Tinnitus in Noise Exposed Workers

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Abstract

Background: Tinnitus in noise exposed workers is worse, which seriously affects the normal life and work. Workers with tinnitus often complain that even going to see the doctor is ineffective. They think tinnitus is caused by occupational noise exposure, which makes tinnitus worse. To find the truth the investigation and analysis of tinnitus including reason, treatment and effect and hearing level was proceeded among all noise-exposed workers in railway transportation mechanical manufacturers in Beijing in 2015.

Methods: Cross-section study was conducted. 519 noise-exposed workers were selected as exposed group, 515 non noise-exposed workers were selected as control group. Self-designed questionnaire was used in the way of face-to-face to get subjects' information including social statistical data, occupational history, past history and living habits.

Results: The incidence of tinnitus was 36.6% among noise-exposed workers, which was significantly higher than that in the control group ($\chi^2 = 40.725$, $P < 0.05$). Meanwhile the incidence of seeing the doctor was 15.8%. The incidence of tinnitus was significantly different in different subgroups of exposed group ($\chi^2 = 6.072$, $P < 0.05$). There was no significant difference between using earphones and tinnitus ($P > 0.05$). In the exposed group the incidence of hearing abnormal in workers with tinnitus was significantly higher than those without tinnitus ($\chi^2 = 18.570$, $P < 0.05$).

Conclusions: Right knowledge, attitude and practice (KAP) would be helpful for workers with tinnitus. Occupational health education and supervision of noise-exposed workers should be further strengthened in this industry. Personal protection should be enhanced so as to improve occupational health.

Background

Tinnitus is a kind of symptom not disease. Tinnitus refers to the long-term or short-term sound in the ear or brain without corresponding external sound source or electrical stimulation. Tinnitus is subjective feeling and others can't hear [1]. Short term tinnitus has little influence on work and life, which can cause short-term distraction. Long-term tinnitus has serious influence such as hearing abnormal, inattention, sleep disorder, upset, restlessness and resulting in a lot of mental pain, affecting normal life and working state, forming a vicious circle [2–4]. So we can understand how painful they are. All may suffer from tinnitus, especially noise-exposed workers [5]. When we carried on occupational health surveillance, a lot of noise exposed workers complained tinnitus disturbed their rests and lives seriously. The workers always told you disappointedly that it did not work even they went to see the doctor. They thought tinnitus was caused by noise-exposure which could made it worse. It seemed that they lost faith in our job—occupational health surveillance. Is that true? What is the reason of tinnitus? How about treatment and effect for tinnitus? Could tinnitus result in hearing abnormal? Do workers misunderstand the tinnitus? Actually tinnitus cause is complex [6]. Machinery manufacturing industry is typical of noise operation, with a large number of noise-exposed workers, a large number of post setting categories, high

intensity noise, steady-state noise. To find out the answer the investigation and analysis of tinnitus was proceeded among all noise-exposed workers in railway transportation mechanical manufacturers in Beijing in 2015.

Methods

Materials:

All noise-exposed workers were selected as the exposed group, non noise-exposed workers were selected as the control group in a machinery manufacturing industry in 2015. One exposed to occupational noise once should be excluded from control group. Exclusion criteria of subjects contained hereditary deafness, conductive deafness, ototoxic deafness, non-noise induced hearing loss (non-NIHL) in speech frequency, history of head injury, chronic middle ear disease, perforated tympanic membrane, previous ear surgery and congenital or acquired ear malformation, etc. Finally 519 workers were recruited in exposed group and 515 were in control group. There were 442 men and 77 women in the exposed group. The age was 19-58 years, the average age was (37.82 ± 10.27) years; the working age was 1-38 years, the average working age was (15.53 ± 10.18) years in the exposed group. There were 448 men and 67 women in the control group. The age was 16-60 years, the average age was (28.64 ± 10.62) years; the working age was 1-40 years, the average working age was (19.22 ± 9.35) years in the control group.

Job exposed to noise means A-weighted equivalent sound level is equal to or greater than 80 dB at workplace in 8 hours per day or 40 hours per week [7]. Hearing abnormal means an adjusted hearing threshold exceeding 25 dB HL in 0.5, 1.0 or 2.0 kHz, which due to noise-exposure [8].

Investigation methods:

Questionnaire

Questionnaire was designed by ourselves including social statistical information, occupational history, past history, individual factor such as smoking, drinking and earphone using, etc [9].

Investigation

Investigation was carried on by trained qualified specialists, in the way of face-to-face.

Statistical methods and analysis:

Cross-section study was conducted. Epidata 3.0 was used to set up database. Statistical analysis software was SPSS 21.0. Dependent variable was presence or absence of tinnitus. Independent variables were factors which may influence tinnitus. An unconditional logistic regression analysis was applied to screen risk factors, where the variables were selected by backward procedure. Elimination level $\alpha=0.10$ and significance level $\alpha=0.05$. Chi square test was chosen to analyze tinnitus character such as causes, diagnosis and treatment, recovery and impact on hearing and significance level $\alpha=0.05$.

Pure tone audiometry (PTA) :

The sound level of the acoustic cabin was routinely measured and found to be always lower than criteria GB/T16403-1996 Acoustics—Audiometric test methods—Basic pure tone air and bone conduction threshold audiometry, which is equivalent to ISO 8253-1. All the subjects' hearing measurements were conducted in the frequencies 0.5,1,2,3,4 and 6 kilohertz (kHz) for both ears. Subjects were tested at least 48h after the last exposure to noise in the previous work shift and leisure noise in order to avoid temporary threshold shift (TTS). Hearing thresholds were adjusted by age and sex in accordance with criterion GB/7582-2004/ISO7029:2000 Acoustics-Statistical distribution of hearing thresholds as function of age.

Results

- 13 factors were selected which may influence tinnitus and classified by quantity. Detail in table 1 and table 2. From table 1 some factors were statistically significant in one-way logistic regression which were age, working age, middle ear diseases, smoking age (year), family history of deafness and sudden deafness. Risk factors were introduced into multi-logistic regression and screened gradually as independent variable. Presence or absence of tinnitus was introduced into multi-logistic regression as dependent variable. Detail of analytical factors and assignments was in table 2. Result of unconditional multi-logistic regression of tinnitus was in table 3. Age of first exposure to noise and age were dummy variables. Based on likelihood ratio test, the multi-logistic regression mode was statistically significant ($\chi^2=9.368$, $P<0.05$). Using stepwise selection, age of first exposure to noise, middle ear diseases and age were entered into multi-logistic regression mode. The regression equation was $\text{Logit}(P)=-2.327+1.501 \text{ age of first exposure to noise}(1)+0.089 \text{ age of first exposure to noise}(2)-0.001 \text{ age of first exposure to noise}(3)+1.002 \text{ middle ear diseases}+1.648 \text{ age}(1)+1.020 \text{ age}(2)+0.622 \text{ age}(3)$.

- The prevalence of tinnitus in exposed group is higher than control group. There is statistically significant difference ($\chi^2=40.727$, $P < 0.05$).

- The prevalence of tinnitus among different wearing earplug groups are different. Table 4.

There is statistically significant difference in general ($\chi^2=6.072$, $P < 0.05$). The prevalence of tinnitus in not wearing earplug group is 41.7% which is higher than the other two groups. Multiple comparisons show that there is statistically significant difference between not always wearing group and not wearing group, but there is not statistically significant difference between always wearing group and not always group, always wearing group and not wearing group.

The prevalence of tinnitus would increase with equivalent sound level. Table 4. There is statistically significant difference on the whole. Multiple comparisons show statistically significant difference between every two groups ($\chi^2_{\text{trend}}=30.491$, $P<0.05$).

The prevalence of tinnitus between two using earphone groups are different without statistically significant difference ($\chi^2=2.406$, $P>0.05$). Table 4.

- The prevalence of treatment are both low in two groups. It is 15.8% in exposed group, which is higher than 7.2% in control group. There is statistically significant difference ($\chi^2=4.203$, $P<0.05$).

Effect of treatment is different without statistically significant difference between exposed group and control group. Prevalence of non-improvement are both high in two groups ($\chi^2=4.761$, $P>0.05$).

- In exposed group hearing abnormal prevalence of workers with tinnitus is higher than without tinnitus. There is statistically significant difference ($\chi^2=18.570$, $P<0.05$). Table 5.

Table 1
Regression Result of One-way Logistic

Variable	P	OR	OR95%CI
age	0.000	0.948	0.931 ~ 0.966
working age	0.000	0.951	0.933 ~ 0.968
middle ear diseases	0.001	2.330	1.382 ~ 3.927
smoking age(year)	0.003	0.964	0.941 ~ 0.988
family history of deafness	0.028	1.628	1.054 ~ 2.514
sudden deafness	0.037	2.991	1.069 ~ 8.364
ototoxic drugs	0.059	1.524	0.984 ~ 2.362
earphone	0.121	0.743	0.509 ~ 1.082
history of explosion	0.153	1.486	0.863 ~ 2.558
knowledge of noise hazard	0.186	1.545	0.810 ~ 2.944
equal sound level	0.327	0.991	0.974 ~ 1.099
history of infectious diseases	0.328	0.813	0.536 ~ 1.232
earplug	0.353	1.098	0.901 ~ 1.338
drinking	0.628	1.098	0.753 ~ 1.601
educational level	0.706	1.047	0.825 ~ 1.328
age of first exposure to noise	0.754	0.996	0.972 ~ 1.021
sex	0.961	1.012	0.612 ~ 1.674

Table 2
Factors and Assignment

Variable	Factors	Assignment
X1	age	number
X2	working age	number
X3	age of first exposure to noise	number
X4	equal sound level	number
X5	middle ear diseases	positive = 1,negative = 0
X6	family history of deafness	positive = 1,negative = 0
X7	sudden deafness	positive = 1,negative = 0
X8	ototoxic drugs	positive = 1,negative = 0
X9	earphone	often = 2,not often = 1negative = 0
X10	history of explosion	positive = 1,negative = 0
X11	history of infectious diseases	positive = 1,negative = 0
X12	earplug	always = 2,not always = 1negative = 0
X13	smoking age(year)	number
Y	tinnitus	positive = 1,negative = 0

Table 3
Unconditional Multi-logistic Regression of Tinnitus

Factors	B	S.E	Wals	P	Exp(B)	Exp(B) (95%CI)
subvirable of age of first exposure to noise			5.621	0.132		
age of first exposure to noise ^a	1.501	0.639	5.523	0.019	4.485	1.283 ~ 15.679
age of first exposure to noise ^b	0.089	0.414	0.047	0.829	1.093	0.486 ~ 2.459
age of first exposure to noise ^c	-0.001	0.331	0.000	0.998	0.999	0.522 ~ 1.911
middle ear diseases	1.002	0.358	7.807	0.005	2.723	1.349 ~ 5.497
subvirable of age			16.722	0.001		
age ^d	1.648	0.428	14.860	0.000	5.199	2.249 ~ 12.020
age ^e	1.020	0.426	5.745	0.017	2.774	1.204 ~ 6.390
age ^f	0.622	0.378	2.710	0.100	1.863	0.888 ~ 3.909
constant	-2.327	0.760	9.368	0.002	0.098	
notes:						
Subvariable of age of first exposure to noise:						
^a ≤20 years old; 20 years old < ^b ≤30 years old; 30 years old < ^c ≤40 years old;						
reference group > 40 years old.						
Subvariable of age: 50 years old ≤ ^d <60 years old;40 years old ≤ ^e <50 years old;						
30 years old ≤ ^f <40 years old; reference group < 30 years old.						

Table 4
Tinnitus in Exposed Group with Different Characteristic

Characteristic	Tinnitus	Non-tinnitus	Total
Earplug			
Subgroup of always wearing earplug	119(36.2)	210(63.8)	329
Subgroup of not always wearing earplug	8(20.5)	31(79.5)	39
Subgroup of not wearing earplug	63(41.7)	88(58.3)	151
Equivalent Sound Level in 8h[dB(A)]			
≤85	125(34.7)	235(65.3)	360
85~90	4(8.3)	44(91.7)	48
90~95	7(63.6)	4(36.4)	11
≥ 95	54(54.0)	46(46.0)	100
Using Earphone			
yes	61(32.3)	128(67.7)	189
no	129(39.1)	201(60.9)	330
notes: number in parenthesis is percentage(%)			
Hypothesis-testing for earplug: $\chi^2 = 6.072, P \leq 0.05$			
Hypothesis-testing for equivalent sound level in 8h[dB(A)]: $\chi^2_{\text{trend}} = 30.491, P \leq 0.05$			
Multiple comparison showed statistically significant difference between every two groups.			
Hypothesis-testing for Using earphone: $\chi^2 = 2.406, P \leq 0.05$			

Table 5
Tinnitus and Hearing Abnormal in Exposed Group

Group	Hearing abnormal	Non-hearing abnormal	Missing	Total
Tinnitus	129(67.9)	31(16.3)	30	190
Non-tinnitus	164(49.8)	106(32.2)	59	329
Total	293	137	89	519
notes: number in parenthesis is percentage(%)				

Discussion

Though age of first exposure to noise, middle ear diseases and age were entered into multi-logistic regression mode, as we all know tinnitus reasons are so complicated. Common causes of tinnitus include long-term exposure to noisy environment; diseases of the auditory system, such as middle ear disease, otosclerosis, Meniere's disease, etc.; systemic diseases, such as hypertension, endocrine disorders, virus infection, high pressure, etc. [6] Noise-exposed workers suffered from tinnitus often so the investigation and analysis was carried out in this cross-section study.

- Tinnitus and earplug: Noise-exposure is a common reason of tinnitus. For noise-exposed workers, without earplug was major cause of tinnitus. Based on table 4 prevalence of tinnitus among different wearing earplug subgroups were different. There was statistically significant difference in general ($P < 0.05$). The prevalence of tinnitus in the group without earplug was 41.7%, which was higher than the other two groups. But multiple comparison results were not expectations ($P \geq 0.05$). It was confused that there was not statistically significant difference between always wearing group and not always group, always wearing group and not wearing group. It seemed it was contrary with expectation. True information of wearing earplug or not was thought to be the key point.

- Tinnitus and equivalent sound level: Though equivalent sound level wasn't entered into multi-logistic regression mode, prevalence of tinnitus would increase with equivalent sound level. Noise of the mechanical manufacturers is steady. Equivalent sound level in 8 hours of 85% job positions was below 85 dB (A) or beyond 95 dB (A). The prevalence of tinnitus were 34.7% and 54.0% respectively, which meant personal protect device (PPD) should always be used, even double devices could be necessary in high-dose job position. Employer should strictly take charge of supervision and restrict noise-exposed time.

- Workers always complained that it did not work since they had gone to see the doctor for the tinnitus. Is that true that noise make tinnitus worse? Based on our findings, I am afraid it is not. First of all, prevalence of treatment were both low in two groups. It was 15.8% in exposed group and 7.2% in control group. Ironically prevalence of caring for ear were both high in two groups. It was 83.7% in exposed group and 91.1% in control group. It was contradictory between attitude and practice. Why? Answer appeared after investigation. Workers thought tinnitus would disappear or improve after treatment. Misunderstanding of treatment was the answer of contradiction and negative practice. Nowadays masking and retraining therapy are common for tinnitus [10-12]. Masking therapy is covering tinnitus with outside sound to relieve suffering. Retraining therapy is teaching patients to get used to tinnitus. Two therapies are neither disappearance nor improvement. So what they need is right KAP (knowledge, attitude and practice). Measurements followed would be helpful, mental counseling, ear care, correcting bad habits such as smoking, drinking a lot, unhealthy diet, staying late often and using earphone a lot, etc.

- As we all know using earphone a lot does harm to hearing level. Based on our findings it

seemed there was no correlation between tinnitus and using earphone $P=0.05$. Earphone type, using time and volume are influence factors. Short time, low volume seldom do harm to ears. Headphone is a better choice than insert phone.

- Tinnitus and hearing abnormal. Tinnitus may lead to hearing abnormal, meanwhile hearing abnormal may lead to tinnitus. It is a bad circle. Some researchers think tinnitus is some kind of physiological reaction just like pain, which is protective for ear. So the noise-exposed workers whose mean hearing threshold is over 40 dB HL in high frequencies with tinnitus should be transferred according to our national standard (GBZ 49-2007 Diagnostic criteria of occupational noise-induced deafness) [13].

Conclusions

The screened risk factors of tinnitus were age, middle ear diseases and age of first exposure to noise. Noise-exposure without earplug was major reason for tinnitus. Prevalence of tinnitus would increase with equivalent sound level. PPD is important for workers, double devices could be necessary. Noise was one reason of tinnitus. But it was wrong to think that noise made tinnitus worse. It was workers' misunderstanding that made situation worse. Tinnitus could lead to hearing abnormal, meanwhile hearing abnormal could result in tinnitus. It was a bad circle. Right KAP would be helpful for patients with tinnitus.

In conclusion, occupational health education, supervision and management should be strengthened for noise-exposed workers. And personal protection devices should always be used by workers during noise-exposure. Both are helpful to reduce or avoid tinnitus. The workers with tinnitus should be correctly guided to help them suppress negative emotions, actively treat, correct bad habits and improve their health.

Abbreviations

KAP: knowledge, attitude, practice; NIHL: noise induced hearing loss; non-NIHL: hearing loss in speech frequency which was not induced by occupational noise-exposure; PTA: pure tone audimetry; TTS: temporary threshold shift; PPD: personal protect device

Declarations

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Author Contributions

Lu Bai, Jianping Yu, Hong Du, Zhuang Shen, Hongyan Yang conceived of this study, acquired data. Lu Bai drafted the paper. Lu Bai and Jianping Yu approves this version of the manuscript and agrees to be accountable for all aspects of the work. All authors have read and approved the manuscript.

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Availability of data and materials

The data sets used and / or analyzed in the current study come from our daily work. It is one of our daily work to carry out regular occupational health surveillance for workers exposed to occupational hazards. According to these data, we carry out occupational health education for workers and promote their occupational health.

Ethics approval and consent to participate

Ethical review on the project was conducted by Beijing Preventive Medicine Research Center Ethics Board. This research study was considered as WITHOUT RISK, since it did not anticipate any intervention or modification of any physiological, psychological or social variable. So a letter of approval for the project was issued, classifying as risk-free.

Before the project investigation, explain the purpose, significance, implementation method to all workers. And promise to protect personal privacy. After knowing the details of the project, workers agree to participate in the investigation, and sign the informed consent form.

Consent for publication

Not applicable.

Competing Interests

None declared.

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