Comparison of audiogram images and distortions of otoacoustic emissions products (DPOAE) on hearing functions of workers exposed to noise at textile factory

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Abstract. A cross-sectional study was done to determine the audiograms and distortion product otoacoustic emissions (DPOAE) in textile factory workers exposed to noise. The prevalence of hearing loss due to noise exposure determined by pure tone audiometry was 73% (66 of 90 subjects), whereas DPOAE was found in 47.8% (43 subjects). Based on logistic regression analysis, male sex was the most influential factor in the process of hearing impairment. On the basis of $\kappa_R$, audiometric and DPOAE examination at 4000 and 6000 Hz frequencies showed significant correlation and weak suitability.

1. Introduction

Noise-induced hearing loss (NIHL) is an industrial problem. Many studies have been conducted to determine the mechanism of NIHL, ranging from standard equipment that can measure the amount of noise exposure to a program of NIHL prevention. NIHL is a sensorineural hearing loss due to exposure to loud noise (>85 dB) for 8 hours of a day, 40 hours a week. The process occurs over a long interval and is usually caused by noise in the work environment [1,2]. According to Robinowitz, [3] NIHL is a high-frequency sensorineural hearing deficit that occurs slowly due to the chronic exposure to high-intensity sound. Fernandez [4] defines NIHL as a sensorineural hearing loss that is progressive and bilateral, with increased hearing threshold occurring at a frequency of 3000–6000 Hz, and high and low frequency hearing loss at up to 75 and 40 dB, respectively.

A textile factory is an industry that produces noise. Based on cooperation between the Department of Otolaryngology, Faculty of Medicine, Universitas Indonesia and management of the PT X Banten textile factory, a program of intensity measurement of noise exposure, pure tone audiometry, and distortion product otoacoustic emissions (DPOAE) evaluation was conducted to assess hearing function of the workers. This study observed the images and suitability between audiograms and DPOAE at 3000, 4000, and 6000 Hz frequencies because most auditory function impairment occurs at those frequencies.

Hearing loss caused by noise exposure may increase temporary (THT) or persistent (PHT) hearing thresholds. A temporary increase occurs because of short-term exposure and requires a recovery process that is approximately equal to the exposure time. If THT persists for long periods, permanent hearing loss will occur without recovery. Noise exposure also affects physiologic and psychologic
functions [2,4,5] Hearing impairment due to noise occurs in 40 million Americans or one-third of all cases of hearing loss due to noise exposure, and the numbers increase each year [6,7].

2. Materials and Methods
A comparative cross-sectional study was done in which independent and dependent variables were collected at the same time to determine the audiogram and DPOAE images of PT X Banten factory workers exposed to noise (noise level >85 dB). The study protocol had been approved by the Health Research Ethics Committee, Faculty of Medicine Universitas Indonesia-Cipto Mangunkusumo Hospital. This research site was selected on the basis of information from the company and measurements using a Mini Sound Level Meter Digitech QM 1589 showing that the factory had a high noise level. The study was conducted in May 2013 until the number of research subjects was met. Secondary data were obtained on the basis of cooperation for the auditory function examination program between the Department of Otolaryngology, Faculty of Medicine, Universitas Indonesia and PT X Banten management.

Inclusion criteria were factory workers who worked in a noise-exposed environment of 85 dB for 8 h per day; age 22–50 years; minimum 5 year work history; no history of chronic otitis media suppurativa, ear surgery, or circumstances related to hearing impairment; and availability of medical record data.

Exclusion criteria were subjects with a known conduction disturbance on tympanometry examination, who were undergoing treatment with ototoxic drugs.

Medical record data were collected from three production units (30 subjects from each, for a total of 90 subjects). Noise exposure was measured using the Mini Digitech Level Sound Meter device (Digitech QM 1589) at the three production units (weaving units, 86 dB; incorporation, 91 dB; spinning, 96 dB).

This study determined the prevalence of hearing loss based on audiogram and DPOAE values to determine the factors affecting hearing function due to noise and whether audiogram and DPOAE images were suitable to evaluate textile factory workers exposed to noise and fit with the research criteria at the PT X Banten factory.

3. Results
Secondary sampling data (90 subjects) were collected between May 4–5 and May 11–12, 2013, at the textile factory. Most subjects (60.0%) were male, and most (72.2%) were 22–40 years old (Table 1). The duration of work varied and was divided into two groups (5–10 and >10 years), with most (58.9%) working 5–10 years (mean, 10.34 ± 4.94 years).

The intensity of the noise source in the work unit was divided into three categories (low, medium, and high), with each work unit including 33.3% of the subjects. Most subjects (91.9%) did not use ear protection. Audiograms revealed normal noise thresholds in 26.7% (average threshold level, 70%) and abnormal thresholds in 73.7% (average, 30%) of the subjects. DPOAE results were “pass” in 52.2% and “refer” in 47.8%.

Table 2 shows a sample demographic based on work unit group (noise source intensity low, medium, and high). Most subjects (22) in the medium-intensity work unit were males, whereas most (16) in the high-intensity work unit were females. Overall, most subjects were 22–40 years old (24 each in the medium-and high-intensity work units), and most had high school or equivalent education (22 each in the low- and medium-intensity work units). A χ² test showed no significant results between sex, age, and education, and work unit groups.

Table 2 also shows the relationship between sample characteristics and occupational factors with duration of work and use of ear protection based on work unit groups. Most subjects worked for 5–10 years (18 each in the low- and high-intensity work units). Only four subjects in the high-intensity work unit habitually wore ear protection. The P value for all occupational factors was not
Table 1. Subject Characteristics.

| Characteristics                  | n  | %   | Mean ± SD |
|----------------------------------|----|-----|-----------|
| **Sex**                          |    |     |           |
| Male                             | 54 | 60.0|           |
| Female                           | 36 | 40.0|           |
| **Age**                          |    |     | 36.63 ± 6.5|
| 22–40 years                      | 65 | 72.2|           |
| 41–50 years                      | 25 | 27.8|           |
| **Education**                    |    |     |           |
| Elementary school                | 4  | 4.4 |           |
| Junior high school               | 26 | 28.9|           |
| Senior high school               | 57 | 63.3|           |
| University                       | 3  | 3.3 |           |
| **Working Period**               |    |     | 10.34 ± 4.94|
| 5–10 years                       | 53 | 58.9|           |
| > 10 years                       | 37 | 41.1|           |
| **Sources of Noise Intensity**   |    |     |           |
| Rendah (>85–90 dB)               | 30 | 33.3|           |
| Sedang (91–95 dB)                | 30 | 33.3|           |
| Tinggi (96–100 dB)               | 30 | 33.3|           |
| **Use of Ear Protection**        |    |     |           |
| Use                              | 3  | 8.9 |           |
| Not use                          | 87 | 91.9|           |
| **Audiogram Images on Noise Exposure (3,4,6 kHz)** |    |     |           |
| Normal                           | 24 | 26.7|           |
| Abnormal                         | 66 | 73.7|           |
| **Level of Hearing Threshold Images** |    |     |           |
| Normal                           | 63 | 70.0|           |
| Abnormal                         | 27 | 30.0|           |
| **DPOAE**                        |    |     |           |
| Pass                             | 47 | 52.2|           |
| Refer                            | 43 | 47.8|           |

significant ($\chi^2$ test). Five subjects in the high-intensity work group had ear ringing complaints after working. Seven subjects in the moderate-intensity work unit experienced fullness in the ear. In the low-intensity work unit, 19 subjects did not have a post-working hearing impairment. Nonaudiometric disorders in the form of fatigue were mostly experienced by nine subjects from the medium-intensity work unit, whereas 20 in the high-intensity work unit did not feel the complaints. There were no statistically significant differences in ringing ear disorders, post-work hearing complaints, and other complaints between the work unit groups ($P \geq 0.05$).

In Table 3, audiometry revealed that 83.3% of the 90 subjects had the highest (3000 Hz) and 44.4% had the lowest (6000 Hz) normal thresholds. The highest (6000 Hz) and lowest (3000 Hz) abnormal thresholds were noted in 55.6% and 16.7% of subjects, respectively. Among DPOAE results with a “pass” finding, the highest and lowest prevalences were found at frequencies of 3000 (92.2%) and 4000 (71.1%) Hz, respectively, whereas the highest and lowest prevalences among the referrals were found at 4000 (28.9%) and 3000 (7.8%) Hz, respectively.
### Table 2. Distribution of Characteristics based on Work Unit Groups.

| Characteristics               | Work Unit Groups |  |  |  | p value |
|-------------------------------|------------------|---|---|---|---------|
|                               | Low (85–90 dB)   | Moderate (91–95 dB) | High (96–100 dB) |         |
| **Sex**                      |                  |                |                |     0.105** |
| Male                         | 18               | 22             | 14             |         |
| Female                       | 12               | 8              | 16             |         |
| **Age Groups**               |                  |                |                | 0.072** |
| 22–40 years                  | 17               | 24             | 24             |         |
| 41–50 years                  | 13               | 6              | 6              |         |
| **Education**                |                  |                |                | 0.165** |
| Elementary/junior high       | 8                | 8              | 14             |         |
| SMA/PT                       | 22               | 22             | 16             |         |
| **Working Period**           |                  |                |                | 0.955** |
| 5–10 years                   | 18               | 17             | 18             |         |
| >10 years                    | 12               | 13             | 12             |         |
| **Use of Ear Protection**    |                  |                |                | 0.340** |
| Yes                          | 1                | 3              | 4              |         |
| No                           | 29               | 27             | 26             |         |
| **Ringing Complain**         |                  |                |                | 0.383** |
| Yes                          | 2                | 5              | 5              |         |
| No                           | 28               | 25             | 25             |         |
| **Post-Working Complain**    |                  |                |                | 0.489** |
| Hard to hear *)              | 3                | 4              | 4              |         |
| Ear fullness *)              | 6                | 7              | 4              |         |
| Loud noise *)                | 0                | 2              | 3              |         |
| Other complaint *)           | 2                | 1              | 2              |         |
| No ada                       | 19               | 16             | 17             |         |
| **Other Complain**           |                  |                |                | 0.171** |
| Hard to concentrate *)       | 3                | 0              | 3              |         |
| Emotional *)                 | 6                | 8              | 6              |         |
| Easily tired *)              | 6                | 9              | 0              |         |
| Others *)                    | 0                | 0              | 1              |         |
| No complaint                 | 15               | 13             | 20             |         |

Note: * joined with statistical analysis, ** χ² test

The highest and lowest prevalences of subjects with a <40 dB threshold were 98.8% at 3000 Hz and 78.9% at 6000 Hz, respectively, compared with 21.1% at 6000 Hz and 1.1% at 3000 Hz, respectively, for subjects with a >40 dB threshold (Table 4). Highest and lowest prevalences of subjects with a DPOAE “pass” result were 92.2% at 3000 Hz and 41.1% at 4000 Hz, respectively, compared with 28.9% at 4000 Hz and 7.8% at 3000 Hz, respectively, for those with “refer” results.
Table 3. Distribution of Audiometric and DPOAE Results.

| Frequency 3000 Hz AD | Audiogram | DPOAE |
|---------------------|-----------|-------|
| Normal              | 75 83.3   | Pass 83 92.2 |
| Abnormal            | 15 16.7   | Refer 7 7.8  |
| Frequency 3000 Hz AS| Normal 74 82.2 | Pass 81 90.0 |
| Abnormal            | 16 17.8   | Refer 9 10.0 |
| Frequency 4000 Hz AD| Normal 63 70.0 | Pass 64 71.1 |
| Abnormal            | 27 30.0   | Refer 26 28.9 |
| Frequency 4000 Hz AS| Normal 65 72.2 | Pass 65 72.2 |
| Abnormal            | 25 27.8   | Refer 25 27.8 |
| Frequency 6000 Hz AD| Normal 56 62.2 | Pass 75 83.3 |
| Abnormal            | 34 37.8   | Refer 15 16.7 |
| Frequency 6000 Hz AS| Normal 40 44.4 | Pass 73 81 |
| Abnormal            | 50 55.6   | Refer 17 18.9 |

Note: AD (right ear), AS (left ear)

Table 4. Distribution of Audiometric and DPOAE Results.

| Frequency 3000 Hz AD | Audiogram | DPOAE |
|---------------------|-----------|-------|
| ≤40 dB              | 89 98.8   | Pass 83 92.2 |
| >40 dB              | 1 1.1     | Refer 7 7.8  |
| Frequency 3000 Hz AS| ≤40 dB 86 95.6 | Pass 81 90.0 |
| >40 dB              | 4 4.4     | Refer 9 10.0 |
| Frequency 4000 Hz AD| ≤40 dB 84 93.3 | Pass 64 71.1 |
| >40 dB              | 6 6.7     | Refer 26 28.9 |
| Frequency 4000 Hz AS| ≤40 dB 82 91.1 | Pass 65 72.2 |
| >40 dB              | 8 9.8     | Refer 25 27.8 |
| Frequency 6000 Hz AD| ≤40 dB 76 84.4 | Pass 75 83.3 |
| >40 dB              | 14 15.6   | Refer 15 16.7 |
| Frequency 6000 Hz AS| ≤40 dB 71 78.9 | Pass 73 81 |
| >40 dB              | 19 21.1   | Refer 17 18.9 |

Note: AD (right ear), AS (left ear)
After bivariate analysis, no significant correlations were noted between age >40 years and abnormalities ($P = 0.092$; odds ratio [OR], 3.5; Table 5). There was no significant relationship between male sex ($P = 0.058$; OR = 2.8) and abnormal threshold. However, $P = 2.80$ indicated a 2.80 times greater risk of an abnormal threshold in males rather than females.

There was no significant relationship between duration of work >10 years and abnormal threshold ($P = 0.103$; OR, 2.657). In the high-intensity work unit vs low intensity, there was no significant relationship with occurrence of abnormal threshold ($P = 0.096$; OR, 2.66). There was no significant relationship between use of ear protection and abnormalities ($P = 0.435$; OR, 1.743).

Table 5. Distribution of the Subjects by Risk Factor for Abnormal Threshold at 3000, 4000, and 6000 Hz ($n = 90$).

| Risk Factor                        | Abnormal Threshold | p     | OR   | 95% CI       |
|------------------------------------|--------------------|-------|------|--------------|
|                                    | Yes | No |       |     | Low | High |
| Age Groups                         |     |     |       |     |     |      |
| >40 years                          | 22  | 3  | 0.092** | 3.5 | 0.941 | 13.017 |
| 22-40 years                        | 44  | 21 |      |     |     |      |
| Sex                                |     |     |       |     |     |      |
| Male                               | 44  | 10 | 0.058** | 2.8 | 1.073 | 7.308 |
| Female                             | 22  | 14 |      |     |     |      |
| Working Periods                    |     |     |       |     |     |      |
| >10 years                          | 31  | 6  | 0.103* | 2.657 | 0.937 | 7.538 |
| 5–10 years                         | 35  | 18 |      |     |     |      |
| Intensity                          |     |     |       |     |     |      |
| High                               | 24  | 6  | 0.096** | 2.66 | 0.480 | 8.463 |
| Moderate                           | 18  | 12 |      |     |     |      |
| Low                                | 24  | 6  |      |     |     |      |
| Use of Ear Protection (*)          |     |     |       |     |     |      |
| No                                 | 61  | 21 | 0.435* | 0.383 | 7.928 |
| Yes                                | 5   | 3  |      |     |     |      |

95% CI, 95% confidence interval.

Furthermore, multivariate analysis was done using logistic regression with existence of abnormal threshold as the dependent variable and independent variables chosen as those with $P < 0.250$ (age, sex, working periods, and intensity of noise source) (See Table 6).

Table 6. Initial Multivariate Analysis.

| Variable                        | p     | OR   | CI (95%)       |
|---------------------------------|-------|------|---------------|
| Age >40 years                   | 0.276 | 2.22 | 0.529–9.317   |
| Male                            | **0.057** | 3.12 | 0.965–10.091  |
| Working periods >10 years       | 0.475 | 1.556 | 0.463–5.23    |
| High-intensity                  | **0.034** | 4.143 | 1.114–15.404  |
Table 7. Final Multivariate Analysis.

| Variable       | p     | OR    | CI (95%)     |
|----------------|-------|-------|--------------|
| Male           | 0.010 | 4.206 | 1.411–12.536 |
| High-intensity | 0.025 | 4.467 | 1.211–16.473 |

The final multivariate analysis results are shown in Table 7. Two independent variables significantly related to the occurrence of an abnormal threshold were male sex and the high-intensity work unit. The magnitude of the strength of a clean relationship (OR adjusted) in males with high-intensity exposure was 4.206 and 4.467. The order of magnitude of the independent variable factor power most influential with occurrence of abnormal thresholds in the sample is male sex followed by high-intensity work unit.

Table 8. Suitability of Audiometric Result and DPOAE 3000 Hz (n = 90).

| DPOAE AS | Audiometric AD | DPOAE AS | Audiometric AS |
|----------|---------------|----------|---------------|
|          | Normal        | Abnormal | Total         |
|          | Normal        | Abnormal | Total         |
| Pass     | 70            | 13       | 83            |
| Refer    | 5             | 2        | 7             |
| Total    | 75            | 15       | 90            |
| 65       | 16            | 81       |
| 9        | 0             | 9        |

$P = 0.096$ (McNemar), $\kappa R = 0.09$ $P = 0.379$. $P = 0.230$ (McNemar) $\kappa R = -0.15$. $P = 0.141$.

Table 9. Suitability of Audiometric Result and DPOAE 4000 Hz (n = 90).

| DPOAE AD | Audiometric AD | DPOAE AS | Audiometric AS |
|----------|---------------|----------|---------------|
|          | Normal        | Abnormal | Total         |
|          | Normal        | Abnormal | Total         |
| Pass     | 51            | 13       | 64            |
| Refer    | 12            | 14       | 26            |
| Total    | 63            | 27       | 90            |
| 51       | 14            | 65       |
| 14       | 11            | 25       |

$P = 1.000$ (McNemar) $\kappa R = 0.33$. $P = 0.002$. $P = 1.000$ (McNemar) $\kappa R = 0.23$. $P = 0.033$. 

Table 10. Suitability of Audiometric Result and DPOAE 6000 Hz (n = 90).

| DPOAE AD | Audiometric AD | DPOAE AS | Audiometric AS |
|----------|---------------|----------|---------------|
|          | Normal        | Abnormal | Total         |
|          | Normal        | Abnormal | Total         |
| Pass     | 53            | 22       | 75            |
| Refer    | 3             | 12       | 15            |
| Total    | 56            | 34       | 90            |
| 39       | 34            | 73       |
| 1        | 16            | 17       |

$P = 0.000$ (McNemar) $\kappa R = 0.34$. $P = 0.000$. $P = 0.000$ (McNemar) $\kappa R = 0.27$. $P = 0.000$.

In Tables 8–10, $\kappa R < 0.4$ indicates a weak suitability. Assessment of probability results shows that the $\alpha$ value is smaller than $P < 0.05$, meaning the $\kappa R$ actually shows a significant relationship between the audiometric and DPOAE examinations to assess the abnormal threshold.

Table 11, 12 and 13 show suitability of audiometric result and DPOAE at 3000 Hz, 4000 Hz and 6000 Hz respectively.
Table 11. Suitability of Audiometric Result and DPOAE 3000 Hz (n = 90).

| DPOAE AS | Audiometric AD | | | | |
|----------|----------------|-----------------|-----------------|-----------------|
|          | ≤40 dB | >40 dB | N | Total |          | ≤40 dB | >40 dB | Total |
| Pass | 82 | 1 | 83 | | 77 | 4 | 81 | |
| Refer | 7 | 0 | 7 | | 9 | 0 | 9 | |
| Total | 89 | 1 | 90 | | 74 | 16 | 90 | |

\(P = 0.070 \) (Mc Nemar) \(κ R = -0.020\), \(P = 0.770\). \(P = 0.230 \) (Mc Nemar) \(κ R = -0.066\), \(P = 0.495\).

Table 12. Suitability of Audiometric Result and DPOAE 4000 Hz (n = 90).

| DPOAE AD | Audiometric AD | | | | |
|----------|----------------|-----------------|-----------------|-----------------|
|          | ≤40 dB | >40 dB | Total | | ≤40 dB | >40 dB | Total |
| Pass | 63 | 1 | 64 | | 63 | 2 | 65 | |
| Refer | 21 | 5 | 26 | | 19 | 6 | 25 | |
| Total | 84 | 6 | 90 | | 82 | 8 | 90 | |

\(P = 1.000 \) (Mc Nemar) \(κ R = 0.229\), \(P = 0.002\). \(P = 1.000 \) (Mc Nemar) \(κ R = 0.265\), \(P = 0.002\).

Table 13. Suitability of Audiometric Results and DPOAE 6000 Hz (n = 90).

| DPOAE AD | Audiometric AD | | | | |
|----------|----------------|-----------------|-----------------|-----------------|
|          | ≤40 dB | >40 dB | Total | | ≤40 dB | >40 dB | Total |
| Pass | 71 | 4 | 75 | | 64 | 9 | 73 | |
| Refer | 5 | 10 | 15 | | 7 | 10 | 17 | |
| Total | 76 | 14 | 90 | | 71 | 19 | 90 | |

\(P = 0.000 \) (Mc Nemar) \(κ R = 0.630\), \(P = 0.000\). \(P = 0.000 \) (Mc Nemar) \(κ R = 0.445\), \(P = 0.000\).

In Table 13, audiometric and DPOAE 6000 Hz ADS results show \(κ R = 0.4–0.75\), indicating adequate suitability, and \(P \leq 0.005\) demonstrates a significant relationship between audiometric and DPOAE examinations to assess abnormal threshold.

4. Discussions

Post-work hearing complaints mostly consisted of a sense of fullness in the ear. This finding is in accordance with those of Marthur et al., [8] who reported signs of increased THT after noise exposure, such as increased sensitivity, uncomfortable sense in the ear after noise exposure, ear fullness, a ringing sensation (tinnitus), and hard to hear in a crowded place. Nonaudiometric disorders associated with noise exposure were reported as fatigue, emotional distress, and difficulty concentrating at work. Canlon, as cited by Oishi, [9] found increased production of hormones in the hypothalamus–pituitary–adrenal (HPA) glands because of acoustic trauma, resulting in increased glucocorticoid hormone spread in the inner ear, and that activation of the HPA gland will suppress the synthesis of glucocorticoids and inhibit glucocorticoid receptors, which will trigger NIHL.

We found a difference in the prevalence of normal and abnormal thresholds in our subjects. The prevalence of an abnormal threshold (73.7%) using audiometry was higher than that using DPOAE (47.8%). According to Hall, [10] the DPOAE results can be passed if the results with audiometric examination are at the 25–40 dB threshold. This is due to decreased activity of otoacoustic emissions. On the basis of this finding, a mild hearing loss (>25–40 dB) on audiometric examination will be accepted as a pass value by DPOAE examination. This also is supported by Kemp, [11] who stated that the DPOAE assessment can detect hearing loss with a <40 dB hearing threshold.
The 6000 Hz frequency showing the most prevalent abnormal thresholds can be explained by the fact that the source of noise exposure at this factory is a high-frequency spinning machine. Satish [12] stated that noise exposure from engine rotation or a piston grinding machine will provide acoustic energy of 0.5 to 1 one octave higher at a frequency that receives maximum intensity at 4000 Hz. On the basis of the theory above, this can explain why the prevalence of abnormal threshold is highest at 6000 Hz compared with 4000 Hz. At 6000 Hz, the abnormal threshold prevalence was greater than the “refer” result according to DPOAE, so the abnormal threshold (>25 dB) according to audiometry will be accepted as the “pass” value by DPOAE, and, therefore, the “refer” DPOAE value at 6000 Hz will be lower than the abnormal audiometric threshold.

In the final multivariate analysis, there was a significant relationship between male sex and the occurrence of abnormal thresholds. This is in accordance with the findings of some researchers in the United Kingdom that males are more likely to suffer from noise threshold than females [8]. This is thought to be related to the greater number of males than females who work and are in a noisy environment at the textile factory. According to Staab, [13] anatomically, there is a difference in size of the male and female ear canals: the length (2.7 mm) and diameter (1.2 mm) of the ear canal are greater in men than in women, so that the received acoustic energy is greater in men. Also, hormonal factors have a role; that is, testosterone serves as the body’s immune defense so that males may have stronger resistance in the face of stress due to noise exposure. Therefore, they may unwittingly accumulate increased acoustic energy so that the process of hearing loss occurs faster than it would in the female model [14-16]. According to Azizi, [17] besides intensity, duration, and frequency of noise source, other factors exist, such as smoking habit in men.

Table 11, 12, and 13 demonstrates weak suitability because of the <40 dB threshold value of the audiometry, which can be accepted as “pass” by the DPOAE. Therefore, the tests were equally weak in assessing the subjects who had an abnormal threshold but a significant relationship. In the above condition, audiometric and DPOAE examinations have advantages and disadvantages in each tool, so these two tests are expected to complement each other so that NIHL can be detected early. The results are valid, so that these tests are useful for workers and clinicians [10].

5. Conclusions
The prevalence of NIHL was 73.3% (66 subjects) with pure tone audiometric examination and 47.8% (43 samples) with DPAOE examination among 90 textile factory workers. On the basis of logistic regression analysis, male sex was the most influential factor in the process of hearing impairment, and \( \kappa \) \( R \) analysis showed a meaningful relationship and a weak suitability of audiometric and DPOAE examinations at 4000 and 6000 Hz.

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