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# Noise exposure as a factor in the increase of blood pressure of workers in a sack manufacturing industry

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ABSTRACT

Workers in manufacturing industries are exposed to noise generated by the manufacturing processes that results in auditory and non-auditory effects on them. This study assessed the relationship between exposure to noise and blood pressures. Sixty two randomly selected male workers in 6 sections of a sack manufacturing company participated in the study with a mean age of 31.6 (SD = 7.7) years. The noise emitted by the machines was obtained using a digital sound level meter. The blood pressures (systolic and diastolic) were obtained using a digital sphygmomanometer. The values of the systolic blood pressure when the workers were off work (SBPO) were consistently lower than systolic blood pressure during the morning duty (SBPM) and systolic blood pressure during the night duty (SBPN). However, no significant differences were observed between diastolic blood pressure of the workers during morning duty (DBPM) and during night duty (DBPN). Similarly, there were no significant differences between the values of DBPM and the diastolic blood pressure of the workers when they were off work (DBPO). The current study seems to suggest that workers should not be exposed to more than 89 dB as this had the least systolic and diastolic blood pressures. The study concluded that exposure to noise significantly increased systolic blood pressure but had no significant increase in the diastolic pressure of the workers.


## 1. Introduction

Noise was derived from the Latin term ‘nausea’ and has been defined as unwanted sound, which is a potential hazard to health and communication (Laad, 2011).

Noise was defined by Bridger (1995) as a sound or sounds at such amplitude that could cause annoyance or interfere with communication. Many workers are exposed to noise at work place and this exposure is the second most important cause of hearing loss after aging process (Rabinowitz, 2000).

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Manufacturing processes generate noise as an unwanted but by-product of their output (Olayinka and Abdullahi, 2009) with more than 70% of noise exposure occurring in the manufacturing industries (Reilly et al., 1998). According to the National Institute of Occupational Safety and Health, an estimated 14% of workers are exposed to noise higher than permissible limit (Lee et al., 2009).

Exposure to noise hinders communication between workers and may also result in different type of physical, physiological and psychological effects on the workers (Raman, 2006; Avwiri and Nte, 2003). Noise-induced stresses adversely affect the performance of human being (Simpson et al., 1994) and noise impaired performance on the focused attention task (Smith, 1991). Also, Ahmadi et al. (2010) cited the report by WHO that noise causes 4 million dollars health damage every day.

Moreover, psychoneurotic and psychosomatic complaints were also observed due to noise exposures (Martinho et al., 1999).

Effects of exposure to noise on workers in the industries have been divided into auditory or non-auditory (Attarchi et al., 2012). The auditory effects include hearing impairment and permanent hearing loss due to excessive noise exposure. The non-auditory effects include stress, related physiological and behavioral effects.

Past auditory studies included the relationship between exposure to noise and hearing loss (Davies et al., 2005; Rabinowitz, 2000; Broste et al., 1989; Clark and Bohne, 1986). However, recent studies have focused on the non-auditory effects of exposure to noise especially the effect of exposure to noise on blood pressure (Attarchi et al., 2012; Babisch, 2011; Chang et al., 2007; Fogari et al., 2001). However, there is no consensus among researchers as to whether exposure to noise led to increase in blood pressure. While some studies agreed that exposure to noise increased blood pressure (Lee et al., 2009; Chang et al., 2007; Lusk et al., 2004; Sakata et al., 2003), others disagree (Fogari et al., 2001; Hessel and Sluis-Cremer, 1994). The combined effects of shift work and exposure to noise have also been studied. Attarchi et al. (2012) observed that rate of hypertension, mean systolic and diastolic BP were higher among shift workers who were exposed to noise that was higher than permissible limit (85 dBA). Few studies on exposure to noise in industries in Nigeria that have been conducted include that of Ighoroje et al. (2004) that assessed the auditory effects of occupational noise among selected industrial workers who had been exposed to over 90 dB(A) of occupational noise for between 1 and 14 yr in Benin City, Nigeria. Their results showed that noise induced hearing impairment were present in 100% of the workers. Olayinka and Abdullahi (2009) did an overview of industrial employees' noise exposure level in five selected processing and manufacturing industries in Ilorin, Nigeria. Their emphasis was on noise emitted by individual industrial machinery from the selected industries.

This study was on the effect of exposure to noise on blood pressure of workers in a sack manufacturing company as there is presently a sparse literature on the subject in Nigeria.

## 2. Methodology

### 2.1. *Company of study*

The study was conducted in a sack manufacturing company between March and April, 2013. The company was established in 1972 as the first woven polypropylene sack producer in Nigeria. It commenced the full production of polypropylene bags and film in 1978.

## 3. Participants

Sixty two randomly selected male workers, with the exclusion of workers that have been diagnosed of high blood pressure, in 6 sections of the company participated in the study. The sections were Granite to Tape (GT); Tape to Fabric (TF); Sack Lamination (LAM); Fabric Printing Section (PREE); Conventional, patch and laminated fabric cutting (CONVERSION) and Power Generation (GENERATOR).

## 4. Informed consents

Participants were informed some few days before the commencement of the study and they were given adequate information. The consents of the participants were obtained before the start of the study.

## 5. Data collection

### 5.1. *Noise level*

The noise emitted by the machines was obtained using a digital sound level meter (EXTECH 407730, EXTECH Instruments, USA). The measurements were obtained in the morning (7 am), afternoon (12 pm) and night (6 pm) according to the user's guide with the selection of 'A' frequency weighting. Three measurements at the mentioned times were obtained on an hourly basis in all the six sections covered by the study. The average of the noise levels were calculated and taken as the mean noise level for each of the section.

### 5.2. *Blood pressure*

The blood pressures (systolic and diastolic) were obtained using a digital sphygmomanometer (OMRON, OMRON Healthcare Europe B. V., China) while participants relax such that any tachycardia due to nervousness was subscribed. The forearm of the participants was slightly pronated and the wrist also slightly flexed.

The blood pressures were obtained two times while workers were at work: between 10 am and 12 pm; 8 pm and 10 pm. The blood pressures were also obtained while the workers were off work. Three readings of the blood pressures were obtained and the average values used as representing

**Table 1 – Descriptive statistics for the obtained data.**

| | N | Minimum | Maximum | Mean | Std. deviation |
|---|---|---|---|---|---|
| SBPM (mmHg) | 62 | 100.00 | 152.00 | 121.6452 | 12.00286 |
| SBPN (mmHg) | 62 | 110.00 | 176.00 | 126.1774 | 12.14060 |
| SBPO (mmHg) | 62 | 100.00 | 142.00 | 117.4355 | 9.98790 |
| DBPM (mmHg) | 62 | 70.00 | 100.00 | 76.9194 | 6.03079 |
| DBPN (mmHg) | 62 | 63.00 | 100.00 | 77.9677 | 7.03846 |
| DBPO (mmHg) | 62 | 70.00 | 92.00 | 75.7097 | 5.54974 |
| Duration at work (Years) | 62 | 1.00 | 20.00 | 9.2419 | 5.37964 |
| Noise (dB) | 62 | 86 | 103 | 92.85 | 5.919 |
| Age (Years) | 62 | 18.00 | 48.00 | 31.6129 | 7.71703 |
| Valid N (listwise) | 62 | | | | |

SBPM = Systolic Blood Pressure during morning duty.
SBPN = Systolic Blood Pressure during night duty.
SBPO = Systolic Blood Pressure during off duty.
DBPM = Diastolic Blood Pressure during morning duty.
DBPN = Diastolic Blood Pressure during night duty.
DBPO = Diastolic Blood Pressure during off duty.

the blood pressures of the workers. The duration of each of the participants at work was also obtained.

### 5.3. *Statistical analysis*

The data obtained were analyzed using the descriptive statistics and One-way Analysis of Variance (ANOVA) on SPSS 16.0 statistical package. For the descriptive statistics, on SPSS, analyze was selected, then descriptives. For analysis using One-way ANOVA, analyze was selected, then compare means and then One-way ANOVA.

## 6. Results

Table 1 shows the descriptive statistics of the data obtained from the study. The values of the systolic blood pressure when the workers were off work (SBPO) were consistently lower than systolic blood pressure during the morning duty (SBPM) and systolic blood pressure during the night duty (SBPN) with $p = 0.001$.

Table 2 shows descriptive of the SBPO, SBPM and SBPN while Table 3 shows the ANOVA table for comparison between the means of SBPO, SBPM and SBPN. From Table 3, since the $p$-value (0.000) is less than 0.05; it means that there is sufficient evidence to conclude that at least one of the means of SBPO, SBPM and SBPN is different from the others.

However, no significant differences were observed between diastolic blood pressure of the workers during morning duty (DBPM) and during night duty (DBPN). Similarly, there were no significant differences between the values of DBPM and the diastolic blood pressure of the workers when they were off work (DBPO).

Fig. 1 shows that the SBPN, SBPM and SBPO values decreased steadily from when the noise level was about 86 dB until the noise level was about 89 dB and increased steadily until the noise level was 91 dB. Their values also decreased from 91 dB until the noise level reached about 95 dB before it increased until the maximum noise level in the factory was reached.

Fig. 2 shows the relationship between the values of DBPM, DBPN and DBPO. The DBPM and DBPO values followed the same from when the noise level was about 85 dB until it was about 90 dB. However, while these values increased, those of DBPN decreased until the noise level was about 88 dB before they increased.

The highest noise values (Fig. 3) were obtained in the power house (generator) followed by TF, PRESS, GT, LAM and CONVERSION in that order. There were no significant differences between SBPM and SBPO for the workers in the power house ($p = 0.138$) and those in CONVERSION ($p = 0.287$). However, there were significant differences between SBPM and SBPO for workers in GT ($p = 0.021$), LAM ($p = 0.008$) and TF ($p = 0.019$). Moreover, there were no significant differences between SBPN and SBPO for the workers in CONVERSION ($p = 0.084$). There were significant differences between SBPN and SBPO for workers in power house ($p = 0.042$), GT ($p = 0.000$), LAM ($p = 0.000$), PRESS ($p = 0.013$) and TF ($p = 0.002$).

**Table 2 – Descriptive of SBPM, SBPN and SBPO.**

| | N | Mean | Std. deviation | Std. error | 95% Confidence interval for mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper bound | | |
| 1 (SBPM) | 62 | 121.6452 | 12.00286 | 1.52437 | 118.5970 | 124.6933 | 100.00 | 152.00 |
| 2 (SBPN) | 62 | 126.1774 | 12.14060 | 1.54186 | 123.0943 | 129.2606 | 110.00 | 176.00 |
| 3 (SBPO) | 62 | 117.4355 | 9.98790 | 1.26846 | 114.8990 | 119.9719 | 100.00 | 142.00 |
| Total | 186 | 121.7527 | 11.90835 | 0.87316 | 120.0301 | 123.4753 | 100.00 | 176.00 |

**Table 3 – ANOVA of SBPM, SBPN and SBPO.**

| | Sum of squares | df | Mean square | $F$ | Sig. |
|---|---|---|---|---|---|
| Between groups | 2370.140 | 2 | 1185.070 | 9.087 | 0.000 |
| Within groups | 23864.484 | 183 | 130.407 | | |
| Total | 26234.624 | 185 | | | |

In all the sections, there were no significant differences between DBPM and DBPO with $p = 0.310$, $p = 0.430$, $p = 0.179$, $p = 0.226$, $p = 0.882$ and $p = 0.279$ for CONVERSION, LAM, PRESS, TF, GENERATOR and GT respectively.

Similarly, in all the sections except for CONVERSION, there were no significant differences between DBPN and DBPO.

## 7. Discussion

The present study confirmed that the blood pressure of the workers increased while at work. Though the workers were in a noisy environment and there was a tendency that a combination of exposure to noise and shift working has an additive effect on occurrence of hypertension (Attarchi et al., 2012), this may not be the case in the present study. This is because all the workers were shift workers and there were significant differences between the blood pressures of the workers while at work and off work with those in the noisier sections having higher blood pressures than others. The current study therefore established that the increase in systolic blood pressures of the workers was as a result of exposure to noise. This is in agreement with the study of Lee et al. (2009) on workers of a metal manufacturing company in Busan, Korea which established a significant relationship between chronic noise exposure and increase in systolic blood pressure. This study also agrees with the studies of Tomei et al. (2000) and Chang et al. (2003). Similarly, Zamanian et al. (2013) stated steel industry workers' systolic blood pressure increased compared to before the exposure to noise though the difference was not statistically significant ($p > 0.05$). Moreover, Sadeq et al. (2013) found that systolic blood pressure and diastolic blood pressure correlated positively with occupational noise levels in the all hospitals they conducted the study. The review of all the studies published in the English language between 2000 and 2013 by Lyzwinski (2014) showed a strong positive association between occupational noise exposure and cardiovascular outcomes. Fogari et al. (2001) found that industrial noise exposure above 85 dBA had a transient effect of increasing systolic blood pressure in people less than fifty years. The current study is however at variance with the study of Hessel and Sluis-Cremer (1994) that found no significant relationship between blood pressure and noise exposure. Though, how noise increase blood pressure has not been properly identified, the release of stress hormones such as steroids and activation of the sympathetic nervous system with release of epinephrine when workers are exposed to noise were identified as the reasons (Kelsey et al., 1999). Chang et al. (2003) also listed two possible mechanisms that initiate hypertension resulting from noise exposure as through sympatheticotonia-induced endothelial lesion and stress-induced hormone

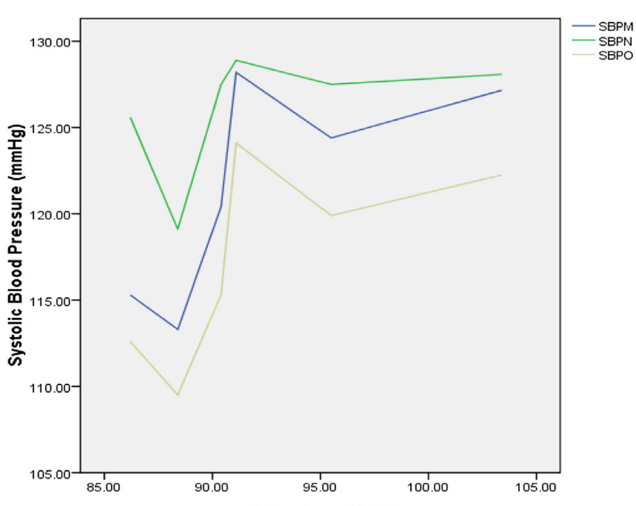


**Fig. 1 – Relationship between noise levels and Systolic Blood Pressure of the participants.**

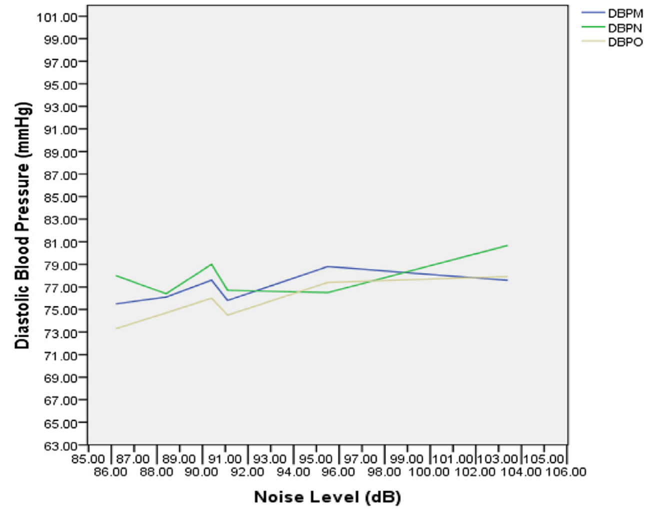


**Fig. 2 – Relationship between noise levels and Diastolic Blood Pressure of the participants. DBPM = Diastolic Blood Pressure in the Morning; DBPN = Diastolic Blood Pressure at Night; DBPO = Diastolic Blood Pressure during off duty.**

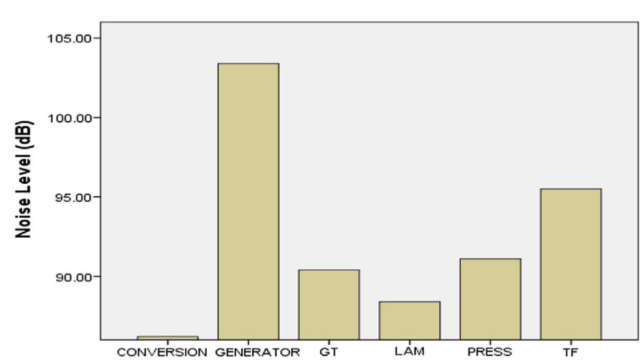


**Fig. 3 – Noise levels in the sections of the company.**

release. Acute noise exposure may lead to the activation of sympathetic reflex immediately (Casto et al., 1989), accelerating the development of structural changes in the cardiovascular system, and finally induce a sustained elevation of blood pressure (Jonsson and Hansson, 1977). Babisch (2011) opined that acute noise exposure, in both laboratory settings where traffic noise was simulated and in real-life environments, can cause increases in blood pressure, heart rate, and cardiac output, likely mediated by the release of stress hormones such as catecholamines.

Another study observed that the biological effects of noise exposure on blood pressure was the high secretion of vasoconstrictors in urine as a result of being exposed to more than 90 dB noise (Neghab et al., 2009). The current study also confirmed an earlier study (Attarchi et al., 2012) that exposure to noise did not significantly increase the diastolic blood pressure. However, it did not support some other studies (Neghab et al., 2009; Ising and Braun, 2000; Motamedzade and Ghazaiee, 2003; van Kempen et al., 2002) that found that exposure to noise significantly increase diastolic blood pressure.

The current study seems to suggest that workers should not be exposed to more than 89 dB as this had the least systolic blood pressures, though the diastolic blood pressures had least values at about 91 dB. However, an experimental study conducted in the laboratory had found that workers' blood pressure increased after exposure to industrial noise levels greater than 95 dBA (Holand et al., 1999). The main limitation of the current study is number of participants that are small and it is therefore suggested that a study with more number of participants should be carried out.

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