The details of smoking and alcohol intake were questioned. Food habits were interviewed for vegetarian and non-vegetarian food intake. The tractor driving hours were estimated on the basis of questions asked about usage of tractor on their own farms based on land holding and leased in land from others, hiring usage on the other farmer's land, transportation activities done for material and people for both personal and hiring and fuel quantity used during the year. The 50 subjects for the control group were chosen from the same ethnic and economic group using the same selection criteria, except that they did not drive a tractor.

Both groups were interviewed for details of work routine, assets held, family profile, health problems, educa-

tion level, transportation mode usage, and noise exposure details to assess the influence of these parameters in producing signs and symptoms of hearing impairment.

Assessment of Hearing Impairment

Pure tone audiograms for 125; 500; 1,000; 2,000; 3,000; 4,000; 6,000; and 8,000 Hz frequencies were conducted by a qualified audiologist. Losses of hearing acuity exceeding 25 dB were considered abnormal however the calculations were also based on taking 0 dB as the reference for measuring hearing loss in these subjects. The testing was performed in a soundproof audiometry room. Temporary threshold shift was eliminated, as the subjects were not exposed to tractor noise or any other agricultural noise on that particular day.

Calculation of Hearing Loss

Each audiogram had threshold level measured at 9 frequencies for each ear, so there were 18 observations generated from each audiogram. As suggested by Marvel et al. [1991] the four frequencies pure tone average (PTA-4) of hearing levels at 500; 1,000; 2,000; and 3,000 Hz were used for mid-frequency hearing loss. High frequency range of 3,000; 4,000; 6,000; and 8,000 Hz was (HFA-4) used for hearing impairment [American Academy of Otolaryngology Committee, 1979]. Threshold of 25-dB (A) and above was considered abnormal but the calculation of hearing was also carried out using 0 dB (A) as reference. When on pure tone audiometry at any frequency no response was obtained even with the maximum level of stimulus (110 dB), it was taken as 110 dB (A) hearing loss for the purpose of calculation.

RESULTS

Measurement of Noise Levels

Measurements of noise level on 51 tractors, 51 threshers, 83 engine pump sets, 70 electric motor pump sets, 89 flourmills, 2 sugarcane crushers, and 87 fodder cutter machines were made on the farms and households of participants of both the groups of TDFs and NTDFs. The measurement of sound levels on different tractor models indicated that the noise level exceeds 100-dB (A) (Fig. 2). Other commonly used equipment like electric pump sets, diesel pump sets, fodder cutter machines, flourmills, and agricultural machines like thresher and sugar cane crusher also exceed 90 dB (A) noise levels (Fig. 2).

NIOSH and OSHA standards were exceeded for 8 hr working in all the machine operations. It was observed that no machine could be operated even for 1-hr duration as per NIOSH standard. Only machines like electric pump sets, thresher, and sugar cane crusher can be operated for more than 2 hr as per OSHA standard (Fig. 2).

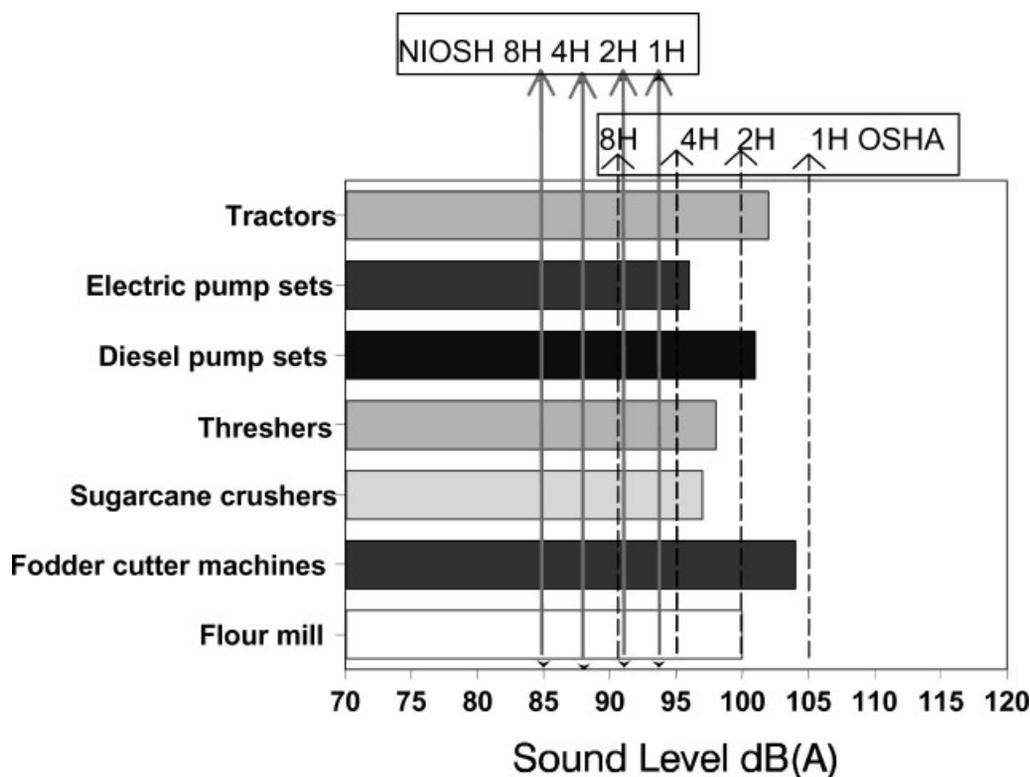


FIGURE 2. Comparison of noise level of different agricultural machines on the farms and homes of study participants with prescribed standards.

Characteristics of Study Group and Control Group

Subjects in both the groups belonged to the same sub-ethnic group (caste) and similar cultural background. All of them were males in the age group (25–45 years). The characteristics and age distribution of study and control groups (TDFs and NTDFs) are given in Tables I and II.

Similarities and differences between study and control group for education, smoking and alcohol intake habits,

manual work performed, family profile, and transportation mode used are given in Table III.

A majority of the subjects—41 (82%) of TDFs and 36 (72%) of NTDFs were smokers (P value = 0.230). Twenty-three (46%) of the TDFs and 17 (34%) of the NTDFs admitted alcohol consumption (P value = 0.220). The assessment based on this suggests that the two groups are not different. The ownership level of motorized two-wheeler and car were low in these two villages and their usage was not high between both groups. NTDFs used more public transport modes like buses, jeeps, and three-wheeled motorized vehicles (commonly known as tempo) whereas TDFs use tractor as a transportation vehicle. Spadework was found to be the most frequently used manual tool for making ridges, irrigation channels, and unearthing. Analysis did not reveal any difference in the usage pattern of the spade in NTDFs and

TABLE I. Characteristics of Tractor Driving Farmers (TDFs) and Non-Tractor Driving Farmers (NTDFs) in the Study

Characteristics	Mean		Standard deviation		P value
	TDF	NTDF	TDF	NTDF	
Age (years)	34.06	33.02	6.35	5.50	0.296
Height (cm)	169.17	169.60	6.23	4.65	0.687
Weight (kg)	57.93	55.00	8.10	6.23	0.046*
Experience (years)	15.56	13.74	6.53	5.79	0.414
Tractor driving experience (years)	12.76	—	5.40	—	—

*Statistically significant at 5% level.

TABLE II. Age Distribution of TDFs and NTDFs, India

Age group (years)	TDFs	NTDFs
25–30	19 (38)	22 (44)
31–35	14 (28)	11 (22)
36–40	6 (12)	13 (26)
41–45	11 (22)	4 (8)

Numbers in parenthesis represents percentage in the respective age group.

TABLE III. Similarities and Differences Between the Study Group and Control Group

Parameters	Similarity/difference (<i>P</i> value*)
Education	Similar (0.690)
Dietary habits	
Food habits	Similar (>0.005)
Smoking	Similar (0.234)
Alcohol intake	Similar (0.220)
Family profile	Similar (>0.050)
Transportation modes	Different (<0.005)
Manual work	
Spade	Similar (0.488)
Carrying farm inputs and produce	Similar (>0.050)
Assistance in manual work (family member and hired labor)	Similar (>0.050)

*Higher in TDFs (study group).

TDFs (*P* value 0.48). The load (farm inputs and farm produce) carried by both drivers and non-drivers were found to be very similar and there was no statistically significant difference between the two groups (all *P* value > 0.150).

Equipment Ownership

The assets owned by the two groups are shown in Figure 3 and difference in possession is shown in Table IV. Owners of bullocks did not possess implements and machines. Bullock-operated implements were higher among NTDFs as they used the bullocks for draft purposes. All the families in the two groups owned milking animals, irrigation equipment, fodder cutting machines, and flourmills.

It was quite difficult to assess the exposure as tractors are not only confined to single farms but are also hired out to other farms for both on the farm and off the farm operations. The analysis revealed that driving hours per annum were in the range of 100–5,000 hr with a median of 1,000 hr and standard deviation of 757 hr.

Hearing Impairment

Four persons in each group reported hard of hearing and the remaining reported normal hearing.

TABLE IV. Agricultural Assets Ownership Between the Two Groups

Equipment	<i>P</i> value
Tractor operated equipment	Different (<0.005)
Bullock and bullock-operated implements	Different (<0.005)
Milking animals	Similar (0.060)
Other equipment	Similar (>0.050)

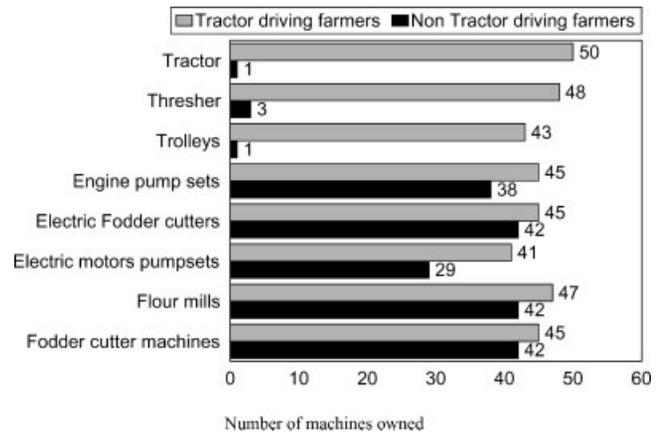


FIGURE 3. Ownership level of different among families of tractor driving farmers (TDFs) and non-tractor driving farmers (NTDFs) equipment.

Audiogram analysis for PTA-4 and HFA-4 are given in Table V. PTA-4 was abnormal for one or both ears in 13 cases in TDFs and 10 cases in NTDFs showing no statistical significance (*P* value = 0.475) while HFA-4 was abnormal in 24 TDFs and 14 in NTDFs making it statistically significant (*P* value 0.0393). This shows that tractor noise affects both HFA and PTA but more predominantly HFA.

The left ear was more severely affected in HFA among TDFs (19 cases) as compared to NTDFs (12 cases). In TDFs the difference between the effect on left and right ear was statistically significant (*P* value 0.002), whereas in NTDFs this difference was not statistically significant.

Considering hearing loss of more than 25 dB (A) in either PTA or HFA as abnormal, the results showed 48% hearing loss among TDFs and 30% in NTDFs (*P* = 0.0393).

Analysis of hearing loss with experience in terms of PTA-4 abnormalities and HFA-4 abnormalities are shown in Figure 4. The analysis infers that with experience, HFA-4 increase in TDFs but statistically this increase is not significant (*P* = 0.348 and 0.817 for TDFs and NTDFs). PTA-4 analysis did not show any increase with experience in both the groups (*P* value 0.817 and 0.216 for TDFs and NTDFs).

TABLE V. Audiogram Analysis of TDFs and NTDFs (Based on 25 dB Criterion)

Parameter	TDF (N = 50)	NTDF (50)	<i>P</i> value
HFA-4			
Presence	24	14	0.0393*
Left ear	19	12	
Right ear	12	11	
Pure tone average (PTA)-4			
Presence	13	10	0.475
Left ear	8	7	
Right ear	10	8	

*Statistically significant at 5% level.

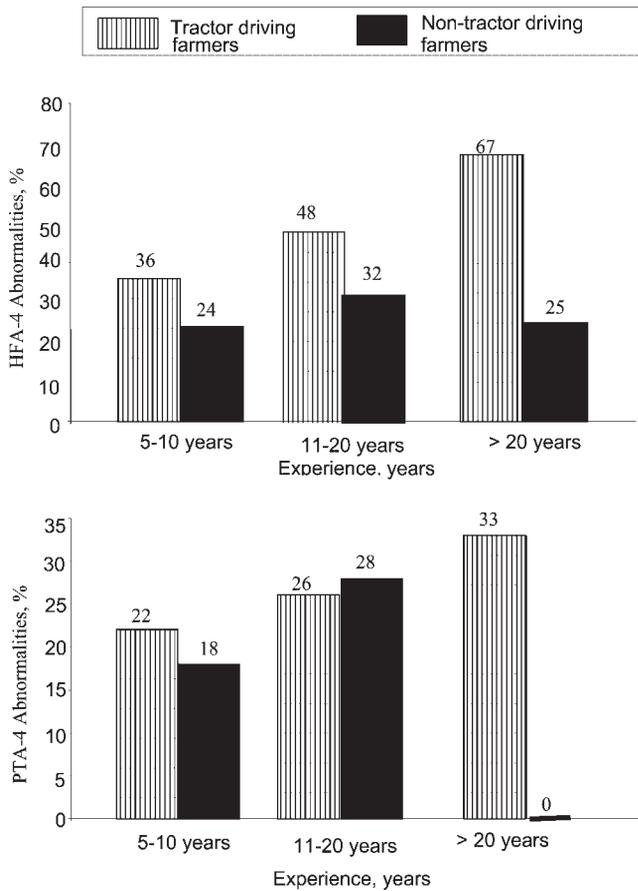


FIGURE 4. Presence of abnormalities (HFA-4 and pure tone average (PTA-4)) in TDFs and NTDFs with experience.

Based on the 0 dB criteria it was found that the hearing levels (HFA-4 and PTA-4) were worst in TDFs as compared to NTDFs (Fig. 5). The average decibel level of PTA-4 was 18.82 and 18.85 dB(A) for left and right ear, respectively for NTDFs whereas for TDFs it was 22.69 and 22.8 dB(A) (Table VI). HFA-4 decibel level for TDFs was 26.54 and 26.2 dB(A) for left and right ear higher than NTDFs whose were 20.6 and 20.35 dB(A) for left and right ear.

DISCUSSION

These results clearly show that farmers are engaged in tasks which expose them to excessive or hazardous levels of noise. All tractors were without cabins and noise exposures were higher than 90 dB (A), which exceeded the OSHA and NIOSH standards. These observations were similar to other studies from other countries [Jones and Oser, 1968; Broste et al., 1989; Bean, 1995; Dennis and May, 1995]. Most of the agricultural machines are used well beyond their recommended economic life. May et al. [1990] and Beckett et al. [2000] observed a similar situation and reasoned that sound reduction efforts in newer tractors may not have benefited

much of the farm population. Several confounding factors are responsible for assessment of hearing loss. These include gender, age, smoking, total work experience, and educational level [Marvel et al., 1991; Beckett et al., 2000; Hwang et al., 2001]. In the present study, both the study and the control groups were chosen in such a way that except for tractor driving the differences between the two groups were minimized as far as possible. Both the study and control groups belonged to the same sub-ethnic group, had similar marital status, lived in similar socioeconomic and cultural context, and had similar dietary habits. Our statistical analysis also shows that the study and the control group were almost similar in all aspects. In this study, presbycusis as a factor was avoided by taking subjects in the age group of 25–45 years. In the present study, 48% TDFs had noise induced hearing loss as compared to 30% in NTDFs. The ownership of equipment among both groups was similar except for the tractor and its associated equipment, indicating higher noise exposure in TDFs than NTDFs. But the percentage of noise induced hearing loss was expected to be more in the present study than as reported by the other studies because all tractors were without a cab, the tractors, and machines had surpassed their economic life, protective devices were not used and tractors were extensively used for custom hiring and performing both on farm and off farm activities of other farmers. Studies from HICs by May et al. [1990] and Gomez et al. [2001] reported 65% NIHL among dairy farmers and 47% NIHL among farmers. But the reasons attributed to lower NIHL in Indian situations may be the lower level of farm mechanization as most of the farm operations are performed manually. Absence of environmentally controlled cabins forces Indian farmers to wrap their face and head with *safa*, a traditional piece of cloth used to wrap the head firmly. This may also reduce noise exposure. The left ear was more frequently affected than the right ear. Similar results have been reported by Marvel et al. [1991], Lawhorne [1976], and Broste et al. [1989]. As tractor operators have to monitor equipment mounted on the rear side, and most farmers look over their right shoulder which exposes their left ear to the noise of the prime mover and exhaust while their right ear is shielded by head shadow. Similarly, as in other agricultural equipment, the usual tendency while working is to support with the left hand and control by right. Also while feeding fodder to a fodder cutter machine or crop to a thresher, the left hand goes first followed by right hand again exposing the left ear to the source of noise. In this study, NTDFs also had higher impairment in left ear as compared to right. With both the criterion of 25 and 0 dB for calculating the hearing loss it was found that the TDFs had more hearing loss as compared to NTDFs. The 0 dB criterion (Table VI) is more sensitive in showing the effect of occupational exposure on hearing threshold whereas the 25 dB criterion used for calculation (Table V) is more indicative of functionally significant hearing loss affecting the livelihood of farmers. During the

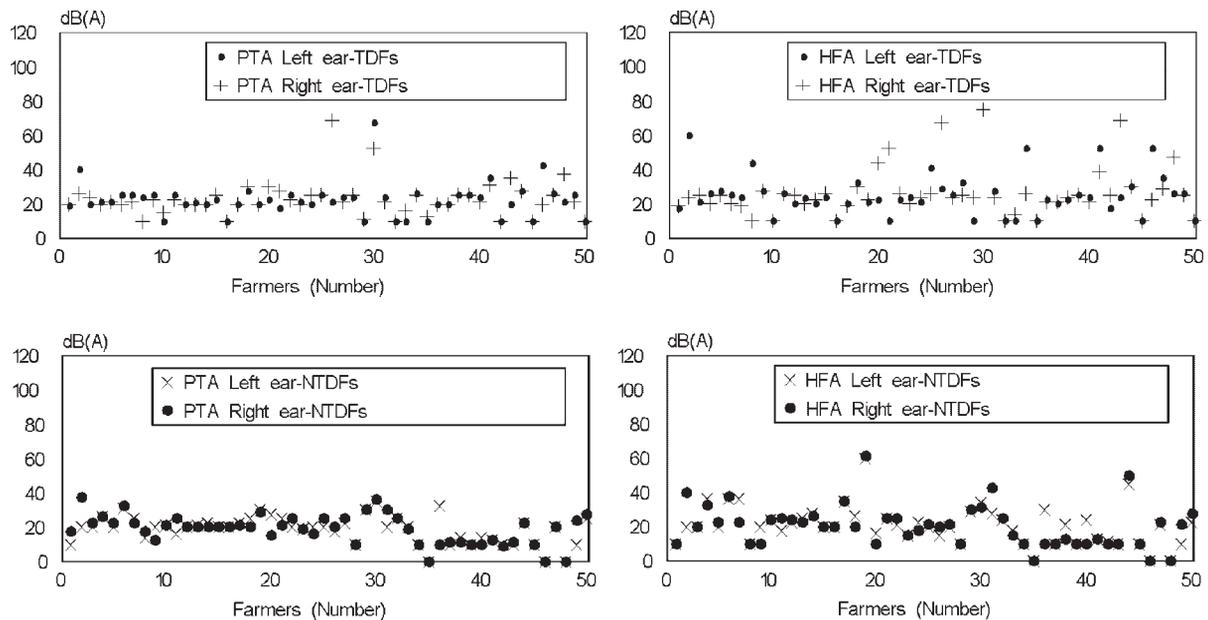


FIGURE 5. Audiogram analysis of PTA-4 and HFA-4 [0 dB(A) criteria] of TDFs and NTDFs.

study, we conducted an experiment to observe the effect of direction of sound on auditory canal by putting a pipe around noise meter. The observation revealed that there is decrease in noise levels in the range of 4–5 dB when the direction is opposite to the motion of tractor (i.e., away from the noise source) similar to the situation we have for the right hand ear while monitoring rear mounted equipment.

In the present study presence of hearing abnormality was not statistically significant with experience, unlike that reported by Hwang et al. [2001]. It is possible that damage occurs in the first few years of exposure and therefore the gradient of exposure linked hearing loss does not vary significantly over years.

CONCLUSIONS

Tractor noise levels used on Indian farms exceeded the recommended safe limits of OSHA and NIOSH prescribed

TABLE VI. Audiogram Analysis of TDFs and NTDFs (Based on 0 dB Criterion)

Parameter	TDF	NTDF	P value
HFA-4			
Hearing loss: left ear	26.54	20.60	0.18
Hearing loss: right ear	26.20	20.35	0.77
PTA-4			
Hearing loss: left ear	22.29	18.52	0.04*
Hearing loss: right ear	22.80	18.85	0.11

*Statistically significant at 5% level.

standards for safe noise levels. TDFs had higher high frequency hearing loss than NTDFs. The hearing loss is more prevalent in left ear. The possible cause of hearing loss is the exposure to high noise levels. The mechanism of damage and prevention needs to be studied further.

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