# Occupational noise induced hearing loss and hypertension: a cross-sectional study among dry food factory workers

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## Abstract

**Background:** Workers in manufacturing industries are exposed to noise generated by the manufacturing processes that results in auditory and non-auditory effects on them. The relationship between occupational exposure to noise and blood pressure is subject to debate in occupational medicine **Objective:** the study objectives were to measure the prevalence of noise-induced hearing loss (NIHL) and hypertension among dry food factory workers and to determine the association between them **Methods:** a cross-sectional study was conducted among workers in dry foods factory. The study included 268 workers selected randomly from the four factory departments. All participants were subjected to pure tone audiometry, blood pressure measurements and BMI calculations, as well as personal and occupational history taking. **Results:** NIHL was present among 15.3% of workers (n=41); mild NIHL represented 65.9% of NIHL cases, moderate and severe NIHL represented 29.3% and 4.9% of cases respectively. Multivariate analysis showed that age, employment duration, smoking, and irregular use of personal protective devices (PPD) were significant risk factors for occupational NIHL. Hypertension was present among 16% (n=43) of workers. On multivariate analysis, hypertension were independently associated with longer employment duration, smoking, family history of hypertension, and NIHL. **Conclusion** NIHL and Hypertension were not uncommon among dry food factory workers. They were both associated with longer employment duration, and smoking. NIHL was strongly associated with the irregular use of PPD. Hypertension was significantly related to unprotected chronic exposure to noise. The strict usage of PPD can decrease the prevalence of both NIHL and hypertension among exposed workers

**Keywords:** Occupational -Noise-NIHL-Hypertension

## Introduction

Noise-induced hearing loss (NIHL) is one of the most common occupational health problems, which produces gradual progressive impairment and disturbs the patient's quality of life. Many workers are exposed to noise at work place and this exposure is the second most important cause of hearing loss after aging process [1]. In the United States, approximately 30 million people are occupationally exposed to hazardous noise every year[2]. And according to the National Institute of Occupational Safety and Health (NIOSH), about 16% of the disabling HL in adults (over four millions) results from occupational noise [3].

Exposure to noise results in different type of physical, physiological and psychological effects on the workers [4]. It also hinders communication between workers and adversely affects the

performance of human being[5]. Also, Ahmadi et al. cited the report by WHO that noise causes 4 million dollars health damage every day[6].

Effects of exposure to noise on workers in the industries have been divided into auditory and non-auditory[7]. The auditory effects include hearing impairment and permanent hearing loss due to excessive noise exposure. The non-auditory effects include physiological effects such as general annoyance & reduction in sleep quality and physical effects such as hypertension & ischemic heart disease[8]

Many epidemiological studies have demonstrated the auditory effects of occupational noise [9]. Previous studies have documented that an audiometric notch at 3, 4 or 6 kHz with recovery at 8 kHz is a sign of noise-induced hearing loss [10-11]. In one industrial-based study, exposure to noise levels ≥ 85 dBA for more than 5 years was associated with hearing loss of 28.3 dB at 4 kHz among automotive assembly workers [12]

Several Egyptian studies on exposure to noise in industries have been conducted including that of Batanony et al. that assessed the auditory effects of occupational noise among selected industrial workers in iron and steel factory and showed that exposed workers suffer from higher prevalence of hearing impairment (39.6%) than their controls (15%) [13]. Also Nada et al. found that 73% of exposed workers in Zefta textile Factory suffered from NIHL[14].

Most food and drink industries have processes which emit high noise levels exceeding the 80dB (A) and 85dB(A) levels which affect their hearing sense adversely[15]. However the epidemiological data on prevalence of NIHL in food factory workers in Egypt is lacking.

Regarding non auditory effects of occupational noise, recent studies have focused on it especially the effect of exposure to noise on blood pressure[16-18]. Nevertheless, epidemiological evidence is still limited, as there is no consensus among researchers as to whether exposure to noise led to increase in blood pressure. Some studies have suggested that occupational noise exposure is associated with a higher risk of hypertension [19-20], but other studies have not revealed any significant interaction. [21-22]

The difference between these studies may be due to the variable use of personal protective equipment (PPE) among workers in high-noise environments. Thus, outer-ear measurements of noise levels alone may be a source of exposure bias because they do not reflect the true intensity of inner-ear exposure [23].

Few studies have used hearing loss at high frequencies as a biological marker for noise exposure to investigate the risk of hypertension. One field study reported significantly higher means of systolic blood pressure (SBP) and diastolic blood pressure (DBP) in workers with an auditory impairment ≥ 65 dB at 3, 4, or 6 kHz compared with those with normal hearing[24].

Therefore, the study objectives were to determine the prevalence of noise induced hearing loss (NIHL) among workers in dry food manufacturing company, and to investigate the relationship between exposure to occupational noise manifested by NIHL and hypertension.

## Participants and methods:

### Study design, time, and setting

A cross-sectional study with internal comparisons was carried out among workers at dry food manufacturing company. Data were collected during the period from March and August, 2015. The company was established in 1925 as the first dry food producer in Egypt. It's located in Qaluobe, the end products of the company included dry milk and coffee powder and other food additives such as soup. The company measures the noise level inside departments twice/year by the use of sound level meter (ANSI type 2 Model452). We obtained the recent data from the factory records which show high level of noise in all factory departments.

### Study Participants:

The study included 268 blue-collar workers selected randomly from 4 departments in the factory in proportionate to the total number of workers in each department. All workers are equally exposed to high level of noise .All workers work 8 hours per day. The selected workers were as follow; 63 workers from coffee production department, 69 workers from food additive product department, and 75 workers from milk department beside 61workers from maintenance and services department.

### Sample size calculation:

Sample size was calculated using PASS® version 11 program, setting the type-1 error (α) at 0.05 and the power (1-β) at 0.8. For calculating the sample size we assumed the prevalence of NIHL and hypertension among workers of 20% ± 5%, this assumptions yield a sample of 246 workers. Taking in consideration refusal of some workers to participate and for allowing internal analysis to identify factors associated with hypertension; the sample increased to 268 workers.

### Tool:

The procedures and examinations done among participating workers consisted of gathering data through questionnaire, measuring the arterial blood pressure, height and body weight measurement , and audiometry tests in all participants. All examinations were performed in company's clinic in the morning prior to the work shift to reduce the influence of diurnal rhythm and effects of acute exposure to noise. It was done for 10 workers /day and every setting took about 20 minute

### 1-Interview questionnaire:

Each participant was subjected to a detailed interview questionnaire. The questionnaire included an inquiry about personal data (age, smoking habits, and family history of hypertension). Also, Occupational history including (duration of employment, site of work, specific job and the frequency of using personal protective devices

### 2-Hearing test:

Audiometric assessment by standard pure-tone audiometry, using Audiometer Orbiter 922 (GN Otometrics, Taastrup, Denmark), measurements were performed by an audiology specialist; bone and air conduction for both ears were individually performed from 0.5 up to 8 KHz. Hearing Loss (HL) was categorized according to WHO guidelines[25] into the following: no impairment ≤25 dB HL; Mild HL: hearing threshold between 26 and 40

dB HL; Moderate HL: hearing threshold between 41 and 60 dB HL; Severe HL: hearing threshold between 61 and 80 dB HL; Profound HL: hearing threshold more than ≥81dB HL.

**3-Blood pressure measurements:**

Blood pressure was measured by a trained nurse using a mercury sphygmomanometer; participants were diagnosed as hypertensive if their mean resting SBP was ≥ 140 mm Hg or if their mean resting DBP was ≥90 mm Hg.

**4-Calculation of Body mass index (BMI):**

The body weight measured in (kg) divided by the square of the height measured in meter ($m^2$).

**Statistical analysis:**

Data collected were entered in Microsoft Excel 2007 then transferred to SPSS format Continuous variables are expressed as mean and Standard Deviation. Categorical variables are expressed as frequencies and percents. **Student t** Test was used to assess the statistical significance of the difference between two study group means. **Chi square** and **Fisher's exact test was** used to examine the relationship between Categorical variables. **Logistic Regression** was used to study independent factors affecting the occurrence of NIHL and Hypertension with adjustment of other confounders. A significance level of $P < 0.05$ was used in all tests. All statistical procedures were carried out using SPSS version 15 for Windows (**SPSS Inc, Chicago, IL, USA).**

**Ethical considerations:**

Administrative approval at work site and a written informed consent from each worker was obtained. The used questionnaire and collected data were anonymous.

## Results

Among all studied workers, the mean age and BMI was 35.4 ±7.56 years and 25.61±3.9 respectively. Smoking was prevalent among 30.2% of workers. About 21% of cases reported family history of hypertension (Table 1).

The mean employment duration among study participants was 10.75± 5.28 years. The studied workers were recruited from different factory departments as follow; 23.5% of study sample from coffee department, 25.7% from milk department, 28% from Food additive department, and 22.8% from services and maintenance department. Machine operator represented the specific job for 54.9% of workers, while 29.9% and 15.3% of workers were production workers and technicians respectively. The majority of workers reported regular PPD usage (88.9%). NIHL was present among 15.3% of workers; mild NIHL represented 65.9% of NIHL cases, moderate and severe NIHL represented 29.3% and 4.9% of cases respectively. Hypertension was detected among 16% of workers. (Table 1)

There was a highly significant difference between workers with and without NIHL as regard age and work duration, as workers with NIHL had higher mean age (38.3± 8.4 Vs 24.9± 7.2) and longer mean employment duration (12.5± 6.5 Vs 8.06± 4.7), however no difference was found regarding BMI. Smoking and PPD non usage were factors associated with NIHL, while other factors like site and

specific job of workers had no relation with NIHL (Table 2).

Using logistic regression to study independent factors affecting NIHL (table 2), it was found that workers with older age are at higher risk of NIHL (OR 2.08; CI; 1.9- 4.07; *p*=0.001). Other independent factors include longer employment duration of the worker (OR 1.137, CI; 1.06-1.22; *p*=0.021), being a smoker (OR 6.3, CI 2.57-15.45; *p*=0.001), and not using PPD (OR 13.7; CI 3.2- 18.2; *p*=0.001).

To study factors associated with hypertension (HTN), we compared between workers with and without hypertension regarding different factors, the comparison revealed a highly significant difference between them hypertensive and non hypertensive cases as regard age and work duration, workers with HTN had higher mean age (42.6± 7.9 Vs 34.12± 6.6) and higher mean employment duration (15.1± 6.35 Vs 7.5± 4.03), however no difference was found regarding BMI. Smoking, family history of hypertension, NIHL were factors associated with HTN, while other factors like site of workers and specific job revealed to be not associated. (Table 3)

After adjustment to potential confounders (age, employment duration, BMI, family history of Hypertension, tobacco use, site and type of job), the multivariate logistic regression analysis showed that noise-induced hearing loss was significantly associated with hypertension even after controlling for potential confounders(OR 2.8; CI 1.12- 9.1; *p*=0.02). Other independent factors associated with higher risk for HTN include longer employment duration (OR 1.2; CI 1.08- 1.3; *p*=0.04), being a smoker (OR 7.9; CI 2.7-23.2; *p*=0.001), and positive family history of Hypertension (OR 2.5; CI 1.09-26.08; *p*=0.03). (Table 3)Significant increase in hypertension among cases with moderate and high level of NIHL compared to mild NIHL cases (64.3% versus 29.3%, p = 0.03) was observed. (Data were not tabulated)

## Discussion

Noise-induced hearing loss is one of the most prominent occupational health hazards worldwide and is a significant contributor to the global burden of disease in adulthood [26-27]
Prolonged and/or repeated exposure to excessive sound over the acceptable daily exposure (85 dBA for 8 hours, a guideline set by the National Institute for Occupational Safety and Health) can cause sensorineural damage to the cochlea. This damage can lead chronic progressive noise-induced hearing loss (NIHL) [28]

Most food and drink industries have processing and packaging machinery producing high noise levels. These are likely to result in employees being subjected to noise exposures above the levels at which employers are required to take action to prevent workers suffering damage to their hearing[29].

Our study revealed that NIHL was present among 15.3% of workers; which is considered a low prevalence when compared to other industries, as a previous study conducted in iron and steel factory in Egypt showed a 39.6% prevalence of NIHL[13], while another study conducted by Farouk et al. among textile workers revealed a 30% prevalence of Occupational hearing loss [30]. However, in a metalworking company in Brazil, the rate of suggestive cases of NIHL was around 15.9%[31] which was quiet similar to our result. The majority of our NIHL cases were of mild form (66%). The

relatively low prevalence of NIHL and the majority of mild form could be attributed to the regular use of personal protective devices by the studied workers, as it was reported to be used regularly by 88% of workers.

Our study showed that after adjusting all confounding factors using logistic regression, NIHL was affected by workers' age, employment duration, smoking and PPD. This was consistent with Nair and Kashyap study which reported that the development of NIHL is affected by many factors like age, noise level, duration of exposure, risk factors like smoking associated and use of ear protectors [32]

Hypertension was present among 16% of all workers exposed to noise, this was inconsistent with Zawella et al. who studied the relationship between noise and hypertension in Egyptian workers and found that the prevalence of hypertension was 33.2% among the noise-exposed group[33]. This difference could be attributed to the lower mean age of our cases compared to cases in zawella study.

The association between occupational noise exposure and hypertension is inconsistent because of an exposure bias caused by outer-ear measurements of noise levels among workers [23]**.** So, in our study we used occupational high frequency hearing loss as a biomarker to investigate the chronic effects of noise exposure on hypertension in 268 dry foods -manufacturing workers.

Our results support the view that chronic occupational exposure to noise manifested by NIHL has the influence of blood pressure. The current study revealed that the frequency of hypertension was significantly higher among workers with NIHL compared to workers without NIHL. This was inconsistent with zawilla et al. found no association between hypertension and hearing impairment or noise-induced hearing loss (NIHL) [33]

However, our result were consistent with a field study that reported significantly higher means of systolic blood pressure (SBP) and diastolic blood pressure (DBP) in workers with an auditory impairment ≥ 65 dB at 3, 4, or 6 kHz compared with those with normal hearing [24] · Similarly, chang et al. reported that there was a significant difference between high hearing loss workers and the low hearing loss workers in the prevalence of hypertension, as 43.5% of the high level hearing loss workers had hypertension compared to only 33.2% of the low Hearing Loss workers[23]. Another study confirm our findings, as it reported a statistically significant prevalence of hypertension and electrocardiographic abnormalities among workers exposed to noise with audiometric deficit compared to workers exposed with normal hearing[34]**.**

Other several studies suggest that elevated blood pressure may be associated with exposure to noise as one of the non-auditory effects.[35-36] Noise may cause hypertension by activating the hypothalamic–pituitary–adrenal and sympathetic nervous systems and thus causing elevated levels of adrenaline, nor-adrenaline, and cortisol.[37–39]

It is worth mentioning that previous studies reported no significant association between elevated blood pressure and chronic exposure to noise levels above 85 dBA when measured using environmental [22] or personal [40] noise monitoring. Such comparisons indicated that assessing occupational noise exposure based on personal or environmental sampling might be

subject to exposure biases in occupational settings with more than 85 dBA noise due to the variable use of PPD. However, using mean high-frequency hearing loss values as markers of noise exposure could overcome this bias[33].

Also, our study showed a relation between duration of employment and Hypertension. This was similar to an industrial-based study that found a significant association between NIHL and length of employment with hypertension among black workers [41]
Our data is also consistent with chang et al. 2011, who also indicated that employment duration was associated with the risk of hypertension in workers[23]

The results of multivariate analysis in the current study confirm that noise exposure as indicated by presence of NIHL was one of the explanatory factors for high blood pressure in the examined group. This finding is consistent with the results of chang et al, who found that noise-induced hearing loss at high frequency was significantly associated with hypertension even after controlling for potential confounders using multivariate logistic regression analysis[23]

Also, in our final multivariate model, other co-variables such as age, smoking and positive family history were independently associated with high blood pressure. These co variables are established risk factors for high blood pressure in the biomedical literature [42-43]

In order to determine the association between severity of NIHL and hypertension, we compared between cases with different degrees of NIHL as regard hypertension. We found that the high/moderate NIHL group had a significant higher percentage of hypertensive case compared to mild cases (64.3% Vs 29.6%). This finding indicates that there is a dose response relationship between level of exposure to occupational noise as represented by severity of hearing loss and the risk of hypertension. This agrees with Chang et al. who reported revealed that high and median HL workers had significantly higher risks of hypertension than low HL workers[23].

The study have few limitations, however, a cross-sectional analysis of a temporal problem might restrict the evidence for a causal relationship between noise exposure and hypertension. Also, some confounders were not taken in consideration such as lipid profile which can affect the occurrence of hypertension.

## Conclusion and recommendation:

In conclusion, workers in dry food factory are exposed to high noise level with a percentage of cases with NIHL among workers. A positive association was found between chronic unprotected noise exposure and blood pressure levels. Our study also suggests that High-frequency hearing loss is a good biomarker for occupational noise exposure, as workers with NIHL were at higher risk for hypertension. It is necessary to educate workers with proper information and training on more effective prevention techniques that aim to reduce levels of noise in the working environment.

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## Table 1: Personal, medical and work characteristics of participants

| **Characteristics** | Mean | ±SD | Minimum | Maximum |
|---|---|---|---|---|
| Age | 35.48 | 7.56 | 23.00 | 59.00 |
| BMI | 25.61 | 3.91 | 23.18 | 27.81 |
| Employment duration | 10.75 | 5.28 | 5.00 | 22.00 |
| **Smoker (n %)** | 81 (30.2) | | | |
| **Family history of Hypertension (n %)** | 55 (20.5) | | | |
| **Working site (n %)** | | | | |
| Coffee | 63 (23.5) | | | |
| Milk | 69 (25.7) | | | |
| Food additives | 75 (28.0) | | | |
| Service | 61 (22.8) | | | |
| **Specific job (n %)** | | | | |
| Production workers | 80 (29.9) | | | |
| Machine operators | 147 (54.9) | | | |
| Technicians | 41 (15.3) | | | |
| **Use of personal protective devices (n %)** | | | | |
| Irregular | 48 (17.9) | | | |
| Regular | 220 (82.1) | | | |
| **Current hypertension (n %)** | 43 (16.0) | | | |
| **NIHL** (n %) | 41 (15.3) | | | |
| **Severity [a] (n %)** | | | | |
| Mild | 27 (65.9) | | | |
| Moderate | 12 (29.3) | | | |
| Sever | 2 (4.9) | | | |

[a] Percentages were taken out of 41 cases of NIHL BMI: body mass index NIHL: noise-induced hearing loss

**Table 2: Relation between NIHL and personal, medical and work characteristics of participants**

| | **NIHL yes** | **NIHL no** | | |
|---|---|---|---|---|
| **Characteristics** | **Mean ± SD** | **Mean ± SD** | **P- value** | **Adjusted OR (95% CI) [d]** |
| Age | 38.39 ± 8.48 | 34.96 ± 7.28 | **0.001[a]** | **2.09 (1.90 – 4.08)** |
| BMI | 25.82 ± 3.12 | 25.71 ± 2.11 | 0.770 [a] | 1.46 (0.57 – 12.4) |
| Employment duration | 12.59 ± 6.59 | 8.06 ± 4.70 | **0.001 [a]** | **1.14 (1.06 – 1.22)** |
| | **N = 41 (%)** | **N = 227 (%)** | **P- value** | |
| **Smoking** | | | | |
| Smokers | 26 (32.1) | 55 (67.9) | **0.000[b]** | **6.31 (2.57 – 15.45)** |
| Non-smokers | 15 (8.0) | 172 (92.0) | | |
| **Working site** | | | | |
| Coffee [e] | 10 (15.9) | 53 (84.1) | | |
| Milk | 17 (24.6) | 52 (75.4) | 0.577 [b] | 1.43 (0.27 – 7.54) |
| Food additives | 12 (16.0) | 63 (84.0) | | 4.62 (0.09 – 19.60) |
| Service | 2 (3.3) | 59 (96.7) | | 0.10 (0.01 – 1.96) |
| **Specific job** | | | | |
| Production workers [e] | 17 (21.3) | 63 (78.8) | | |
| Machine operators | 17 (11.6) | 130 (88.4) | 0.145 [b] | 0.35 (0.11 – 1.06) |
| Technicians | 7 (17.1) | 34 (82.9) | | 4.49 (0.46 – 43.92) |
| **Use of personal protective devices** | | | | |
| Irregular | 10 (35.7) | 18 (64.3) | **0.004[c]** | **13.76 (3.25 – 18.24)** |
| Regular | 31 (12.9) | 209 (87.1) | | |
| **Current hypertension** | | | | |
| Yes | 17 (39.5) | 26 (60.5) | **0.000 [b]** | 2.13 (0.93 – 13.05) |
| No | 24 (10.7) | 201 (89.3) | | |

[a] Student t-test was used [b] Chi Square test was used [c] Fisher exact was calculated
[d] Binary logistic regression was used [e] The reference category BMI: body mass index
NIHL: noise-induced hearing loss OR: Odds ratio Bold indicates significant OR and p

**Table 3: Relation between Hypertension and personal, medical and work characteristics of participants**

| | Hypertension | No hypertension | P- value | Adjusted OR (95% CI) [c] |
|---|---|---|---|---|
| **Characteristics** | **Mean ± SD** | **Mean ± SD** | | |
| Age | 42.63 ± 7.92 | 34.12 ± 6.68 | **0.001[a]** | 1.03 (0.95 – 1.12) |
| BMI | 25.62 ± 3.87 | 24.90 ± 2.21 | 0.090 [a] | 1.09 (0.99 – 1.19) |
| Employment duration | 15.19 ± 6.35 | 7.52 ± 4.03 | **0.001 [a]** | **1.22 (1.09 – 1.36)** |
| | **N = 43 (%)** | **N = 225 (%)** | **P-value [b]** | |
| **Smoking** | | | | |
| Smokers | 30 (69.8) | 51 (22.7) | **0.000** | **7.98 (2.74 – 23.26)** |
| Non-smokers | 13 (30.2) | 174 (77.3) | | |
| **Working site** | | | | |
| Coffee [d] | 5 (7.9) | 58 (92.1) | | |
| Milk | 15 (21.7) | 54 (78.3) | 0.06 | 2.13 (0.17 – 9.13) |
| Food additives | 15 (20.0) | 60 (80.0) | | 3.98 (0.91 – 21.74) |
| Service | 8 (13.1) | 53 (86.9) | | 0.78 (0.10- 1.24) |
| **Specific job** | | | | |
| Production workers [d] | 13 (16.3) | 67 (83.8) | | |
| Machine operators | 24 (16.3) | 123 (83.7) | 0.965 | 0.68 (0.08 – 2.21) |
| Technicians | 6 (14.6) | 35 (85.4) | | 3.43 (1.43 – 5.87) |
| **Family history of hypertension** | | | | |
| Yes | 25 (58.1) | 30 (13.3) | **0.000** | **2.57 (1.10 – 26.09)** |
| No | 18 (41.9) | 195 (86.7) | | |
| **NIHL** | | | | |
| Yes | 17 (41.5) | 24 (58.5) | **0.000** | **2.86 (1.12 – 9.16)** |
| No | 26 (11.5) | 201 (88.5) | | |

[a] Student t-test was used [b] Chi Square test was used [c] Binary logistic regression was used
[d] The reference category BMI: body mass index OR: Odds ratio
NIHL: noise-induced hearing loss NI: not included in logistic regression Bold indicates significant OR and p