Original Article

Noise-Induced Hearing Loss Still a Problem in Shipbuilders: A Cross-Sectional Study in Goa, India

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Abstract

Background: Workplace safety regulations seek to mitigate noise-induced hearing loss (NIHL), conventionally associated with the shipbuilding industry. Despite this, are workers still predisposed to NIHL? **Aims:** To study the prevalence of NIHL among noise-exposed subjects in the shipbuilding industry in Goa and to compare it with that among the non-exposed population working in the same industry in relation to certain relevant factors. **Subjects and Methods:** This is a cross-sectional study in the shipbuilding industry, Goa This study examined 552 workers: 276 shipbuilders and 276 office staff, of similar age, duration of employment and socio-economic status working at a shipbuilding enterprise. An interviewer-administered questionnaire was followed by audiometry. Values were presented as percentages, Mean (SD) and odds ratio (OR) and its 95% confidence interval (CI) (Woolfe's method). Fisher's exact test and binary logistic regression were used. *P* value of < 0.05 was taken as significant. SPSS version 16 was used. **Results:** NIHL was found in 17 (6%) shipbuilders, while no office staff was detected to have this condition (OR = 37.29, 95% CI 22.42-62.18). The shipbuilders with NIHL were 52.5 years of age and had been employed for 30.4 years, on an average. None of the 17 cases of NIHL were found to be using earplugs consistently; 11 reported using them "sometimes" and six "never" used them. **Conclusions:** NIHL continues to affect shipbuilders, owing their non-compliance to workplace regulation. Health education is the need of the hour.

Keywords: Asia, Audiometry, Earplugs, Hearing loss, Noise, Occupational health, Smoking, Welding

Introduction

Noise-induced hearing loss (NIHL) is the most prevalent and preventable occupational disease in most Asian countries,[1] and occupational noise is the most common cause of NIHL in adults.[2] Studies of noise-exposed workforce have found NIHL in about 40% of the workers, the prevalence ranging between 19% and 56%.[3,4] It is seen largely in the manufacturing industry, particularly the shipbuilding industry; the latter is notoriously known to be one of the noisiest.[5] The Indian Factories Act (1996 amendment) lists NIHL as a notifiable and compensatable disease.[6]

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Workplace safety regulations are aimed at preventing NIHL. Despite this, are shipbuilders still predisposed to NIHL? This study examines NIHL in shipbuilders compared with workers not exposed to noise, and explores its relation to certain relevant factors implicated in the multi-factorial aetiology of NIHL (age, duration of exposure, middle ear disease and chemical exposures including tobacco).[2,7-11]

Subjects and Methods

Study subjects

A cross-sectional study was conducted involving 552 workers employed in the shipbuilding industry in Goa, India, from June 2008 to March 2009. All subjects were males. The required sample size was 266, taking prevalence of NIHL among noise-exposed populations as 40%,[4] absolute precision of 6% and at the 95% confidence level (the calculation is as follows: $n = [4pq/D^2] * 100 = [4 * 0.4 * 0.6/(0.6)^2] * 100 = 266$). Because this paper is a part of a bigger study focussing on the health of welders, the subject selection criterion was occupation of

welding. All welders were exposed to noise at the shipyard. The total number of welders employed in this industry was 276. All 276 welders participated in this study (participation rate = 100% [276/276]). The welders worked 44 h a week on an average. A noise survey of the shipyard measured levels beyond 90 dB in some pockets where noise-generating processes like hammering, gouging, riveting and cutting of metal sheets took place, while the noise level in places where noisy machinery like generators and blowers were positioned were in the range of 70-80 dB. The average noise level of the shipyard was 65 dB (SD: 15 dB). It is important to note, however, that this value was obtained during the course of the noise survey, and that the noise levels tend to differ significantly with time depending on factors such as how many ships are being worked on at a given time in the shipyard, each ship is at which stage of construction (which dictates the types of noise-generating process that would be required), etc.

The comparison group comprised of 276 members of the office staff working in the same shipbuilding industry matched to the shipbuilders in terms of age, sex and socio-economic status. They were not exposed to noise during the course of work in the offices, which were located away from the shipyard. The average noise level at the office was 35 dB. Informed consent was obtained from all subjects prior to inclusion in the study. The study protocol was approved by the institutional ethics committee.

Data collection methods

An interviewer-administered questionnaire was used to record patient details, history of diminished hearing (Do you feel you have a hearing loss?[12]), ototoxic drug intake, current or past middle-ear disease, smoking habits[13] and consistency of use of earplugs. Because the members of the shipbuilders' group were welders by occupation, history of exposure to hot metal fragments entering the ear was also asked in view of the possibility of "welder's ear,"[14-16] which may range from non-symptomatic tympanic perforation to trans-tympanic injury to the facial nerve[14,15] causing middle-ear disease and conductive hearing loss.[16]

This was followed by otoscopic examination of each subject to detect cerumen (which warranted softening and cleaning before audiometry), tympanic perforation and signs of active middle-ear disease. The study subjects underwent pure tone audiometry testing at the beginning of the shift following a minimum 12-h mandatory noise-free period. This was performed by an experienced technician using the Modified Hughson-Westlake procedure on a regularly calibrated instrument (Arphi Digital Diagnostic Audiometer Model 2001 V6, Arphi Electronics Pvt. Ltd, Prabhadevi, Mumbai, India). Air conduction was assessed for pure tones of 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz of sound levels between -10 dB and 110 dB. Pure tone thresholds for bone conduction were also determined.

Definition of NIHL and grades

Audiometric diagnostic criteria for NIHL included all of the following observations on the audiogram: The impairment is predominantly sensorineural (air–bone gap average at 1, 2 and 4 kHz is less than 15 dB), the boilermaker's notch present in the 3-6 kHz range and hearing loss is bilateral and symmetrical (less than 25 dB at 500 Hz and less than 40 dB at 1000 Hz) in both ears.[5,9,17,18] Hearing loss based on the audiometric value taken as average of 500, 1000, 2000 and 4000 Hz was graded as given in Table 1.[19] Odds ratio (OR) and its 95% confidence interval (CI) (Woolfe's method[20]) calculated manually were used to determine the presence and strength of association between the variables. Fisher's exact test and binary logistic regression were also used. *P* value of less than 0.05 was taken as statistically significant. SPSS version 16 (Chicago, IL, USA) was used for the purpose of data analysis.

Results

This cross-sectional study was conducted from 9th June 2008 to 26th February 2009.

Characteristics of both study groups

The shipbuilders were comparable to the office staff in terms of age, duration of employment and smoking habit [Table 2].

Hearing loss

The prevalence of hearing loss detected by audiometry (undifferentiated as NIHL or other) was clearly greater (7.6% [21/276]) among shipbuilders compared with office staff (1 in 276), as seen in Table 3. All the 22 subjects found to have hearing impairment on audiometry gave positive history of diminished hearing.

NIHL

OR and its 95% CI were used to determine the presence and strength of association between variables. The audiograms of 6% (17/276) shipbuilders were found to conform to the audiometric diagnostic criteria for NIHL, while no office staff was detected to have this condition (OR = 37.29, 95% CI 22.42-62.18) [Table 4].

The remaining four shipbuilders had conductive type of hearing loss. Of these, one was a case of congenital deafness with Grade IV hearing loss while three had middle-ear disease (two with Grade I and one with Grade II hearing loss). The member of the office staff who had Grade I hearing loss of conductive type was a case of chronic suppurative otitis media. The association between NIHL and age, duration of employment and use of earplugs is statistically significant, as shown in Table 5.

Characteristics of NIHL cases

The mean age of shipbuilders with NIHL was 52.5 years,

with a standard deviation of 4.12 years, and they had been employed for an average of 30.4 years (standard deviation 4.89 years). Five of them were smokers, one was an ex-smoker and the rest were non-smokers; the OR for smoking and NIHL was 2.09 (95% CI 0.70-1.09). Of the 17 cases of NIHL, none were found to use earplugs regularly; 65% (11/17) reported using them "sometimes" and 35% (6/17) "never" used them, despite the earplugs being freely available at the workplace.

Non-compliance with earplugs and reasons

Of the 276 shipbuilders, 24% (66/276) were consistent earplug users, 66% (182/276) used them "sometimes" while the remaining 10% (28/276) were "never" users. When the 210 (76% [210/276]) inconsistent users (182 "sometimes" and 28 "never" users) were asked to state their principal reason, 50% (104/210) said that earplugs interfered with communication, jeopardising coordination in work and decreasing perception of warning signals. Discomfort was cited by 33% (69/210), while the rest said they perceived no need to use hearing protection as they did not feel that noise levels were high enough to warrant such use. However, binary logistic regression showed that the duration of employment was a stronger predictor of hearing loss among welders (OR = 1.162, 95% CI 1.063-1.271, $P = 0.001$) than earplug use (OR = 0.956, 95% CI 0.326-2.806, $P = 0.935$).

Table 1: Grading of hearing loss[19]

Grade of hearing impairment	Audiometry ISO value* (better ear)	Performance
0 No impairment	≤25 dB	No, or very slight, hearing problems. Able to hear whispers
1 Slight impairment	26-40 dB	Able to hear and repeat words spoken in normal voice at 1 m
2 Moderate impairment	41-60 dB	Able to hear and repeat words using raised voice at 1 m
3 Severe impairment	61-80 dB	Able to hear some words when shouted into better ear
4 Profound impairment including deafness	≥81 dB	Unable to hear and understand even a shouted voice

*International Organization for Standardization, average of 500, 1000, 2000, 4000 Hz

Table 2: Characteristics of shipbuilders and office staff with respect to relevant factors

Variables	Shipbuilders	Office staff
Age (completed years)		
Mean (SD)	43.2 (11.37)	42.2 (11.16)
Range	19-59	21-59
Duration of employment (completed years)		
Mean (SD)	19.9 (11.5)	19.1 (10.38)
Range	1-40	1-40
Smoking habit *n* (%)		
Smoker	48 (17)	37 (13)
Ex-smoker	16 (6)	10 (4)
Non-smoker	212 (77)	229 (83)
Age of smokers (completed years)		
Mean (SD)	45.5 (9.57)	43.2 (10.27)

Related factors

None of the subjects in either group had auditory problems before employment. While 34 shipbuilders and 19 office staff gave history of ototoxic drug intake, none of these reported diminished hearing or were found to have auditory morbidity on audiometry.

Thirty-three shipbuilders gave positive history of diminished hearing, of which 64% (21/33) were found to have hearing loss on audiometry while the remaining 12 had temporary threshold shift (which recovers in the 12-h mandatory period of quiet that is required before audiometric testing). The only member of the office staff who reported diminished hearing was found to have Grade I hearing loss on audiometry.

Three shipbuilders and four office staff gave history of middle-ear disease ever and, although none of them had active disease at the time of the study, the three shipbuilders were found to have hearing loss on audiometry (two Grade I and one Grade II). Eighteen shipbuilders admitted to have ever had welding sparks or hot metal fragments entering their ears, of which three had minor central perforations of the tympanic membrane, although none of them had hearing impairment on audiometry.

Discussion

The Directorate General of Factories Advisory Services and Labour Institutes, India, has recommended a maximum of 90 dB (A) as the permissible limit for 8 h continuous noise exposure.[6] A recent noise survey of this shipyard in

Table 3: Hearing loss in shipbuilders and office staff

Hearing loss	Shipbuilders		Office staff		Total	
	No.	%	No.	%	No.	%
Grade I	19	6.8	1	0.4	20	3.6
Grade II	1	0.4	0	0.0	1	0.2
Grade III	0	0.0	0	0.0	0	0.0
Grade IV	1	0.4	0	0.0	1	0.2
None	255	92.4	275	99.6	530	96.0
Total	276	100	276	100	552	100

Table 4: NIHL in shipbuilders and office staff

NIHL	Shipbuilders		Office staff		Total	
	No.	%	No.	%	No.	%
Present	17	6.2	0	0	17	3.1
Absent	259	93.8	276	100.0	535	96.9
Total	276	100	276	100	552	100

Table 5: Relation between NIHL and age, duration of employment and use of earplugs among shipbuilders (*n*=276)

Variables	Noise-induced hearing loss				Total		*P* value from Fisher's exact test	Rows taken in the Fisher's test to make a 2×2 table
	Present		Absent					
	No.	%	No.	%	No.	%		
Age								
19-30 years	0	0	69	26.6	69	25.0	0.001	19-40 years
31-40 years	0	0	22	8.5	22	8.0		41-60 years
41-50 years	4	23.5	91	35.1	95	34.4		
51-60 years	13	76.5	77	29.7	90	32.6		
Duration of employment								
1-10 years	0	0	82	31.7	82	29.7	0.001	1-20 years
11-20 years	0	0	31	12.0	31	11.2		21-40 years
21-30 years	10	58.8	104	40.2	114	41.3		
31-40 years	7	41.2	42	16.2	49	17.8		
Use of earplugs								
Always	0	0	66	25.5	66	23.9	0.015	Always
Sometimes	11	64.7	118	45.6	129	46.7		Any use less than always
Never	6	35.3	75	29.0	81	29.3		
Total	17	100	259	100	276	100		

Goa (unpublished data) revealed that there are some foci where noise levels exceed 90 dB (A) and that such levels are highly variable and are dependent on the type of shipbuilding activity that takes place at a given time in the yard.

The primary outcome of this study was to determine the burden of NIHL among shipbuilders as compared with office staff, the former being exposed to noise during the course of work and the latter not so exposed. This study found that shipbuilders had a greater prevalence of NIHL compared with the office staff of the same organisation by virtue of exposure to high levels of noise at the workplace. This was despite the fact that workplace regulations pertaining to noise control and use of protective equipment were in place. This implies that shipbuilding still puts workers at a higher risk of NIHL if compliance on the part of the workers is not thorough, as evidenced by the finding that all the subjects with NIHL were inconsistent in the use of earplugs. An alarming 76% (210/276) of the shipbuilders were inconsistent users of earplugs, 6% (12/210) of whom had already developed a temporary threshold shift, which is the precursor of NIHL.

Earlier cross-sectional studies of noise-exposed workforces have found hearing protection as the most feasible means of NIHL prevention, although plagued by a number of issues. Inconsistent use of hearing protection is an issue not limited to developing countries[3,21-24] where poor availability of such protection[23] compounds the problem, but is also observed in the developed world,[25-27] despite easy availability at the workplace.

In the current study, none of the consistent users of earplugs were found to have NIHL, while 6% (11/182) of the "sometimes" users and 21% (6/28) of the "never" users were found to have NIHL. The fact that "always" use of earplugs protects hearing, but using them "sometimes" is in practice similar to non-use,[3] explaining the prevalence of NIHL in such settings where any level of compliance less than complete is unlikely to confer protection from auditory effects of noise. The reasons for non-compliance uncovered by our study, which mainly include discomfort and interference in effective communication, are similar to those reported by other studies.[3,25] An additional reason for non-compliance is the component of temporary threshold shift; when workers get through the first few weeks of exposure, they often feel as though they have "got used" to the noise. But, what has most likely happened is that they have started to incur a temporary hearing loss, which impairs their hearing during the workday and usually subsides during the night, but which, upon repeated exposures, leads to NIHL.[9,25] This study however has found that the duration of employment is a stronger predictor of NIHLas compared with non-regular use of earplugs, suggesting that duration of employment should be a preferred criterion for screening for NIHL among these workers, irrespective of a worker's compliance to earplug use.

The current study found that the workers with NIHL were on an average over 50 years of age, and had been employed in the industry for over 30 years. The role of age and experience in the aetiology of NIHL is acknowledged to be ambiguous,[9] with some sources reporting that hearing deteriorates with age and NIHL occurs in addition to this,[3,7,10,11] and others believe that it is the "young and tender" ear of the younger worker that is more susceptible to effects of noise compared with the "trained and resilient" ear of the older employee.[10]

NIHL has been studied in relation to a number of factors, including ototoxic drugs, middle-ear disease and smoking habits. While the relationship between ototoxic drugs and NIHL is known to be synergistic,[9,28] middle-ear disease reduces the flow of energy to the cochlea and therefore diminishes the amount of NIHL produced by a given noise.[9] The relationship

of smoking andNIHL[7,29] is biologically plausible in view of the effects of nicotine on the vascular system; however, some authors do not concur to this.[9,28] This study did not find a statistically significant association between either of these factors and NIHL, which may be attributed to the relatively small number of cases of NIHL found in this study.

The strengths of this study lie in the sound scientific study question that seeks to study a relatively neglected condition, adequate sample size and detailed analysis. However, this study has been carried out within the constraints commonly observed among researchers from developing countries, such as non-availability of state-of-art technology, namely noise dosimeters for accurate measurement of ambient noise at the level of every individual worker. Despite the study being of a cross-sectional design (and thereby obviating possibilities to explore temporal relations between exposures and outcomes), the association of NIHL with occupation as a shipbuilder despite regular use of earplugs has clearly emerged.

The findings of this study have been of use in alerting the authorities to the still-prevalent problem of NIHL in Goa. The authors recommend similar studies, especially in developing countries, in settings involving significant noise exposure even if safety regulations are in place. An augmented worker-awareness and education program must be supplemented by providing them with an enabling environment that is only possible by enforcing stringent regulations rendered powerful by means of strong policy decisions in this direction.

References

1. Fuente A, Hickson L. Noise-induced hearing loss in Asia. Int J Audiol 2011;50:S3-10. Available from http://informalhealthcare.com/doi/full/10.3109/14992027.2010.540584. [Last accessed on 2012 Jul 20].
2. Azizi MH. Occupational Noise-induced hearing loss. Int J Occup Environ Med 2010;1:116-23.
3. Ahmed HO, Dennis JH, Badran O, Ismail M, Ballal SG, Ashoor A, *et al*. Occupational noise exposure and hearing loss of workers in two plants in eastern Saudi Arabia. Ann Occup Hyg 2001;45:371-80.
4. Raffle PA, Adams PH, Baxter PJ, Lee WR. Hunter's diseases of occupations. 8thed. London: Edward Arnold Publishers; 1994.
5. Prevention of Noise induced Hearing Loss, Report of an informal consultation. Geneva: World Health Organisation; 1997. Available from: http://www.who.int/entity/pbd/deafness/en/noise.pdf. [Last accessed on 2012 May 02].
6. Raidas RB, Waghe SS, Lanjewar PP. Occupational Health: Some basic considerations. Central Labour Institute. Ministry of Labour and Employment, Government of India; 2008.
7. Ferrite S, Santana V. Joint effects of smoking, noise exposure and age on hearing loss. Occup Med (Lond) 2005;55:48-53.
8. Noise-Induced Hearing Loss of Occupational Origin: A Guide for Medical Practitioners. 1st ed. Occupational Safety and Health Service, Department of Labour. New Zealand: Wellington; 1994. Available from: http://www.osh.dol.govt.nz/order/catalogue/pdf/nihl.pdf. [Last accessed on 2012 May 02].
9. Otolaryngology (Otology and neuro-otology). In: Paparella, Shumrick, Gluckman, Meyerhoff, editors. Volume 2. 3rd ed. Philadelphia: W. B. Saunders; 1991.
10. Rosenhall U. The influence of ageing on noise induced hearing loss. Noise Health 2003;5:47-53.
11. Rubak T, Kock SA, Koefoed-Nielsen B, Bonde JP, Kolstad HA. The risk of noise-induced hearing loss in the Danish workforce. Noise Health 2006;8:80-7. Available from: http://www.noiseandhealth.org/text.asp?2006/8/31/80/33538. [Last accessed on 2012 May 02].
12. Sindhusake D, Mitchell P, Smith W, Golding M, Newall P, Hartley D, *et al*. Validation of self-reported hearing loss: The Blue Mountains Hearing Study. Int J Epidemiol 2001;30:1371-8.
13. World Health Organisation. Guidelines for controlling and monitoring the tobacco epidemic. Geneva: WHO; 1998. p. 76-101.
14. Lyndon GS. Welding and thermal cutting. In: Encyclopaedia of Occupational Health and Safety. 3rded. Geneva: ILO; 1983. p. 2290-5.
15. Panosian MS, Dutcher PO Jr. Transtympanic facial nerve injury in welders. Occup Med (Lond) 1994;44:99-101.
16. Sjögren B. Effects of gases and particles in welding and soldering. In: Zens C, Dickerson O, Horvath E, editors. Occupational Medicine. 3rded. St Louis: Mosby Year Book Inc; 1994. p. 917-25.
17. Occupational Exposure to Noise: Evaluation, Prevention and Control: NIOSH Cooperative Agreement with WHO for 1994-1995. Available from: http://www.who.int/occupational_health/publications/noisebegin.pdf. [Last accessed on 2012 May 02].
18. Guidelines for detection of Noise Induced Hearing Loss. American College of Occupational and Environmental Medicine. 2002. Available from: http://www.acoem.org/guidelines.aspx?id=846. [Last accessed on 2012 May 02].
19. World Health Organization. Grades of hearing impairment. Available from: http://www.who.int/pbd/deafness/hearing_impairment_grades/en/index.html. [Last accessed on 2012 May 02].
20. Knapp RG, Miller MC. Clinical epidemiology and biostatistics. Williams and Wilkins; 1992. p. 240-1.
21. Maisarah SZ, Said H. The noise exposed factory workers: The prevalence of sensori-neural hearing loss and their use of personal hearing protection devices. Med J Malaysia 1993;48:280-5.
22. Minja BM, Moshi NH, Riwa P. Noise induced hearing loss among industrial workers in Dar es Salaam. East Afr Med J 2003;80:298-302.
23. Ologe FE, Akande TM, Olajide TG. Noise exposure, awareness, attitudes and use of hearing protection in a steel rolling mill in Nigeria. Occup Med (Lond) 2005;55:487-9.
24. Toppila E, Pyykko I, Starck J. The use of hearing protectors among forest, shipyard and paper mill workers in Finland–a longitudinal study. Noise Health 2005;7:3-9. Available from: http://www.noiseandhealth.org/text.asp?2005/7/26/3/31645. [Last accessed on 2012 May 02].
25. Leinster P, Baum J, Tong D, Whitehead C. Management and motivational factors in the control of noise induced hearing

loss (NIHL). Ann Occup Hyg 1994;38:649-62.

26. Reilly MJ, Rosenman KD, Kalinowski DJ. Occupational noise-induced hearing loss surveillance in Michigan. J Occup Environ Med 1998;40:667-74.
27. Palmer KT, Griffin MJ, Syddall HE, Davis A, Pannett B, Coggon D. Occupational exposure to noise and the attributable burden of hearing difficulties in Great Britain. Occup Environ Med 2002;59:634-9. Available from: http://ncbi.nlm.nih.gov/pmc/articles/PMC1740364/pdf/v059p00634.pdf. [Last accessed on 2012 May 02].
28. Touma JB. Controversies in noise-induced hearing loss (NIHL). Ann Occup Hyg 1992;36:199-209.
29. Topilla E, Pyykko I, Starck J, Kaksonen R, Ishizaki H. Individual risk factors in the development of noise-induced hearing loss. Noise Health 2000;2:59-70. Available from: http://www.noiseandhealth.org/text.asp?2000/2/8/59/31750. [Last accessed on 2012 May 02].

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