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The Effects of Noise Pollution on the Prevalence of High Blood Pressure and Abnormal Pulse Rate on Workers in select Industries in Nnewi

***Ogbo, O. G.; *Onuoha, D. C.; Okonkwo, U. C. and Amaechi, M.**
*Environmental Management Department, Nnamdi Azikiwe University, Awka.

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ABSTRACT: *This study investigates the impact of noise pollution on the prevalence of high blood pressure and abnormal pulse rate among workers in selected industries in Nnewi, Nigeria. Utilizing a cross-sectional design, the research encompassed 250 workers exposed to varying levels of noise pollution. Data on blood pressure, pulse rate, and noise exposure were collected and analyzed using descriptive and inferential statistics. The findings reveal a significant correlation between prolonged exposure to high noise levels and increased instances of high blood pressure and abnormal pulse rates among the participants. These outcomes underscore the critical need for stringent noise control measures and regular health monitoring in industrial settings to mitigate the adverse health effects associated with noise pollution. This research contributes to the body of knowledge on occupational health, emphasizing the importance of creating a safer work environment to enhance workers' wellbeing.*

KEYWORDS: noise pollution effects; high blood pressure prevalence; abnormal pulse rates; industrial workers.

INTRODUCTION

Background to the Study

In recent times, the investigation into the health impacts of environmental factors has broadened, with noise pollution emerging as a significant concern, particularly within industrial work environments. Traditionally, research on the health effects of noise pollution has predominantly focused on hearing impairment, recognizing it as the most direct and well-documented outcome of prolonged exposure to elevated noise levels (Basner, Babisch, Davis, Brink, Clark, Janssen, & Stansfeld, 2014). Nonetheless, a growing body of evidence suggests that the repercussions of noise exposure extend far beyond auditory damage, implicating it in a variety of health issues including

cardiovascular diseases, sleep disturbances, and even psychological stress (Münzel, Schmidt, Steven, Herzog, Daiber, & Sørensen, 2018).

The industrial city of Nnewi, known for its vibrant manufacturing sector, presents a unique setting to study these effects due to the prevalent high-noise environments within its industries. This research is particularly timely, given the increasing recognition of cardiovascular diseases as a leading cause of global morbidity and mortality(World Health Organization, 2021). High blood pressure, a primary risk factor for cardiovascular conditions, affects a significant portion of the global adult population, with the World Health Organization highlighting its prevalence and its substantial contribution to the global disease burden (World Health Organization, 2021).

Emerging studies propose a link between noise exposure and elevated blood pressure and abnormal pulse rates, suggesting that the stress response triggered by noise can lead to significant cardiovascular changes (Babisch, 2006). These changes are thought to be mediated by biochemical reactions to stress, including the release of cortisol and adrenalin, which in turn can lead to peripheral vasoconstriction and alterations in heart rate and blood pressure (Ueta Y, Dayanithi G, and Fujihara H. 2011). Furthermore, the industrial workplace, with its combination of noise pollution and other stressors, may create a compounded risk environment for the development of hypertension among workers.

Given the high prevalence of hypertension, the potential for noise exposure within industrial settings to exacerbate or contribute to cardiovascular conditions, and the need for comprehensive research into the non-auditory effects of noise, this study aims to explore the relationship between noise pollution and the prevalence of high blood pressure and abnormal pulse rates among workers in select industries in Nnewi. This exploration is driven by the hypothesis that exposure to industrial noise levels, potentially above the conventional threshold of 85 dB(A) deemed harmful to hearing, could be significantly associated with increased risks of hypertension and related cardiovascular anomalies.

Aim and Objectives

Building on the foundational understanding of the potential health impacts of noise pollution within industrial settings, this study sets forth specific objectives to elucidate the relationship between noise exposure and cardiovascular health outcomes among workers in Nnewi North Local Government Area of Anambra State. The targeted objectives are as follows:

1. To Identify the Levels of Noise Pollution in Three Select Industries: This objective aims to measure and document the ambient noise levels present in three select industries within Nnewi. By quantifying the noise exposure, this study seeks to provide a baseline understanding of the auditory environment to which workers are subjected daily. This measurement will be pivotal in assessing the extent of noise pollution and its potential deviation from what is considered a safe and healthy working environment.

2. To Compare the Levels of Noise Pollution with NESREA Permissible Limits: The National Environmental Standards and Regulations Enforcement Agency (NESREA) has set forth guidelines and permissible limits for environmental noise to safeguard public health. An essential objective of this research is to compare the documented noise levels from the selected industries against these regulatory standards. This comparison will not only highlight compliance or lack thereof but also underscore the potential regulatory gaps in protecting workers from the non-auditory effects of noise pollution.
3. To Determine the Prevalence of High Blood Pressure and Abnormal Pulse Rate among Workers exposed to noise pollution: Focusing on workers in the production sections of these industries who have been exposed to the industrial environment for five years or more, this study aims to assess the prevalence of high blood pressure and abnormal pulse rates. By comparing these health outcomes between workers in high-noise areas and those in control (lower noise) environments within the same industries, the study seeks to directly investigate the correlation between long-term noise exposure and cardiovascular health risks. This objective is pivotal in understanding the broader health implications of industrial noise pollution beyond the immediate auditory effects, potentially informing future workplace health policies and interventions.

Through these objectives, the study aspires to provide a comprehensive analysis of the interplay between industrial noise pollution and cardiovascular health risks. The outcomes are anticipated to contribute significantly to the body of knowledge on environmental health, specifically within the context of industrial settings in developing countries like Nigeria. Moreover, the findings could serve as a critical resource for policymakers, industry stakeholders, and health professionals in crafting strategies to mitigate the health impacts of noise pollution on workers.

MATERIALS AND METHODS

Study Design and Population

This study utilized a cross-sectional survey research design to investigate the association between noise pollution and its effects on high blood pressure, abnormal pulse rates, and hearing loss among workers in Nnewi, Anambra State, Nigeria. The research was conducted between the 4th and 22nd of November 2019, focusing on a target population of workers from three large-scale manufacturing industries within the Nnewi North Local Government Area. The study population included individuals who had worked on the factory floor or production section for a minimum of five years.

Health, Socioeconomic, and Environmental Data

Primary data were collected using instruments such as a sound level meter, automatic blood pressure monitors, and a tuning fork, alongside a structured questionnaire. The questionnaire gathered demographic information and assessed respondents' exposure to noise pollution, hearing acuity, and the presence of management systems for noise control within the industries.

Data collection occurred over three weeks, with samples taken twice a day: before the work shift began and after 4-5 hours of operation. Noise level readings were taken at five points within each production section, and the mean value was recorded. Health data on blood pressure, pulse rate, and hearing acuity were collected simultaneously with questionnaire responses.

Definition of Exposure and Outcome

Noise exposure was assessed using a BAFX digital sound level meter to collect sound levels within the production areas and control environments of the industries. Health outcomes, including high blood pressure and abnormal pulse rates, were measured using automatic blood pressure monitors. Hearing acuity was evaluated using the Rinne and Weber Screening test conducted by a physician.

Ethical Considerations

The methodology ensures respect for the privacy and voluntary participation of the respondents, adhering to ethical standards for research involving human subjects. Although not explicitly stated in the provided text, seeking approval from an appropriate ethics committee and ensuring informed consent from all participants would be crucial steps in the research process.

RESULTS

Levels of noise pollution in the industry

The noise level from Industry A, Industry B, and Industry C are presented in Table 1 below.

Table 1: Levels of noise pollution in the industry

S/N	Industry	Day 1 (Leq)	Day 2 (Leq)	Day 3 (Leq)	Mean Value (Leq)	Control/office area (Leq)
1.	Industry A	96.4	96.6	95.2	96.2	80.3
2.	Industry B	96.2	95.8	97.6	96.5	86.7
3.	Industry C	90.1	89.6	90.6	90.1	85.9

Source: Researchers Field Study

Table 1 shows that Industry C had a mean noise level of 90.1 dB and was the quietest industry among the three. The office area of the Industry C plant which served as the control for Industry C had a noise level of 85.9dB. Industry A industries had a mean noise level of 96.2 dB and the office area which also served as the control for this industry had a noise level of 80.3dB. Industry B was the nosiest of the three industries studied with a mean noise level of 96.5dB. The office area in the Industry B complex served as the control for the Industry B and had a noise level of 86.7dB.

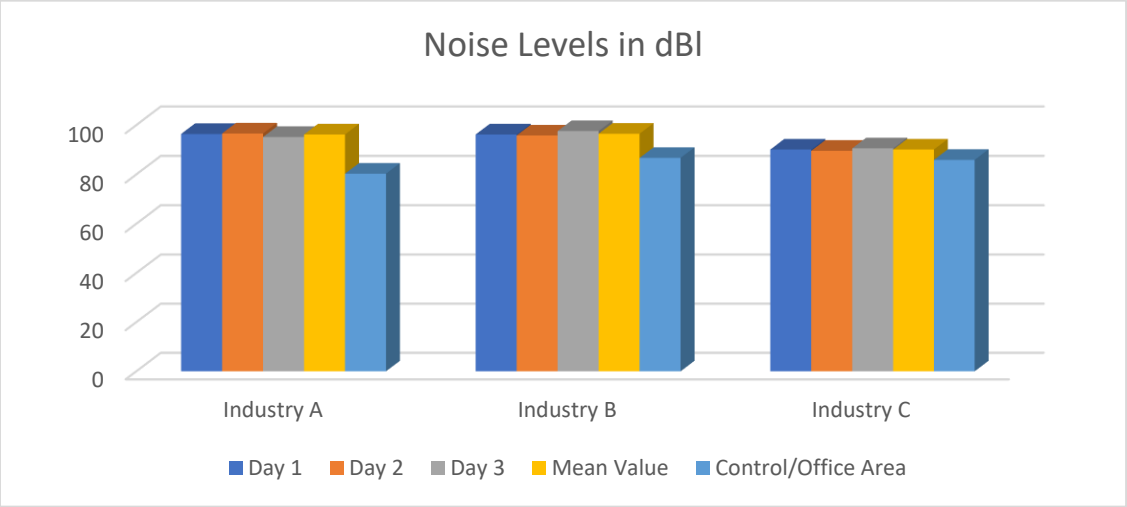

Figure 1: The noise levels in the industries represented in a bar chat.

Levels of noise pollution compared with NESREA

The average noise levels recorded from the three industries were compared with the NESREA permissible noise limits for factory and are presented in Table 2.

Table 2: Levels of noise pollution compared with NESREA

S/N	INDUSTRY	LEQ IN DB(A) MEAN VALUE	NESREA PERMISSIBLE LIMIT
1.	Industry A	96.2	85
2.	Industry B	96.5	85
3.	Industry C	90.1	85

Source: Researchers Field Survey

The table 2 shows that all three industries where operating at noise levels above the NESREA permissible noise limits. Industry C which is the quietest amongst the three industries had an average noise level of 90.1dB and was 5.1dB nosier than the NESREA recommended limit. Industry A industries and Industry B had noise levels of 96.2dB and 96.5dB respectively and were 11.2dB and 11.5dB nosier than the NESREA permissible limits for factory floor respectively.

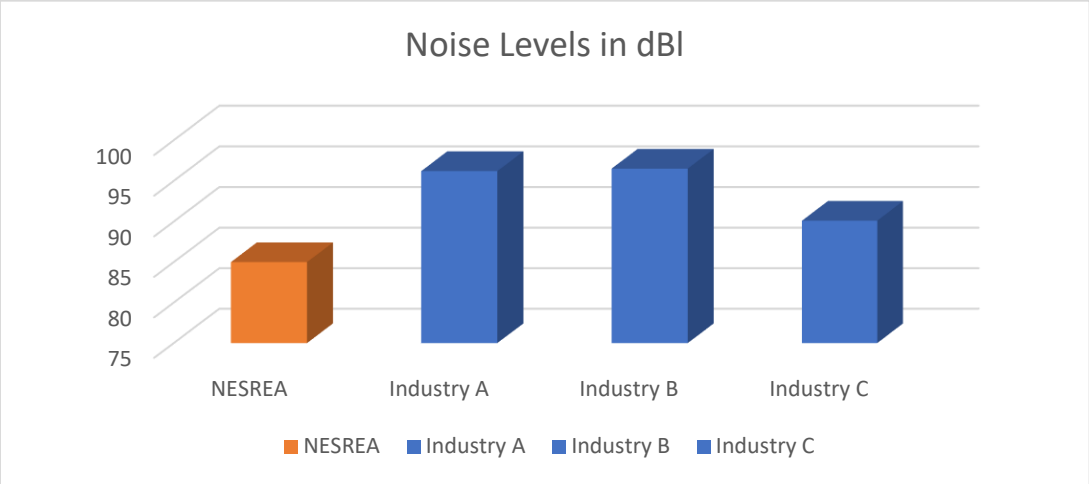

Figure 2: The noise levels in the industries compared to the NESREA permissible limits for factory floor.

Measurement of blood pressure and pulse rate.
To assess the health effects of the noise levels on the workers in the industry, the Systolic and Diastolic blood pressures of the workers were measured as well as their pulse rate and the data gathered is presented below.

Measurement of blood pressure and pulse rate of the control group
Measurement taken for the control group which was made up of the workers in the industry who worked at the administrative block is presented in table 3

Table 3: Systolic, Diastolic and Pulse rate measurement for the control group

SN	Industry		Systolic (mmHg)	Diastolic (mmHg)	Pulse rate (Beats/minute)
1.	Industry A	**Before Exposure**	127.1429	75.57143	72.57143
		After Exposure	126	75	72
		Net Change	-1.1429	-0.57143	-0.57143
2.	Industry B	**Before Exposure**	126.8	76	72
		After Exposure	124.6	74.8	69.2
		Net Change	-2.2	-1.2	-2.8
3.	Industry C	**Before Exposure**	129.75	79	78.75
		After Exposure	128.5	77.5	78
		Net Change	-1.25	-1.5	-0.75

Source: Researchers Field Survey

Table 3 shows that both the average systolic and diastolic blood pressure as well as pulse rate of all workers in the control group decreased after exposure. The data shows that before exposure, the average systolic and diastolic blood pressure for workers in Industry A industries was 127.1429mmHg and 75.57143mmHg respectively and became 126.0000mmHg and 75mmHg

respectively after exposure. The average Pulse rate for Industry A was recorded as 72.57143beats/minute before exposure and 72.000beats/minute after exposure.

The average systolic and diastolic blood pressure for workers in the control group for Industry B was recorded as 126.8mmHg and 76.00mmHg respectively before exposure and became 124.6mmHg and 74.8mmHg respectively after exposure. The average Pulse rate for Industry B was recorded as 72.000beats/minute before exposure and 69.2000beats/minute after exposure.

The average systolic and diastolic blood pressure for workers in the control group for Industry C was recorded as 129.75mmHg and 79.00mmHg respectively before exposure and became 128.5mmHg and 77.5mmHg respectively after exposure. The average Pulse rate for Industry C was recorded as 78.750beats/minute before exposure and78.000beats/minute after exposure.

The net change before and after exposure of the systolic blood pressure for Industry A industries is -1.1429 mmHg while the same reading for Industry B and Industry C were -2.2 mmHg and -1.25 mmHg respectively. The net change for the Diastolic blood pressure for Industry A industries, Industry B and Industry C was give as -0.57143mmHg, -1.2 mmHg and -1.5 mmHg respectively. The net change for the pulse rate of the workers in Industry A industries, Industry B and Industry C was recorded to be -0.57143 beats/minutes, -2.8 beats/minutes and 0.75 beats/minutes respectively.

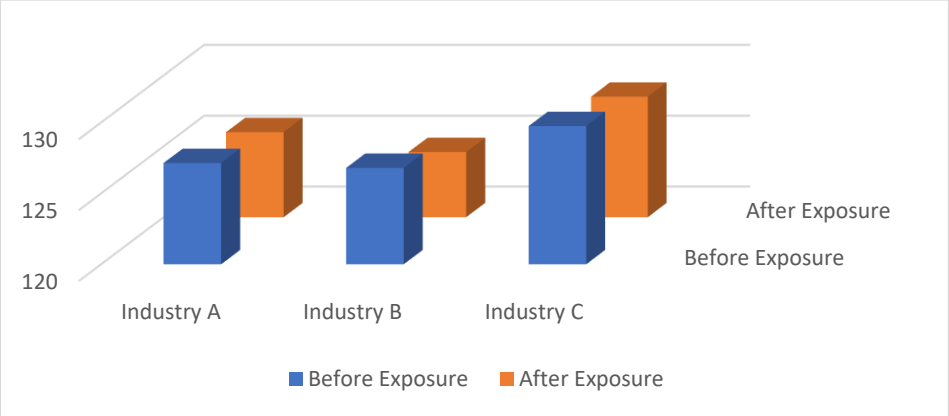

Figure 3: Systolic Blood Pressure (mmHg) of the Control Groups

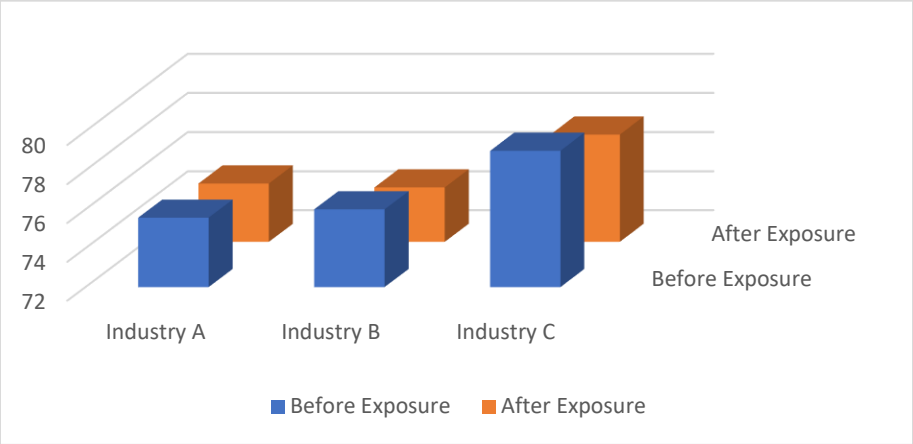

Figure 4: Diastolic Blood Pressure (mmHg) of the Control Groups

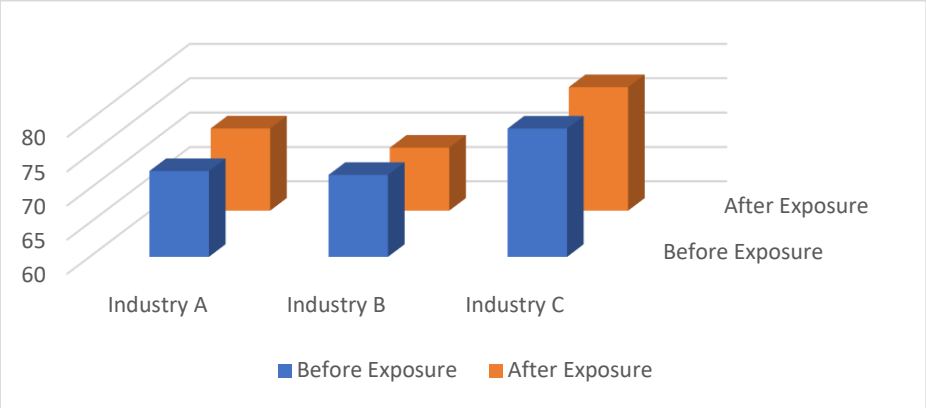

Figure 5: Pulse rate (Beats/minute) of the Control Groups

Measurement of blood pressure and pulse rate of the respondents

Measurement taken for the respondents which were made up of the workers in the industry who worked on the factory floor or production section is presented in Table 4

Table 4: Systolic, Diastolic and Pulse rate measurement for the respondents

SN	Industry		Systolic (mmHg)	Diastolic (mmHg)	Pulse rate (Beats/minute)
1.	Industry A	**Before Exposure**	134.3784	79.27027	76.89189
		After Exposure	135.4865	81.27027	80.78378
		Net Change	1.1081	2.00000	3.89189
2.	Industry B	**Before Exposure**	131.4091	78.227	77.27273
		After Exposure	134.5000	80.36364	79.77273
		Net Change	3.0909	2.13664	2.50000
3.	Industry C	**Before Exposure**	137.3333	78.5	77.91667
		After Exposure	139.0833	80.08333	80.58333
		Net Change	1.7500	1.58333	2.6666

Source: Researchers Field Survey

Table 4 shows that both the average systolic and diastolic blood pressure as well as pulse rate of all respondents increased after exposure. The data shows that before exposure, the average systolic and diastolic blood pressure for workers in Industry A industries was 134.3784mmHg and 79.27027mmHg respectively and became 135.4865mmHg and 81.27027mmHg respectively after exposure. The average Pulse rate for Industry A was recorded as 76.89189beats/minute before exposure and 80.78378beats/minute after exposure.

The average systolic and diastolic blood pressure of respondents in Industry B was recorded as 131.4091mmHg and 78.227mmHg respectively before exposure and became 134.5000mmHg and 80.36364mmHg respectively after exposure. The average Pulse rate for Industry B was recorded as 77.27273beats/minute before exposure and 79.77273beats/minute after exposure.

The average systolic and diastolic blood pressure for workers in the control group for Industry C was recorded as 137.3333mmHg and 78.50mmHg respectively before exposure and became 139.0833mmHg and 80.08333mmHg respectively after exposure. The average Pulse rate for Industry C was recorded as 77.91667beats/minute before exposure and 80.5833beats/minute after exposure.

The net change before and after exposure of the systolic blood pressure for Industry A industries is 1.1081mmHg while the same reading for Industry B and Industry C were 3.0909mmHg and 1.7500mmHg respectively. The net change for the Diastolic blood pressure for Industry A industries, Industry B and Industry C was calculated to be 2.000mmHg, 2.13664mmHg and 1.58333mmHg respectively. The net change for the pulse rate of the workers in Industry A industries, Industry B and Industry C was recorded to be 3.89189 beats/minutes, 2.5000 beats/minutes and 2.6666beats/minutes respectively.

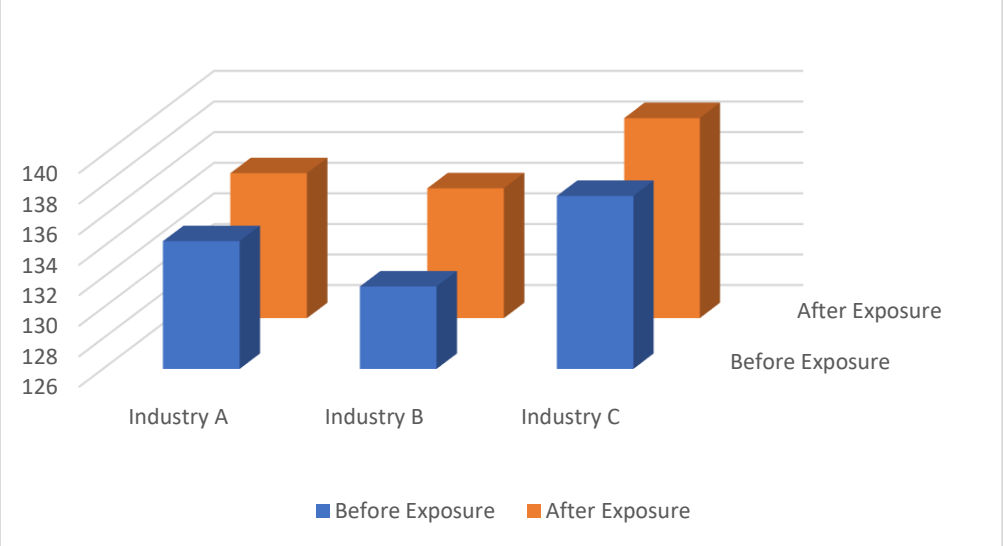

Figure 6: Systolic Blood Pressure (mmHg) of the Respondents

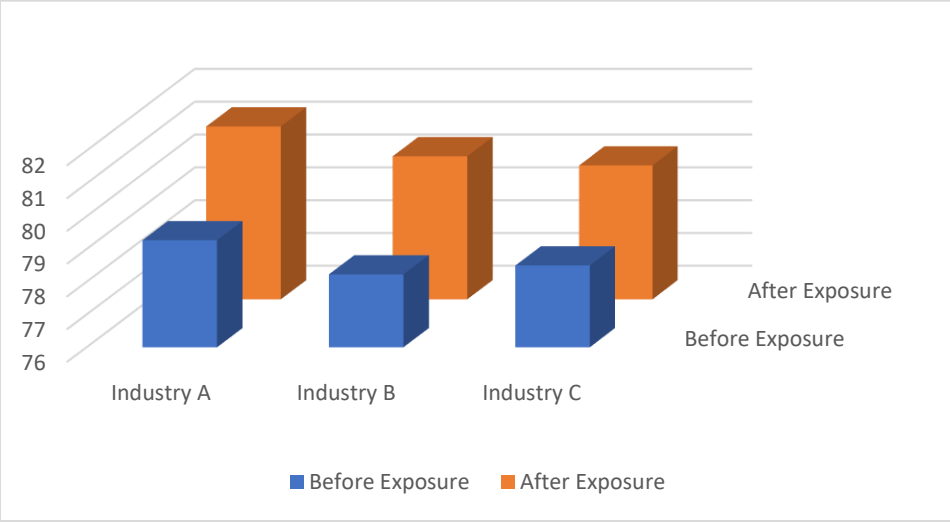

Figure 7: Diastolic Blood Pressure (mmHg) of Respondents

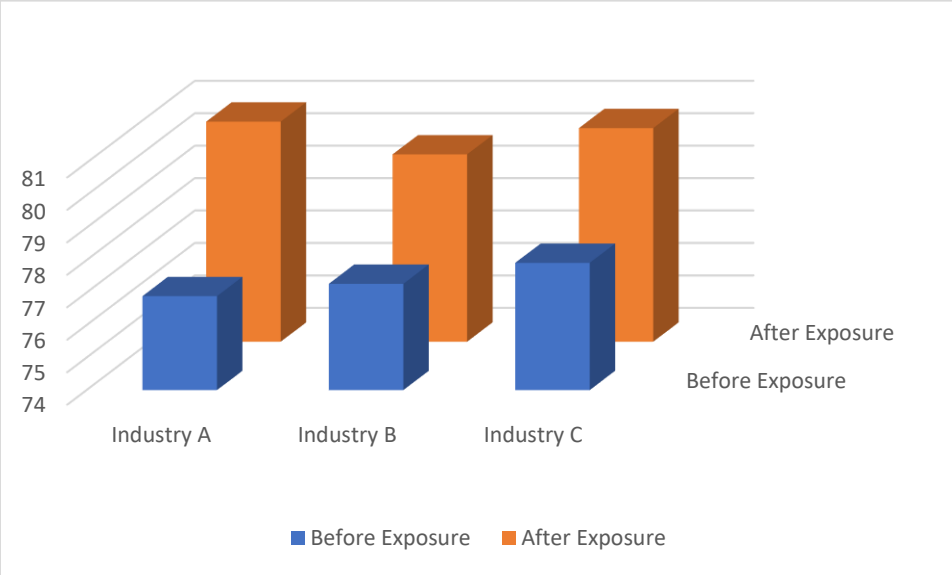

Figure 8: Pulse rate (Beats/minute) Respondents

Hypothesis Testing

The hypothesis stated for this study is that there is no significant difference between the incidence of high blood pressure and abnormal pulse rate between the workers in the production section and those in the control who have spent five years and more in the three industries of study.

Table 4.19: Regression Tests[b]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.993	7.969E3[a]	3.000	168.000	.000
	Wilks' Lambda	.007	7.969E3[a]	3.000	168.000	.000
	Hotelling's Trace	142.303	7.969E3[a]	3.000	168.000	.000
	Roy's Largest Root	142.303	7.969E3[a]	3.000	168.000	.000
Variations	Pillai's Trace	.811	2.405E2[a]	3.000	168.000	.000
	Wilks' Lambda	.189	2.405E2[a]	3.000	168.000	.000
	Hotelling's Trace	4.295	2.405E2[a]	3.000	168.000	.000
	Roy's Largest Root	4.295	2.405E2[a]	3.000	168.000	.000
Before and After	Pillai's Trace	.801	2.252E2[a]	3.000	168.000	.000
	Wilks' Lambda	.199	2.252E2[a]	3.000	168.000	.000
	Hotelling's Trace	4.022	2.252E2[a]	3.000	168.000	.000
	Roy's Largest Root	4.022	2.252E2[a]	3.000	168.000	.000
Variations * Before and After	Pillai's Trace	.811	2.396E2[a]	3.000	168.000	.000
	Wilks' Lambda	.189	2.396E2[a]	3.000	168.000	.000
	Hotelling's Trace	4.279	2.396E2[a]	3.000	168.000	.000
	Roy's Largest Root	4.279	2.396E2[a]	3.000	168.000	.000

a. Exact statistic

b. Design: Intercept + Variations + Before and After + Variations * Before and After

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Systolic	1707.903[a]	3	569.301	3.583	.015
	Diastolic	34100.739[b]	3	11366.913	291.954	.000
	Pulse Rate	785.419[c]	3	261.806	5.343	.002
Intercept	Systolic	1795152.608	1	1795152.608	1.130E4	.000
	Diastolic	864284.690	1	864284.690	2.220E4	.000
	Pulse Rate	602514.319	1	602514.319	1.230E4	.000
Variations	Systolic	1592.493	1	1592.493	10.022	.002
	Diastolic	13202.851	1	13202.851	339.109	.000
	Pulse Rate	593.814	1	593.814	12.118	.001
Before and After	Systolic	3.570	1	3.570	.022	.881
	Diastolic	15781.841	1	15781.841	405.349	.000
	Pulse Rate	15.600	1	15.600	.318	.573
Variation * Before and After	Systolic	48.995	1	48.995	.308	.579
	Diastolic	18181.473	1	18181.473	466.982	.000
	Pulse Rate	60.565	1	60.565	1.236	.268
Error	Systolic	27014.213	170	158.907		
	Diastolic	6618.774	170	38.934		
	Pulse Rate	8330.213	170	49.001		
Total	Systolic	3132597.750	174			
	Diastolic	1264183.250	174			
	Pulse Rate	1052963.500	174			
Corrected Total	Systolic	28722.116	173			
	Diastolic	40719.513	173			
	Pulse Rate	9115.632	173			

a. R Squared = .059 (Adjusted R Squared = .043)

b. R Squared = .837 (Adjusted R Squared = .835)

c. R Squared = .086 (Adjusted R Squared = .070)

Table 4.20: Estimated Marginal Means (Grand Mean)

Dependent Variable	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Systolic	131.092	1.233	128.657	133.527
Diastolic	90.961	.611	89.756	92.166
Pulse Rate	75.947	.685	74.595	77.299

The Multivariate tests table reveals that for all three effects, the observed significance levels for the multivariate tests (Pillai's, Wilks', Hotelling's and Roy's) are small. Therefore, their associated null hypotheses (no variation difference, no before and after difference and no variation*before

and after interaction) are rejected. In a nut shell, the test for both variations $F(3,168) = 2.41$, $p < 0.05$ and before and after $F(3, 168) = 2.25$, $p < 0.05$ are statistically significant, indicating that experimental when compared to control and before when compared to after differed significantly in their overall blood pressure (systolic and diastolic) and pulse rate.

The Between-Subjects Effects show that the variation differences for systolic, diastolic and pulse rate are highly significant ($p < 0.05$). For before and after exposure, the results show significant difference for only diastolic. The results also show significant variation*before and after interaction effect for only diastolic while for systolic and pulse rate $p > 0.05$.

Consequently, we are rejecting the null hypothesis and accepting the alternate hypothesis that there is a significant difference between the incidence of high blood pressure and abnormal pulse rate between the workers in the production section and those in the control who have spent five years and more in the three industries of study.

Discussion of Findings on the prevalence of high blood pressure and abnormal pulse rate on workers in the production section and those in the control who have spent five years and more in the three industries of study as a result of the levels of noise pollution?

Excessive noise pollution has been blamed not only for hearing damage and community annoyance but also for hypertension, fatigue, heart trouble, serum lipid, triglycerides, platelet, count, plasma viscosity, glucose and reduced motor efficiency (Regecova and Kellerova, 1995). Table 4.6 showed the change in systolic, diastolic blood pressure as well as the change in pulse rate, before and after noise exposure. Data gathered showed that after noise exposure, the blood pressure (systolic and diastolic) of respondents increased in all the three industries. In the same vain, the pulse rate also recorded a spike in all three industries. In other to access if the increase of these parameters had a significant relationship with the noise exposure, the numbers were exposed to statistical analysis. The regression analysis revealed that there was a significant relationship between the increased levels of blood pressure and pulse rate with the noise exposure (Table 4.19). This finding is in line with various other finding across fields that noise does have a significant effect on blood pressure (Munzel, 2017; Yousif and Mahdi 2013; Reza and Hassan 2013)

Non-hearing Effects of Noise Exposure

The association between noise exposure and blood pressure is supported by various studies employing similar methodologies but differing in exposure and outcome definitions. Significant research, including Chang et al. (2003), Powazka et al. (2001), and Tomei et al. (2010), has observed notable increases in blood pressure among workers exposed to elevated noise levels, although not all such studies have classified these individuals as hypertensive. Further, Narlawar et al. (2006) and Souto Souza et al. (2009) reported a higher prevalence of high blood pressure among workers exposed to noise levels ≥ 85 dB(A), thus strengthening the connection between occupational noise exposure and hypertension. Conversely, Inoue et al. (2005) noted an inverse

relationship, thereby emphasizing the intricate dynamics between noise exposure and blood pressure.

These studies collectively call for a reevaluation of the deemed safe noise exposure levels. Notably, even exposures considered safe (≤ 85 dB(A)) have been linked with a higher prevalence of hypertension, suggesting that the current legislation may not sufficiently protect workers from the non-auditory health effects associated with noise.

Limitations

The cross-sectional design of the study limits the ability to establish a causal relationship between noise exposure and high blood pressure. Additionally, the reliance on data from annual mandatory health evaluations, which lacked regular scientific research quality control measures, may have affected the completeness and accuracy of the data. The classification of workers as hypertensive based on a single occasion's blood pressure measurements could lead to over-diagnosis. Variables such as socioeconomic status, which could confound the association between noise exposure and high blood pressure, were not directly collected but were inferred from available indicators, potentially limiting the accuracy of socioeconomic status assessment.

Public Health Relevance

The study highlights the public health importance of addressing noise exposure in the workplace, especially given the high prevalence of hypertension among workers exposed to noise levels considered safe by current standards. The findings suggest that revising noise exposure limits to consider both hearing and non-hearing health effects is crucial for protecting worker health. The study emphasizes the need for comprehensive health evaluations that include assessments for conditions like hypertension, which may not currently be considered in the context of occupational noise exposure.

CONCLUSION

The primary objective of our study was to contribute evidence supporting the hypothesis that there is an association between noise exposure and high blood pressure among industrial workers. Despite the inherent limitations of our research approach, including its cross-sectional design and the challenges related to data completeness and accuracy, the findings significantly bolster the argument for a link between these variables. This is particularly relevant given the ongoing uncertainty within the biomedical literature regarding the non-auditory effects of noise exposure. While the association between noise exposure and auditory effects is well-documented and broadly accepted in environmental epidemiology, the implications of noise on non-auditory health outcomes, such as high blood pressure, remain less clearly defined.

Our study underscores the need to reconsider the noise exposure levels deemed safe for auditory effects when evaluating potential non-auditory outcomes. By highlighting an association between high blood pressure and noise levels currently considered safe, our research adds an important perspective to the ongoing discussion about occupational health standards. It suggests that current

noise exposure limits may need to be adjusted to adequately protect workers' health against both auditory and non-auditory effects.

Furthermore, our findings serve as a call to action for decision-makers and regulatory agencies to establish more precise noise exposure guidelines. Such adjustments are crucial to ensuring that the health of workers is not compromised by occupational noise exposure. Additionally, this study aims to raise awareness among workers about the potential health effects of their occupational environments, encouraging a more proactive approach to personal health monitoring and advocacy for safer workplace conditions.

In conclusion, while our study contributes to the body of evidence on the health impacts of noise exposure, it also highlights the urgent need for further research, improved regulatory standards, and increased awareness of occupational health risks. By doing so, it reinforces the importance of safeguarding worker health through comprehensive and evidence-based occupational safety policies.

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