

HEARING LOSS IN RELATION TO OCCUPATIONAL NOISE LEVELS AMONG WORKERS IN A POLYESTER FIBER FACTORY IN THAILAND

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ABSTRACT:

Background: Excessive occupational noise is a problem in all regions around the world, and is associated with many work activities, including manufacturing. In Thailand, synthetic fiber production is one business which has high noise level in the workplace. So this study was a cross-sectional study conducted in a Polyester Fiber factory in Pathumthani province during May-June 2015. The purposes of this study were to find the prevalence of hearing loss and risk factors associated with hearing loss in 119 polyester fiber workers. The study areas were the cutting, spinning, and drawing processes which average 8 hours of noise exposure per day. In some areas noise level was more than 85 dB(A).

Methods: Associations between dependent and independent variables were assessed with bivariate analysis and multiple logistic regression models.

Results: The prevalence of hearing loss was 7.6%. There were 3 main analytical findings, as follows: 1. There was no significant association of any hearing loss with either of the measured noise levels ($p > 0.05$); 2. In all analyses, risk of hearing loss was significantly higher in subjects who did not always use ear plugs than in those who always used them; 3. Independent variables were more strongly associated with hearing loss in the right ear than with hearing loss in the left ear or hearing loss in either ear.

Conclusion: Although prevalence of hearing loss in this study was low, to reduce the burden of hearing loss in the future, hearing conservation programs, and safety and health education for industrial workers, would be desirable.

Keywords: Hearing loss, Occupational health, Polyester fiber factory, Thailand

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INTRODUCTION

Occupational noise is noise in the workplace associated with many work activities, such as working with impact processes, handling materials, or flying commercial jets and manufacturing [1]. High level of occupational noise is a pervasive hazard with many adverse effects to human such as hearing loss [2]. Excessive occupational noise is a problem in all regions of the world. In 1992 Statistical Abstracts of the United States of America accounting production workers, revealed that there are approximately 30 million American workers have occupational noise exposure [3]. In United Kingdom, there was an evidence estimated that more than 2 million people are regularly exposed to

high noise levels over 85 decibel-A and have severe difficulties in hearing attributable to noise in the workplace [4]. Hearing loss affects more than 250 million people worldwide. In 2002, World Health Organization (WHO) estimated hearing loss is the 13th most frequent burden of disease in medium and high income countries, and will become among the top ten burden of disease by the year 2030 [5].

In Thailand, hearing loss is one of the important occupational diseases which undergo surveillance by Bureau of the Occupational & Environmental Disease monitoring. In 2003, there are 1,839 companies that have high noise level workplace. The worker who exposed to high noise level and have a risk of noise-induced hearing loss are estimated at 116,462 persons. Most of them were found in central region [6]. The analysis of injury or occupational disease from Social Security Office,

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Ministry of Labor during 2008-2012 reported that there are 146,781 cases approximately affected by injury or occupational disease each year. The top 5 provinces which most workers exposed to injury or occupational disease are Bangkok, Samutprakarn, Chonburi, Samutsakorn, and Pathumthani Provinces [7].

Regarding to Ministerial Regulations, no.9, Ministry of Industry B.E. 2535 (1992) and Notification no. 5/2535, Ministry of Public Health B.E. 2535 (1992) identified synthetic fiber factory (including polyester fiber factory) [8] is a high noise level business. So this study was conducted in a polyester fiber factory in Pathumthani province which noise level in many workplaces more than 85 dB(A) and workers must work during working hour in the area as a routine work. Study results might prove useful to consider for occupational health improvement of these workers in the future.

MATERIAL AND METHOD

Study design

This study was conducted in a polyester fiber factory in Pathumthani province in Thailand. The study areas are high noise level area more than 85 dB(A) total 5 areas which workers must work during working hour total 119 persons. These areas are cutter, spinning, and drawing section.

Workplace noise level monitoring

Workplace noise level was monitored by third party (registered company to Department of Industrial Work, Ministry of Industry) 1 time per year as Ministry of Labor's regulation, Thailand B.E. 2549 (2006). Workplace noise level was monitored by sound level meter (Model 2127, ACO, Japan) on A-weighting during 8 working hours at the height same as human ear level (1.5 meter from floor).

Audiometry test

Audiometry test was performed by licensed audiologist from the hospital, to follow Ministry of Labor's regulation, Thailand B.E. 2547 (2003). Audiometry test measured the threshold of hearing each ear, by a pure-tone air conduction at frequencies 500, 1000, 2000, 3000, 4000, and 6000 Hz respectively. Then interpretation of the data was conducted; If an average hearing threshold level in either ear that equals or exceeds 25 decibel at 500, 1000, 2000, 3000 Hz and equals or exceeds 45 decibel at 4000, 6000 Hz, the data were interpreted to indicate hearing loss [8].

Questionnaire

This study collected the data by using a

standardized interview questionnaire. The questionnaire follows the Guidelines of Hearing Loss Monitoring from Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, 2004. Before collecting the data, the questionnaire was reviewed by three experts to verify validity (index of consistency: IOC) and revised for appropriate. Then a pilot study was conducted to verify reliability with 30 workers in a Polyester Fibers factory in Ayutthaya province. The draft had administered to these workers. The reliability value of Cronbach's alpha coefficient of the questionnaire was 0.785

The questionnaire consisted of 3 parts; Part I : Socio-demographic characteristics and working history, Part II : Personal health and risk behavior, and Part III : Hearing protective device uses.

Data management

Workplace noise monitoring result and audiometry test were considered at secondary data of the factory for 1 year. Noise measurements were made in April 2014. Audiometry was done in September 2014.

The questionnaire was administered to the participants by the researcher and 2 research assistants (interviewers) who are public health officers by face-to-face interviews during weekdays in May-June 2015.

Data analysis

Descriptive statistics was used to measure both independent variables: workplace noise level, socio-demographic characteristic and risk behavior, and dependent variable: hearing loss. Therefore present by central tendency (mean, median), frequency, min-max, and percentages.

Bivariate analysis (Fisher's exact test) and multiple logistic regressions analysis were used to evaluate the relationship and for estimating the association of independent variables with dependent variables.

Statistical analysis of this study was performed by using SPSS 16.0 (University licensed). All the statistical analyses will be based on a statistical significance level equal to 0.05 or less.

The research instrument is reviewed by Ethical Review Committee, Chulalongkorn University to ensure that the questionnaire excludes the sensitive issues which is ethically incorrect.

RESULTS

Workplace noise level was monitored at high noise level area total 5 areas located in cutter, spinning, and drawing section. The results in 2014 present that average 8 hours of noise level all areas was between 67.8-92.0 dB(A). The maximum noise

Table 1 Workplace noise level characteristics in year 2014

Area	Average 8 hr [dB(A)]	Max [dB(A)]
Polymerization: Cutter section	67.8	86.0
Filament yarn: Spinning section	90.9	101.1
Filament yarn: Drawing section	92.0	99.6
Industrial yarn: Drawing section	83.1	99.5
Staple fiber: Spinning section	88.2	105.8
Standard	90.0	140.0

Table 2 Frequency distribution of workplace noise level, socio-demographic and association with hearing loss (HL), bivariate analysis

Characteristics	n (%)	Either ear		Left ear		Right ear	
		HL (%)	P-value	HL (%)	P-value	HL (%)	P-value
Section			0.621		0.705		0.863
Polymerization:cutter	13 (10.9)	1 (7.7)		1 (7.7)		1 (7.7)	
Filament yarn:spinning	21 (17.6)	3 (14.3)		2 (9.5)		2 (9.5)	
Filament yarn:drawing	59 (49.6)	3 (5.1)		3 (5.1)		3 (5.1)	
Industrial yarn:drawing	14 (11.8)	1 (7.1)		0		1 (7.1)	
Staple fiber:spinning	12 (10.1)	1 (8.3)		1 (8.3)		1 (8.3)	
Sex			0.185		0.240		0.137
Male	53 (44.5)	6 (11.3)		5 (9.4)		6 (11.3)	
Female	66 (55.5)	3 (4.5)		2 (3.0)		2 (3.0)	
Age (years)			0.034*		0.093		0.047*
20-29	9 (7.6)	1 (11.1)		1 (11.1)		0	
30-39	39 (32.8)	0		0		0	
40-49	55 (46.2)	5 (9.1)		4 (7.3)		5 (9.1)	
50-59	16 (13.4)	3 (18.8)		2 (12.5)		3 (18.7)	
Education			0.741		0.646		0.697
Primary school	4 (3.4)	0		0		0	
High school/Vocational certificate	103 (86.6)	8 (7.8)		6 (5.8)		7 (6.8)	
Diploma/ High vocational certificate	6 (5.0)	1 (16.7)		1 (16.7)		1 (16.7)	
Bachelor's degree/ higher	6 (5.0)	0		0		0	
Income			1.000		1.000		1.000
Less than 10,000 Baht	1 (0.8)	0		0		0	
10,000 Baht/higher	118 (99.2)	9 (7.6)		7 (5.9)		8 (6.8)	
Working duration (years)			0.588		0.507		0.323
1-5	18 (15.1)	1 (5.6)		1 (5.6)		0	
6-10	14 (11.8)	0		0		0	
11-20	37 (31.1)	2 (5.4)		1 (2.7)		2 (5.4)	
≥ 20	50 (42.0)	6 (12.0)		5 (10.0)		6 (12.0)	
Working hour per day (hours)			0.037*		0.015*		0.067
6-7	64 (53.8)	8 (12.5)		7 (10.9)		7 (10.9)	
≥ 8	55 (46.2)	1 (1.8)		0		1 (1.8)	
Working history			0.559		0.468		0.516
Yes	10 (8.4)	1 (10.0)		1 (10.0)		7 (6.4)	
No	109 (91.6)	8 (7.3)		6 (5.5)		1 (10.0)	

Remark HL = Hearing loss
Statistically significant *P-value* < 0.05

level was between 86.0-105.8 dB(A). These result is shown in Table 1.

About 119 workers were included in the study. There 53 males (44.5%) and 66 females (55.5%). Most age of workers are in a range 40-49 years (55 persons, 46.2%). Mean of age is 40.6 ($\pm$ 7.59), minimum age is 24, and maximum age is 55 years

old. Most workers graduated from high school or vocational certificate 103 persons (86.6%). Almost workers 118 persons (99.2%) get an income more than 10,000 Baht per month. 50 persons (42.0%) have working experience more than 20 years. Mean of working experience is 17.9 ($\pm$ 9.73), minimum working experience = 1, maximum working

Table 3 Frequency distribution of personal behavior and association with hearing loss, bivariate analysis

Characteristics	n (%)	Either ear		Left ear		Right ear	
		HL (%)	P-value	HL (%)	P-value	HL (%)	P-value
Listen to a song by headphones			0.740		0.479		1.000
Every day	4 (3.4)	0		0		0	
Every week	6 (5.0)	0		0		0	
Less than 1 time per week	24 (20.2)	3 (12.5)		3 (12.5)		2 (8.3)	
Never	85 (71.4)	6 (97.1)		4 (4.7)		6 (7.1)	
Go to discotheque, pub, karaoke			0.712		0.652		0.681
Every week	1 (0.8)	0		0		0	
Every month	1 (0.8)	0		0		0	
Less than 1 time per month	21 (17.6)	2 (9.5)		2 (9.5)		2 (9.5)	
Never	96 (80.7)	7 (7.3)		5 (5.2)		6 (6.2)	
HPDs uses			-		-		-
Yes	119 (100.0)	7 (5.9)	-	7 (5.9)		8 (6.7)	
No	0	0		0		0	
Type of HPDs			0.601		0.594		0.594
Ear plug : foam	104 (87.4)	9 (8.7)		7 (6.7)		8 (7.7)	
Ear plug : silicone	15 (12.6)	0		0		0	
Ear muff	0	0		0		0	
Frequency to use HPDs			0.001 *		0.001 *		< 0.001 *
Use every times during work	89 (74.8)	2 (2.2)		1 (1.1)		1 (1.1)	
Use sometimes during work	30 (25.2)	7 (23.3)		6 (20.0)		7 (23.3)	
Never use	0	0		0		0	

Remark HL = Hearing loss, HPDs = Hearing protective device
Statistically significant *P-value* < 0.05

experience = 37 years. Most workers 64 persons (53.8%) usually work around 6-7 hours per day, and workers 109 persons (91.6%) have no working experience in the past. The result of hearing test in either ear or both ears shows that prevalence of hearing loss is 7.6% (9 from 119 persons). There was no significant association between workplace noise level each section and hearing loss in either ear, left ear, and right ear (*P-value* > 0.05) but there was significant negative association between working hour per day and hearing loss (*P-value* < 0.05). Age was also positively and significantly associated with hearing loss in either ear, right ear (*P-value* < 0.05) as shown in Table 2.

Regarding personal behavior, the result from questionnaires show that most of workers 85 persons (71.4%) have never listened to a song by headphones and workers 96 persons (80.7%) have never go to discotheque, pub, or karaoke. All workers 119 persons (100.0%) used hearing protective devices (HPDs) and most of HPDs are ear plug-foam. Most workers 89 persons (74.8%) use HPDs every time during work. Association of personal behavior and hearing loss in either ear, left ear and right ear shows that frequency to uses hearing protective devices (HPDs) is significantly associated with hearing loss (*P-value* < 0.05) as shown in Table 3.

In multiple logistic regression models, there

was a significant association between hearing loss either ear, left ear, right ear and workers who use HPDs sometimes, more than who use HPDs every time during work (*P-value* < 0.05). Adjusted risk of hearing loss in the right ear was significantly lower in females than males than males (*P-value* < 0.05) as shown in Table 4 and 5.

DISCUSSION

In the present study, there was no association of measured noise level with hearing loss. The prevalence of hearing loss was low, only 7.6%. This may have limited the statistical power to detect an association of hearing loss with noise level (as well as with other independent variables). Also, measured noise levels were not especially high; perhaps they were too low to exhibit associations with hearing loss as measured in this study. Furthermore, the noise measurements used in analysis were area measurements made over only one day; they may not have been representative of subjects' personal noise exposures.

However the results of noise level average 8 hours in some areas were higher than the standard of Ministry of Industry B.E. 2546 (2003) and Ministry of Labor B.E. 2549 (2006) which limit noise average 8 hours shall not exceed 90 dB(A) and also higher than the standard of Ministry of Labor B.E. 2553 (2010) which specified to conduct the hearing

Table 4 Multiple logistic regression relating to hearing loss with average noise level

Characteristics	Either ear			Left ear			Right ear		
	Adj. OR	95% CI	P-value	Adj. OR	95% CI	P-value	Adj. OR	95% CI	P-value
Noise average level 8 hr. 2014 dB(A)	1.013	0.907-1.131	0.822	1.011	0.890-1.148	0.868	1.014	0.880-1.169	0.843
Female vs. male	0.244	0.039-1.533	0.132	0.186	0.022-1.599	0.125	0.059	0.005-0.685	0.024 *
Age (years)	1.942	0.504-7.488	0.335	1.194	0.275-5.177	0.813	4.839	0.682-34.326	0.115
Working duration (years)	1.044	0.357-3.048	0.937	1.262	0.355-4.482	0.719	1.770	0.415-7.541	0.440
Working hours (hr. per day)	0.219	0.024-2.012	0.179	0.000	0.000	0.997	0.243	0.020-2.903	0.264
Use HPDs sometimes vs. always	8.709	1.528-49.631	0.015 *	16.454	1.610-168.201	0.018 *	19.668	1.793-215.792	0.015 *
Remark	Statistically significant <i>P-value</i> < 0.05								

Table 5 Multiple logistic regression relating to hearing loss with maximum noise level

Characteristics	Either ear			Left ear			Right ear		
	Adj. OR	95% CI	P-value	Adj. OR	95% CI	P-value	Adj. OR	95% CI	P-value
Noise max level 2014 dB(A)	1.028	0.877-1.205	0.736	0.997	0.837-1.187	0.970	1.058	0.849-1.317	0.617
Female vs. male	0.254	0.045-1.430	0.120	0.198	0.025-1.545	0.122	0.058	0.006-0.615	0.018 *
Age (years)	2.017	0.510-7.980	0.318	1.167	0.254-5.364	0.843	5.203	0.707-38.272	0.105
Working duration (years)	1.015	0.339-3.040	0.979	1.291	0.348-4.788	0.702	1.714	0.396-7.413	0.471
Working hours (hr. per day)	0.226	0.024-2.110	0.192	0.000	0.000	0.997	0.268	0.022-3.216	0.299
Use HPDs sometimes vs. always	9.217	1.608-52.834	0.013 *	16.885	1.675-170.173	0.016 *	22.281	1.935-256.603	0.013 *
Remark	Statistically significant <i>P-value</i> < 0.05								

conservation program if noise level in the workplace is higher than 85 dB(A). These high noise levels could affect to hearing of workers to be more hearing loss in the future. As the study in 1997 from Department of Occupational Health reported about hearing loss and accident of workers in textile factories total 853 persons, which noise level and working duration was significantly associated with hearing loss [8].

Regarding to the different of criteria for hearing loss consideration, different studies have detected different prevalences of hearing loss. In Thailand, prevalence of hearing loss was found in the workplace which have high level noise from 4.6%-83% [8]. In this study, the prevalence of hearing loss was low - 7.6% (9 from 119 persons) by using the criteria to identify hearing loss as the guideline of Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand – after hearing test, if an average hearing threshold level in either ears that equals or exceeds 25 decibel at 500, 1000, 2000, 3000 Hz and equals or exceeds 45 decibel at 4000, 6000 Hz, it means hearing loss. Although some workers was not found to be hearing loss, but they have risk and might have the hearing loss in the future.

The study also found use of ear plugs less than all the time was consistently associated with increased risk of hearing loss. Further research is required to ascertain the reasons for this observation.

When observed at the association between hearing loss either ear, left ear, and right ear with sex. The study found that hearing loss is significantly associate with female in the right ear ($P\text{-value}>0.05$) more than male. Normally hearing loss occurs in both ears (bilateral) more than one ear (unilateral). However it depends on sensitivity of each ear and each person (genetic factor). Same as the study in 1986 of boat driver total 92 persons, the results presented that the driver exposed to hearing loss 76 persons (83%). It also found that all drivers suffered from hearing loss in right ear more than left ear [9]. And another studied in 1991 in a pellets factory in Chonburi province, the study found that prevalence of hearing loss of workers was 52.30%. Most workers exposed to hearing loss both ears and left ear affected from hearing loss more than right ear [10].

Although most workers used hearing protective devices (HPDs) every times during work (74.8%) but after analyzed the association between hearing loss either ear, left ear, and right ear with frequency to uses hearing protective devices (HPDs), the results show that uses of HPDs sometimes is significantly associate with hearing loss ($P\text{-value}<0.05$) more

than uses of HPDs every times. When observe the actual operation of the workers in the workplace, the workers sometimes did not wear HPDs during work. That might be causes from the HPDs is not comfortable for using, HPDs is not enough, or the workers did not have the enough knowledge for using HPDs.

CONCLUSION

There were 3 major findings in the current study, as follows; 1. There was no significantly association of any hearing loss with either of the measured noise levels ($p > 0.617$); 2. In all analyses, risk of hearing loss was significantly higher in subjects who did not always use ear plugs than in those who always used them; 3. Independent variables were more strongly associated with hearing loss in the right ear than with hearing loss in the left ear or hearing loss in either ear. Further research is required to explain the observed associations.

LIMITATION AND RECOMMENDATION

According to this study is cross sectional study which was conducted in a time period, so the workers who transferred to other sections or retired were excluded in the study. These workers might have risk or tend to have hearing loss in the future. The monitoring of hearing loss situation in these workers should be continued.

This study was performed within specific industry company as polyester fiber factory, there is no the past research which study in the same type of factory. So this study could be the new survey and will be useful for further researches to study. However the result from this study could not compare with other same type of factories.

Although this study only found the prevalence of hearing loss 7.6%, all the workers especially who work in high noise level area more than 85 dB(A) still need to conduct audiometry test at least 1 time per year and compare the result with baseline audiogram.

In the researcher's opinion, the present findings do not yet support specific recommendations for factory owners or policy makers. However to protect the workers from get hearing loss in the future, improved hearing conservation programs, safety and health education for industrial workers, and HPDs uses enforcement would be desirable.

This study may give an idea for further researches to gain more knowledge of public health. For health personnel, this finding will be useful to give advice to workers in order to encourage the

workers to find the way to protect themselves from occupational hearing loss.

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