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Original Article

Time to Noise-Induced Hearing Loss among Different Type of Shift Work among Steel Workers: A Survival Study

Abolfazl Nikpour, *Mohammad Gholami Fesharaki

Department of Biostatistics, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran

***Corresponding Author:** Email: Mohammad.gholami@modares.ac.ir

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Abstract

Background: There have been few reports on relationships between Shift Work (SW) and time to Noise-Induced Hearing Loss (NIHL). This research explores the relation between SW and time to NIHL among male workers.

Methods: Between 1990 and 2015, this historical cohort study was conducted. Two different definitions events (Low Frequency Hearing (LFH) and High Frequency Hearing (HFH)) of NIHL An average pure-tone hearing threshold was thresholds at 1, 1.5 and 2 kHz for LFH(un-normal>20) and 4, 6 and 8 kHz for HFH (un-normal>20) for Air (AC) and Bone (BC) conduction, in both ears, respectively. In this study Kaplan–Meier and Multilevel Cox Model in addition R version 3.2.1 and MLWiN software used to analysis data. *P*-values less than 0.05 are considered to be statistically significant

Results: There were 6632 male workers in the research survey (mean age=35(±5)). Among these subjects, 2678 (40%),278 (4%) and 3676 (56%) were Day Workers (DW), Weekly Rotating Shift workers (WRS) and Routinely Rotating Shift workers (RRS), respectively. The result of this study showed more hazard risk of ear problem in LFH (Hazard=1.55 with 95% CI= (1.06-1.39)) and HFH (Hazard=1.08 with 95% CI= (1.04-1.13)) in RRS rather than day workers. In WRS group ear problem has been seen just in LFH (Hazard=1.55 with 95% CI= (1.2-2.0)).

Conclusion: The findings of the 15-year historical cohort study generally support a relationship between SW and time to NIHL. Therefore, more actions in the field of noise control, greater use of safety devices as well as increased staff training on the use of safety devices recommended for shift worker.

Keywords: Hearing loss; Noise-induced; Occupational; Shift work schedule

Introduction

Noise-induced hearing loss (NIHL) is a well-known health problem related to otolaryngology (1). Noise exposure may have adverse effects on the functioning of different parts of the body, such as cardiovascular (2, 3), circulation (4), processes, and performance (5).

Hearing loss due to exposure to noise in the workplace is a major health problem (6, 7). In fact the major cause of NIHL is noise pollution in the workplace (8-10). 1.3 billion people are suffering from hearing loss due to noise exposure (11).

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Occupational-induced hearing loss (ONIHL) is responsible for 16% of cases of disabling hearing loss in adults (11, 12). ONIHL does not directly cause premature mortality but results in a significant disability (13).
ONIHL risk ranges from one workplace to another. A steelmaking work is one of the high-risk occupations in the area of hearing problems (14, 15). Another hazardous condition impacting the ONIHL is shift work (16, 17). Shift work is refers to any work schedule that falls outside the hours of 7 am and 6 pm (18). Almost 20%-25% of the employed labor force in developed nations involves shift works (19). The previous study supported the effect of shift work on cardiovascular issues, immunological parameters, metabolic syndrome and diabetes, obesity and physical characters (20).
Despite numerous studies in field of ONIHL has been don but no specific study hasn't done for the investigating the relationship between working on shift work and Time to NIHL so this study aimed to explore the relation between SW and time to NIHL among male workers.

Materials and Methods

This historical cohort study was carried out on 6632 employees in Iran (Isfahan) subjected to audiometric tests between 1990 and 2015. The participants in this study selected using two stage stratified sampling. The samples were selected in each work area and sub work area. After explaining the aim of study, if the selected workers passed the inclusion criteria they interviewed and the audiometry test has been done for them.
The inclusion criteria in this study were official jobs during the study with at least two years of working experience and exclusion criteria were retirement death or dismissal (Fig. 1). After interring the participants were re-evaluated for audiometry test at one-year intervals.

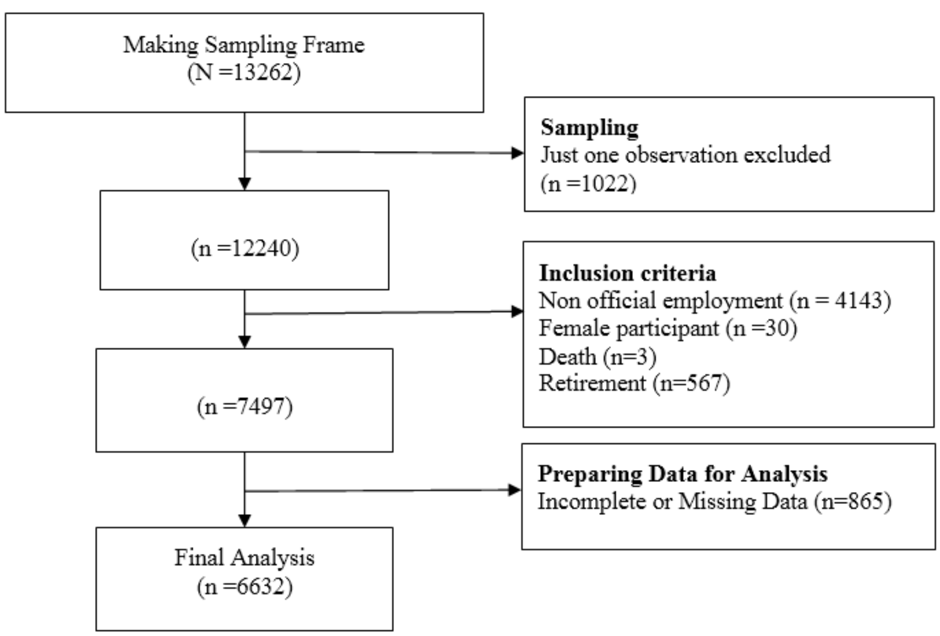

Fig. 1: Cohort Follow Diagram

In this research, the use of ALPS diagnostic audiometer (Model AD 229e, interacoustics Denmark Co. Ltd) was used by trained audiologist to calculate hearing thresholds at different frequencies of air conduction.

The test was conducted out in an enclosed acoustic room following the requirements of ANSI S3.1-1991, away from the workplace with at least 16 h pause from last exposure. Pure-tone hearing thresholds for Bone-Conduction (BC) and Air-Conduction (AC) are measured in both ears at 1k, 1.5 k, 2 k, 4 k, 6 k and 8 kHz.

In addition, two separate NIHL meanings have been established as the average binaural pure-tone (PTA). Hearing threshold for the following frequencies higher than 20 dB, 1-High Frequency Hearing (HFH) defined as (4 kHz + 6 kHz +8 kHz)/3) and 2-Low Frequency Hearing (LFH) defined as (1 kHz + 1.5 kHz +2 kHz)/3). Hearing loss was determined as hearing threshold level greater than 20 dB at LFH and HFH (CLFH= LFH>20 dB, CHFH= HFH>20 dB). Moreover, the time to CLFH and CHFH considered as response variables and shift schedule considered as independent variable.

In this report the schedule of shift time (RRS: Routine Rotating Shift workers, WRS: Weekly Rotating Shift workers, DW: Day workers) is presented in Gholami-Fesharaki et al study (21).

Tarbiat Modares University Medical School's Medical Ethics Committee approved the study (code number: IR.MODARES.REC.1397.223).

Statistical Analysis

Statistical analysis was carried out using the "survival" package in version 3.2.1 of the R software. Chi-square test was used to compare categorical variables and ANOVA and Kruskal Wallis Test were used to compare continuous variables. In addition, Kaplan–Meier (22) test was used to compare time to NIHL between shift and day worker. In this study for combining the survival function, Multilevel Cox Model (23) and MLWiN software version 2.1 has been used. *P*-values less than 0.05 are considered to be statistically significant.

Results

Overall, 6632 male workers were included in the study sample (mean age=35(±5)). Among these participants, 2678 (40%), 278 (4%) and 3676 (56%) were day workers, weekly rotating shift workers and routinely rotating shift workers, respectively. The study participants ' demographic information is presented in Table 1 according to the shift schedule.

Table 1: Demographic information of participants according to the shift schedule at first examination of study

Variable	*RRS n=3676*	*WRS n=278*	*DW n=2678*	*Total n=6632*
Continues	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Age (yr)*	34.66±5.74	33.40±5.77	34.16±5.67	35±5.34
Work Experience (yr)*	9.01±5.66	8.38±5.64	8.18±5.67	6.43±5.66
Categorical	n(%)	n(%)	n(%)	n(%)
Gender (Male)	3676(100%)	278(100%)	2678(100%)	6632(100%)
Smoker (Yes)*	734(20%)	34(12.2%)	323(12.1%)	1096(16.5%)
Education (Upper diploma)*	315(8.6%)	25(9.0%)	1314(49.1%)	1658(24.9%)

RRS: Routine Rotating Shift workers, WRS: Weekly Rotating Shift workers, DW: Day workers
*: all variables are significantly different in 3 groups

Since, mean age and mean work experience are somehow comparable among three groups but having higher education is common in DW, but being smoker is more prominent in shift workers.

The mean survival time for day worker in both ears and Audiometry test (AC and BC) is higher than shift workers. These differences are higher in CHFL rather than CLFH (Table 2).

Table 2: The mean survival time for ear problems during 15-years follow-up

Audiometry	*Ear*	*Low Frequency Hearing (LFH) (1 kHz +1.5 kHz +2 kHz)/3)>20*			*P-value*	*High Frequency Hearing (HFH) (4 kHz +6 kHz +8 kHz)/3>20*			*P-value*
		RRS	**WRS**	**DW**		**RRS**	**WRS**	**DW**	
Air-Conduction (AC)	Left	11.45 (11.37, 11.52)	11.24 (10.95, 11.54)	11.61 (11.54, 11.69)	0.002	6.49 (6.33, 6.64)	6.99 (6.42, 7.55)	7.19 (7.01, 7.38)	<0.001
	Right	11.43 (11.35, 11.50)	11.43 (11.18, 11.69)	11.62 (11.55, 11.70)	0.002	6.95 (6.80, 7.11)	7.28 (6.73, 7.83)	7.83 (7.65, 8.02)	<0.001
Bone-Conduction (BC)	Left	11.57 (11.50, 11.63)	11.49 (11.25, 11.74)	11.70 (11.63, 11.76)	0.023	7.74 (7.58, 7.89)	7.89 (7.35, 8.43)	8.31 (8.13, 8.49)	<0.001
	Right	11.60 (11.53, 11.65)	11.47 (11.23, 11.72)	11.70 (11.63, 11.76)	0.025	8.18 (8.03, 8.33)	8.33 (7.82, 8.84)	8.82 (8.65, 8.99)	<0.001

RRS: Routine Rotating Shift workers, WRS: Weekly Rotating Shift workers, DW: Day workers

In Table 3, the result of Multilevel Cox regression for the investigating the risk factor of working in shift work controlling for education, age, work experience, ear and technique has been presented. The result of this study showed more hazard risk of ear problem in LFH (Hazard=1.55 with 95% CI= (1.06-1.39)) and HFH (Hazard=1.08 with 95% CI= (1.04-1.13)) in RRS rather than day workers. In WRS group ear problem has been seen just in LFH (Hazard=1.55 with 95% CI= (1.2-2.0)). In addition, the survival function of ear problems (LFH & HFL) according to the different type of shift work has been presented in Fig. 2.

Table 3: The result of Multilevel Cox regression for the investigating the risk factor of working in shift work controlling for education, age, work experience, ear and technique

Variable	*LFH*		*HFH*	
	Hazard 95% CI	P-value	Hazard 95% CI	*P*-value
RRS|DW	1.21 (1.06-1.39)	0.006	1.08 (1.04-1.13)	<0.001
WRS|DW	1.55 (1.2-2)	0.001	1.07 (0.97-1.17)	0.161
Education (year)	0.88 (0.81-0.95)	0.001	0.89 (0.87-0.91)	<0.001
Age (year)	1.05 (1.03-1.07)	<0.001	1.07 (1.07-1.08)	<0.001
Work experience	1.03 (1.01-1.04)	0.001	1.01 (1-1.01)	<0.001
Ear (Left | Right)	1.02 (0.91-1.14)	0.742	1.17 (1.13-1.22)	<0.001
Technique (AC|BC)	1.3 (1.16-1.46)	<0.001	1.43 (1.38-1.49)	<0.001

RRS: Routine Rotating Shift workers, WRS: Weekly Rotating Shift workers, DW: Day workers

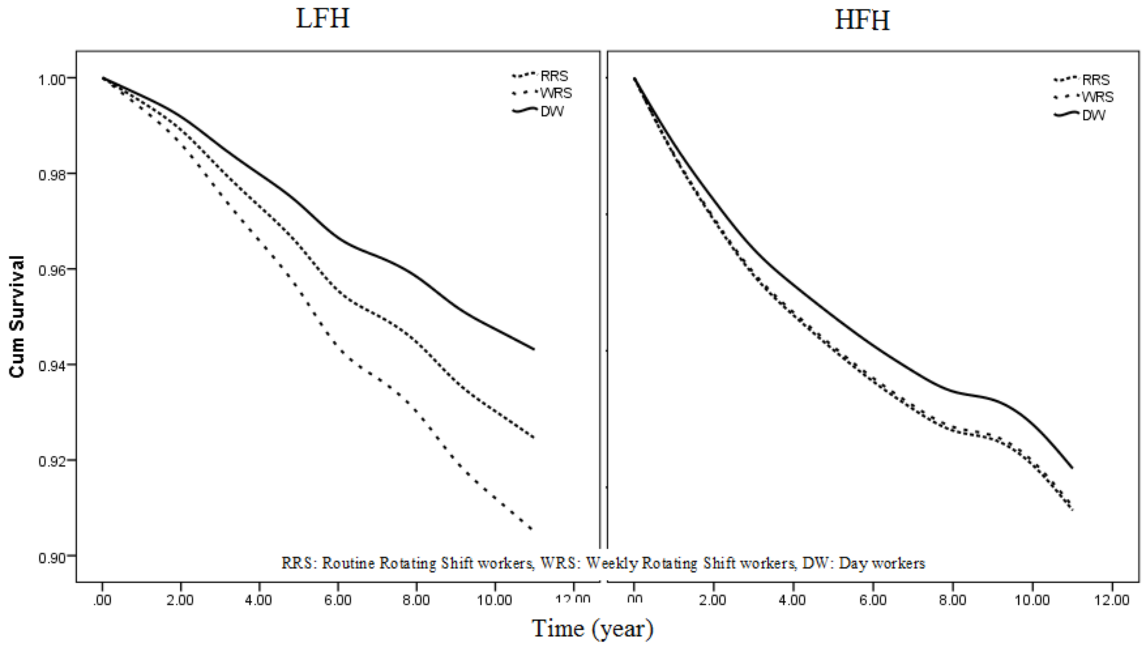

Fig. 2: The survival function of ear problems (LFH & HFL) according to the different type of shift work

Discussion

The result of this historical cohort study showed that more hazard risk of ear problem in LFH and HFH in RRS rather than day workers. In WRS group ear problem has been seen just in LFH. In addition hearing problems on shift worker was more likely than day workers during the 10 years of follow-up, indicating that shift workers develop hearing problems in a shorter period of time than day shifts. The mean survival time for day worker in both ears and Audiometry test (AC and BC) is higher than shift workers. These differences are higher in CHFL rather than CLFH. Moreover, shifting work, particularly in the RRS group is a lower time for the NIHL problem rather than a daily worker. More findings showed that the WRS (worked the 12-h work schedule) suffered a lower time to NIHL problem rather than RRS (eight-hour shift) group. Chou et al. (8) study supported the above findings. Such results can be due to the use of Hearing Protection Devices (HPDs) in a different type of shift work (15, 16). The proportion of smokers among these three groups is the reason for such a relationship Smoking played an additive role in hearing loss among staff in close contact with prolonged exposure to noise (24, 25). Smoking can speed up NIHL (26, 27). The another justification reported steady period would potentially explain observation of hearing cell death that (8), in turn speeds up the ear cell death process for a period of up to 14 days (28-30).

The strengths points of this research were the use of a powerful type of study (historical cohort study), appropriate sample size, homogeneity of the study population and use of comlex statistical modeling (Multilevel Cox regression).

Some of the limitations of the research were the non-evaluation of the NIHL family and disability history to determine past job interactions, sleep, income and stress as potential confounding factors and in addition inability to track participants from 2015 to 2020.

Conclusion

The findings of the 15-year historical cohort study generally support a relationship between SW and time to NIHL. Therefore, more actions in the field of noise control, greater use of safety devices as well as increased staff training on the use of safety devices recommended for shift worker.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

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