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Impact of Noise Pollution on the Hearing Capability of Industrial Workers in Lagos State, Southwest, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors performed the study design and experimental configurations. The field work was performed by author WCA and in discussion with author ASO. Authors ASO and WCA processed the final data and wrote the first short draft of the manuscript. Author ASO read and approved the final manuscript.

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ABSTRACT

Noise induced hearing loss is a long known occupational hazard. The hearing loss is usually irreversible but preventable. The purpose of this study is to determine the impact of noise pollution on the hearing capability of industrial workers in Lagos State, Southwest, Nigeria. The study was carried out in the following industries: West African Gas Pipeline Company (WAPCo), Badagry; Niji-Lukas Engineering and Fabrication Firm, Isheri-Idimu; Beta Glass Company, Agbara; Alimoso Printing Press and Sawmill Factory, Ibereko - Badagry. Out of 105 subjects randomly selected by simple random sampling method, 100 subjects responded, which consist of Noise-exposed and Non-noise exposed, based on their noise exposure level in their work environment. Audiometric examination and noise mapping of the various departments in each industry were conducted. The data were analysed using Microsoft Excel spread sheets and IBM Statistical Package (SPSS) Software (Version 20.0) and the results are presented in percentage tables and multiple bar charts. Subjected inferential statistics for formulated hypotheses were analysed using Analysis of Variance (ANOVA), with 5% level of significance (P<0.05). The study showed that West African Gas Pipeline

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workers had a hearing threshold value of 23.68±5.27, which is on a close value with 22.29±4.92 of the control group (Non-noise exposed) and Alimoso Printing Press has 24.6±5.28, while Sawmill Factory workers, Beta Glass Industrial workers and Niji-Lukas Engineering Industry workers suffer mild noise induced hearing loss with 29.79±7.62, 30.18±8.27 and 41.5±6.4 threshold values respectively. The study also showed a poor usage of personal protective equipment by the workers in the industries; 68% of Sawmill Factory workers, 25% in Beta Glass Industry, 8% in WAPCo, 60% in Printing Press and 25% of Niji-Lukas workers do not use hearing protective device at all. This prevalence of occupational noise-induced hearing loss among the industrial workers is high due to exposure to high noise level above 85 dBA, poor usage of hearing protective device and a prolonged exposure to noise (10-12 hours per day).

Keywords: Noise pollution; hearing capability; industrial workers; work environment.

1. INTRODUCTION

Industrial noise is one of the major sources of noise pollution. Noise is generally defined as the unpleasant sounds which disturb human beings physically and physiologically and cause environmental pollution by destroying environmental properties [1]. Sound becomes unwanted when it either interferes with normal activities, such as sleeping, conversation, or disrupts or diminishes one's quality of life and health.

Industrial noise is a noise associated with industrial processes that may cause hearing damage as a result of the high decibel level, particularly among employees who experience consistent and prolonged exposures, like people on the factory floor. Measures for controlling industrial noise are necessary in order to protect workers. Prolonged exposure to unpleasant noises or even a pleasant sound which is too loud can lead to hearing impairment, severe mental disorientation and in some cases violent behaviour [2,3].

One of the important problems of noise sources is industrial noise. The general effect of industrial noise on the health of workers has been a topic of debate among scientists for a number of years [4]. The large, medium and small scale hand tool manufacturers in developing countries are lagging far behind in implementing hearing conservation, noise control programmes, occupational health and safety programmes. These industries have plenty of devices and machines that are considered as a source of noise, such as: rotors, cutting machines, motors, compressors, electrical machines, internal combustion engines, drilling, crushing, fans and transportation resources. The noise level generated depends mainly on the type of the noise source such as the kinds of machines, distance from the source to the employee or receiver and the nature of the working environment. Consequently, the workers of hand tool industrial are exposed to the noise levels beyond the permissible limits. High noise exposure in industries not only affects the communication among the workers, but also leads to other psychological and physiological effects on the workers [5].

Hearing problem is as a result of any unwanted sound that our ears have not been built to filter and can cause problems within the body [6]. Our ears can take in a certain range of sounds without getting damaged. Constant exposure to loud levels of noise can easily result in the damage of our ear drums and loss of hearing. It also reduces our sensitivity to sounds that our ears pick up unconsciously to regulate our body's rhythm. Then excessive noise is clearly a health problem. The interference is felt at three distinct levels, that is audio-logical, biological and sociological [7].

It is imperative for industrial workers to take proactive steps in protecting themselves from the harmful effects of noise pollution. If people must be around loud sounds, they can protect their ears with hearing protection (e.g. ear plugs or ear muffs). There are various strategies for combating noise in industries, home, school, workplace, and the community. Negative effects of noise on human beings are generally of a physiological and psychological nature. Hearing losses are the most common effects among the physiological ones. It is possible to classify the effects of noise on ears into three groups: acoustic trauma, temporary hearing losses and permanent hearing loss [8,9].

Noise does not only disturb human work, sleep, rest and communication but it also damages the hearing capacity and evokes other psychological, physiological and possibly pathological reactions. Noise contributes to the development of

cardiovascular problems, like heart disease and high blood pressure due to construction of the peripheral blood vessels [10]. Experiments have shown that rise in noise level will result in hearing loss in workers exposure to high noise level [11-13].

This study, is therefore, carried out in five different industries in Lagos state, Nigeria. The sites are West African Gas Pipeline Company (WAPCo), Badagry; Niji-Lukas Engineering and Fabrication Firm, Isheri-Idimu; Beta Glass Company, Agbara; Alimoso Printing Press and Sawmill Factory, Ibereko – Badagry, with the aim of identifying the sources of the noise pollution, measuring the noise level with sound level meter (SLM), administering well-structured questionnaires and conducting audiometric examination to determine the impact of noise pollution on the hearing capability of the industrial workers in Lagos state, Southwest, Nigeria.

2. MATERIALS AND METHODS

2.1 Area of Study

The study took place at Alimosho, Isheri-Idimu, Badagry and Agbara industrial estate of Lagos state. The following industries were used for the study: West African Gas Pipeline Company (WAPCo), Badagry; Niji-Lukas Engineering and Fabrication Firm, Isheri-Idimu; Beta Glass Company, Agbara; Alimoso Printing Press and Sawmill Factory, Ibereko – Badagry.

2.2 Research Design

A combination of experimental and survey design was used for the study.

2.2.1 Experimental design

Experimental design was used to determine the hearing threshold level of the industrial workers and to ascertain the level of noise emitted from each noise source in the industry. Permission was sought from the Human Resources personnel and verbal approval from the leaders in Industries where there is no HR person in order to conduct clinical audiometric examination on the workers across the units where production takes place in the company, including those that are not having direct contact with the equipment i.e. the control group. As the employers would not allow their workers leave worksite, and go to nearby audiometric test room or hospital for audiometry, the audiometric examination was conducted in office room, company's clinic ward and open place with background noise level of 35-40 dBA. The test was done for 100 workers as against 105 samples across the industries. A pure tone audiometry was done in 5 dBA steps at frequency 500, 750, 1000, 1500, 2000, 3000, 4000, 6000, 8000 Hz for both ears using calibrated manual type air conduction instrument, EB-350-I and was recorded on a standard audiogram. Hence, hearing impairment was calculated and classified using the pure tone average of frequencies of 500, 1000 and 2000Hz according to the World Health Organization Guidelines for Community Noise [14];

Normal hearing =< 25 dBA hearing threshold level (HTL).
Mild hearing impairment = 26-40 dBA.
Moderate hearing impairment = 41-60 dBA HTL.
Severe hearing impairment = 61-80 dBA HTL [15].

2.2.2 Audiometer description

A manual type air conduction instrument, EB-350-I, portable all solid audiometer designed for industrial, medical and school hearing tests, with factory calibration of ANSI-69 reference levels was used to conduct audiometric examination on the workers to determine hearing threshold loss (HTL). Frequency ranging from 125 Hz to 8000 Hz and a pure tone audiometry scaled from 0 dBA to 110 dBA were calibrated on the instrument. The audiometer contains accessories like double headset / cable assembly and patient signal /cable assembly.

2.2.3 Noise survey

In each of the industries, the intensity of the noise was determined with the use of a digital calibrated sound level meter (SLM) at each noise source point. The Testo- 815 compact class sound level meter was used. It is calibrated in decibel (dBA), within 50-120 dBA range and with accuracy of +2 dBA at 114 dBA sound levels and a standard reference of 0.0 dBA at 0.002 micro-newton per square meter. The maximum noise-levels range obtained are:

i. West African Gas Pipeline Company (WAPCo); 88.9 dBA - 123.1 dBA
ii. Niji - Lukas Engineering and Fabrication Firm; 85.6 dBA - 94.7 dBA
iii. Beta Glass Company; 96.8 dBA - 97 dBA

iv. Sawmill Factory; 90.2 dBA - 97.5 dBA
v. Alimoso Printing Press; 80 dBA- 86 dBA

2.3 Survey Design

In addition to the experimental survey, a well-structured 25- self-responded health status questionnaire was administered. This is to determine the hearing status of the workers, cutting across the worker's personal data, personnel sensitivity to noise, psychological effect and physiological effect of the noise on the workers. An average of twenty (20) questionnaires were administered in each of the five industries to workers exposed to high noise level and the non-noise exposed workers, (control group) which comprises of the housekeepers, security men, office staff, sales men and women that do not have direct contact with the source of noise pollution. A total of 105 questionnaires were distributed among worker across the industries, 100 questionnaires were properly administered (control group inclusive). The purpose of the questionnaire includes:

- To determine the effect of noise on workers' age.
- To establish a cognitive effect of noise pollution on the industrial workers over a service period in each industry.
- To determine workers attitude and comments towards the use of hearing protective devices.

The responses in the questionnaires were transferred to a four point likert scale by assigning the rating from 1 to 4, with response interpretation relatively varying from strongly agreed, agreed, strongly disagreed to disagree to rate the responses.

2.4 Procedure for Data Collection and Analysis

The researchers having put ear protection equipment inserted a dry cell battery and switched on the sound level meter. The calibration switch was turned high for the measurement of high noise level. The trigger was then pressed and an infra-rayed red lens light pointed at the point of interest and noise level was measured and recorded. Data were collected from the noise sources in the five industries selected for the study.

The audiometric examination was performed in the offices and the clinic with low noise level. The audiometer was powered with the A.C. cable connected to the power output source. On the upper right corner of the audiometer panel is a power ON-OFF switch which when switched on will show an indicator on the pilot light. The worker to be sampled was made to be comfortably seated opposite the researchers and facing a side so that he cannot directly observe the facial expression or hand manipulation of the researcher. A table with the audiometer placed on it, was used to separate the researcher and the worker. However, the researcher explained to the worker on how the audiometric test will go in order for him to have a clear understanding of the exercise. A headset was placed on the worker's head and a signal button for him to press when he hears a tone and to relax the button if he does not, with each tone varying in intensity.

The researchers started with 500 Hz frequency from decibel of about 70 dBA, decreasing the intensity level in step of 10 dBA until a decibel setting is arrived at where there is no response. At this point, we started increasing the decibel setting in step of 5 dBA. The lowest tone decibel dial setting at which the worker responded was recorded and is considered as his hearing threshold. This was also repeated for confirmation before proceeding to the next frequency. The exercise was conducted on both ears (Blue for left ear and Red for right ear) and the results were charted on an audiogram. The pure tone average of the results on decibel levels for 500, 1000 and 2000Hz frequency was calculated for hearing threshold level (HTL) for both ears.

For statistical analysis, all questionnaires administered and audiometric results evacuated were collected and analyzed using Analysis of Variance (ANOVA) as Microsoft Excel. Statistical Package for Social Scientists (SPSS) was used to test the hypotheses and result analysis.

3. RESULTS AND DISCUSSION

The results of the analyses are presented, beginning with the noise intensity and the presentation of demographics of the respondents in each industry.

3.1 Industrial Noise Intensity

The intensity of the Noise level in each of the Industries is presented in Table 1 to 5.

Table 1. Noise level measured at Sawmill Factory

Equipment type	Maximum noise level (dBA)
Band saw	91.7
Planning saw	90.2
Cross cut saw	97.5
Molding saw	95
Peeler	92
Ambient	61.4

Table 2. Noise level measured at Niji Lukas Engineering and Fabrication Company

Equipment type	Maximum noise level (dBA)
Diesel generator	89.2
Milling machine	87
Grinding machine	94.7
Bending machine	85.6
Ambient	56.7

Table 3. Noise level measured at West African Gas Pipeline Company (WAPCo)

Equipment type	Maximum noise level (dBA)
Gas turbine compressor	123.1
Gas engine generator house	103.9
Air compressor	88.9
Ambient	58.4

3.2 Descriptive Statistics

Table 6 and Fig. 1 represent responses from the respondents in order to determine the age distribution of workers that are exposed to noise pollution in each industry. The result in the table and figure implies that the age distribution is relatively similar. The result also showed that majority of the workers is within the age bracket of 31-40 years while others are within the age bracket 20-30 years.

Table 4. Noise level measured at Beta Glass Company

Equipment type	Maximum noise level (dBA)
Production Hall	96.8
Compressor / Boiler	96.5
Furnace Area	96.8
Hot End	97
Utility Section	91.0
Gate Ambient	71.7

Table 5. Noise level measured at printing press

Equipment type	Maximum noise level (dBA)
Letter press printing machine	83

Table 7 and Fig. 2 represent responses to elucidate the attitude of workers towards the use of personal protective equipment (PPE) in each industry. The result showed that workers at WAPCo are more oriented on the use of PPE, while workers at Sawmill and others did not show good attitude towards the use of hearing protective devices.

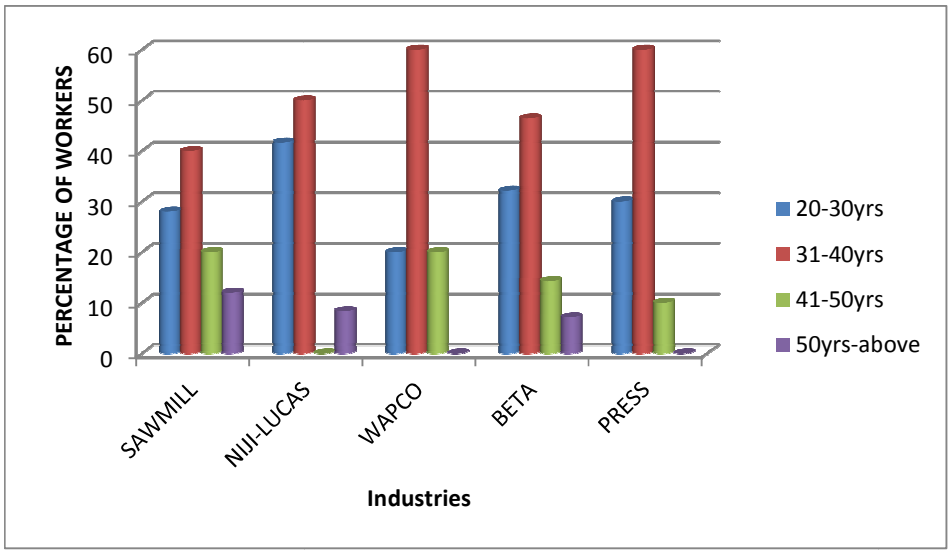

Fig. 1. Age distribution of workers in each industry

Table 8 and Fig. 3 represent responses to ascertain the number of years of exposure to noise pollution in each industry as deduced from the service years in the industry. The results showed that majority of the workers have only spent 5 years in the industry. More also, a significant percentage of the workers have only spent between 5-10 years working in the industries while a small percentage of the workers have spent more than 10 years. It is also worth knowing that no worker has spent above 20 years in Niji-Lucas.

Table 6. Age distribution of workers in each industry

Age- group	Sawmill	Niji-Lucas	WAPCo	Beta	Press
20-30 yrs	7	5	5	9	3
31-40 yrs	10	6	15	13	6
41-50 yrs	5	0	5	4	1
50 yrs-above	3	1	0	2	0
Total	25	12	25	28	10

Table 7. Attitude of workers towards the use of personal protective equipment in each industry

PPE usage	Niji-Lucas	Sawmill	WAPCo	Beta	Print
Very often	0	20	68	50	20
Occasionally	50	4	24	21.42857	20
Seldom	25	8	0	3.571429	0
Not at all	25	68	8	25	60
Total	100	100	100	100	100

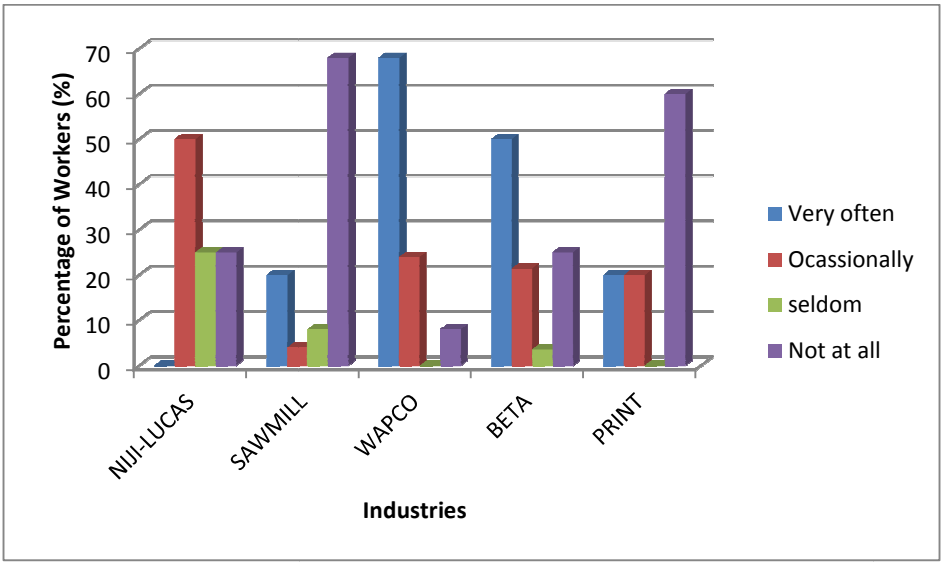

Fig. 2. Attitude of workers towards the use of personal protective equipment in each industry

Table 8. Number of years spent in the industry by workers in each industry

	Niji-Lucas	Sawmill	WAPCo	Beta	Print
1-4 yrs	5	11	5	12	3
5-10 yrs	3	8	8	11	5
11-20 yrs	4	4	4	3	1
21-35 yrs	0	2	2	2	1
Total	12	25	19	28	10

Table 9 and Fig. 4 represent responses from the respondents to ascertain the daily exposure hours of the workers to noise pollution in each industry as deduced from the hours spent at work per day. The result shows that majority of the workers spent between 10-12 hours at work. At Niji-Lucas, no workers spend 8-9 hours at work. A significant percentage of the respondents also spend 8-9 hours in the industries except at Niji-Lucas. Workers at WAPCo tend to spend more hours at work than workers in other industries.

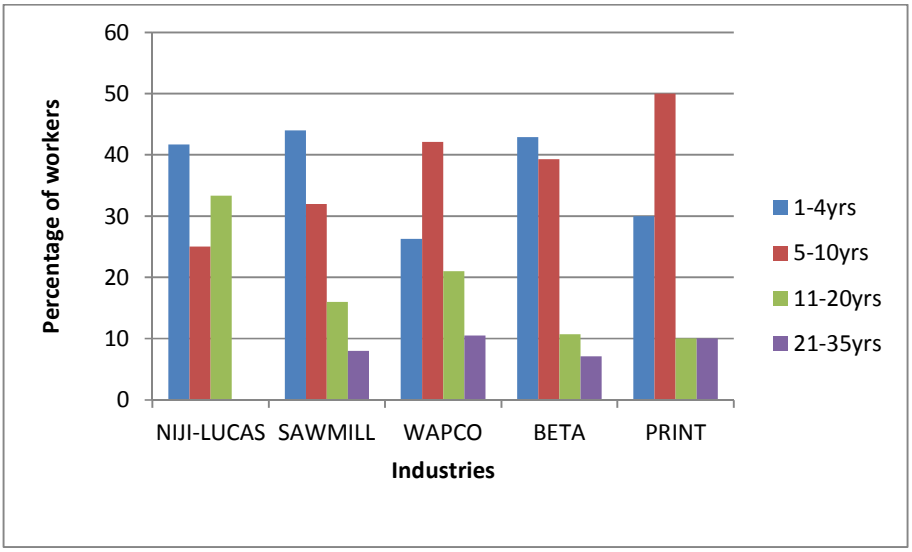

Fig. 3. Percentage number of years spent in the industry by workers in each industry

Table 9. Number of hours per day spent at work by workers in each industry

	Niji-Lucas	Sawmill	WAPCo	Beta	Print
4-6 hours	2	11	3	7	2
8-9 hours	0	13	12	16	4
10-12 hours	10	1	10	5	4
13-24 hours	0	0	0	0	0
Total	12	25	25	28	10

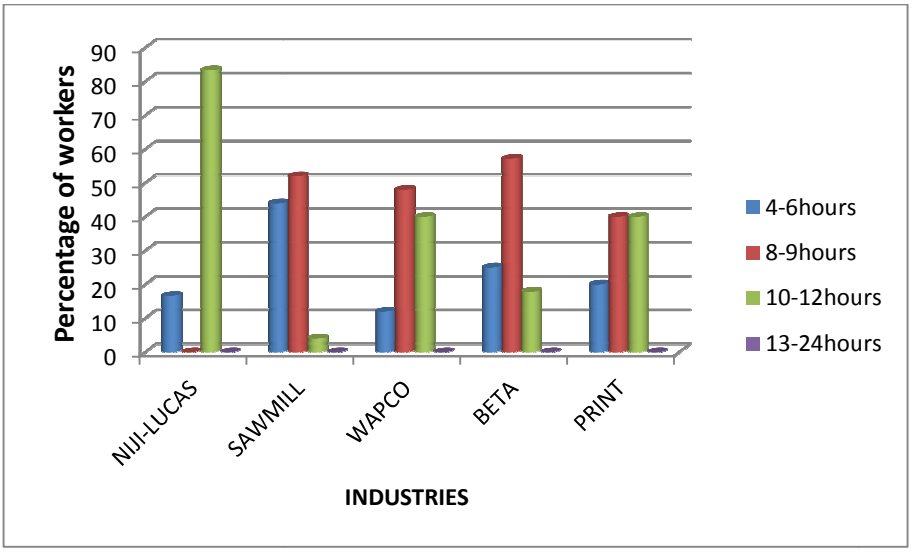

Fig. 4. Percent number of hours per day spent at work by workers in each industry

Table 10 and Fig. 5 represent the result from the audiometric examination on the workers left ears. These results show the hearing threshold level of noise exposed workers as compared to the control group (non-noise exposed workers) in each industry. From the results, it is observed that large percentages of the subjects in the control group have normal hearing capability as seen in their audiometric result (i.e. =<25 dBA). However, subjects that are exposed to noise pollution have their hearing threshold levels higher than normal. Hence, suffer noise induced hearing loss or disabling hearing capability. It is also worth knowing that workers in Sawmill and Beta glass suffer noise induce hearing impairment than others. It is obvious that higher percentage of her workers had hearing threshold values above normal. Also, no worker in Niji-Lucas is within a normal hearing threshold value. Higher number of WAPCo and Printing Press staff is within a normal hearing threshold value when compared to workers of other industries.

Table 11 and Fig. 6 represent the result from the audiometric test on the workers right ears. These results show the hearing threshold level of the workers when exposed to noise pollution as compared to the non-non exposed workers (control group). It was observed that large percentages of the subjects in the control group have normal hearing threshold value (=< 25 dBA). However, subjects that are exposed to noise pollution have hearing threshold values above normal 25dBA HTL, hence, suffering from noise induced hearing loss. It is also worth knowing that workers in Sawmill suffer noise induced hearing impairment than others. Also, majority of the workers in WAPCo had normal hearing threshold value when compared to other workers in similar condition.

Table 10. Degree of left ears hearing Impairment of workers exposed to noise pollution in each industry as compared to control group

	Control	Niji-Lucas	Sawmill	WAPCo	Beta	Press
Normal hearing <25 dBA	85.72	0	30.43478	77.778	41.667	63.64
Mild hearing impairment 26-40 dBA	14.286	44.444	60.870	22.222	37.5	27.27
Moderate Hearing impairment I 41-60 dBA	0	55.556	8.696	0	20.833	9.09
Severe Hearing Impairment 61-80 dBA	0	0	0	0	0	0

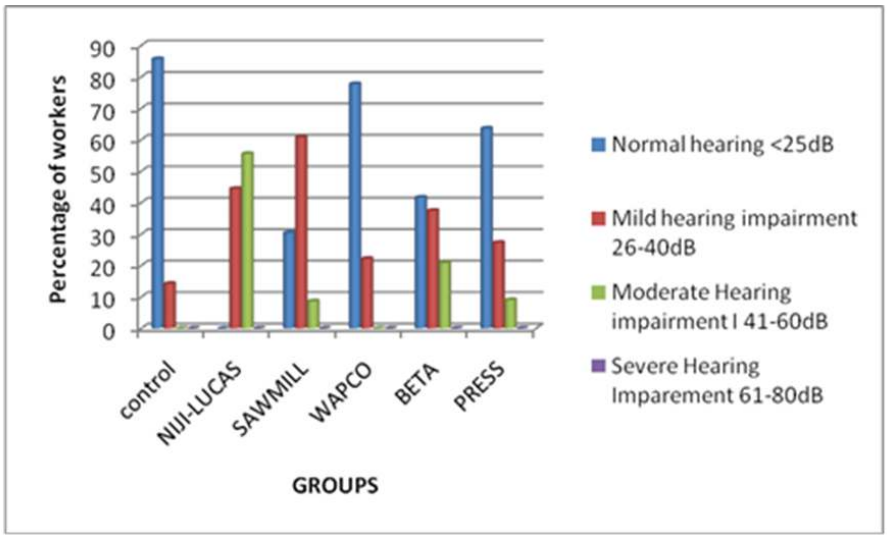

Fig. 5. Degree of left ears hearing Impairment of workers exposed to noise pollution in each industry as compared to control group

Table 11. Degree of right ears hearing Impairment of workers exposed to noise pollution in each industry as compared to control group

	Control	Niji-Lucas	Sawmill	WAPCo	Beta	Press
Normal hearing <25 dBA	71.428	0	30.43478	72.222	50	80
Mild hearing impairment 26-40 dBA	28.573	55.556	56.522	22.222	37.5	20
Moderate Hearing impairment I 41-60 dBA	0	44.44	13.04348	5.556	12.5	0
Severe Hearing Impairment 61-80 dBA	0	0	0	0	0	0

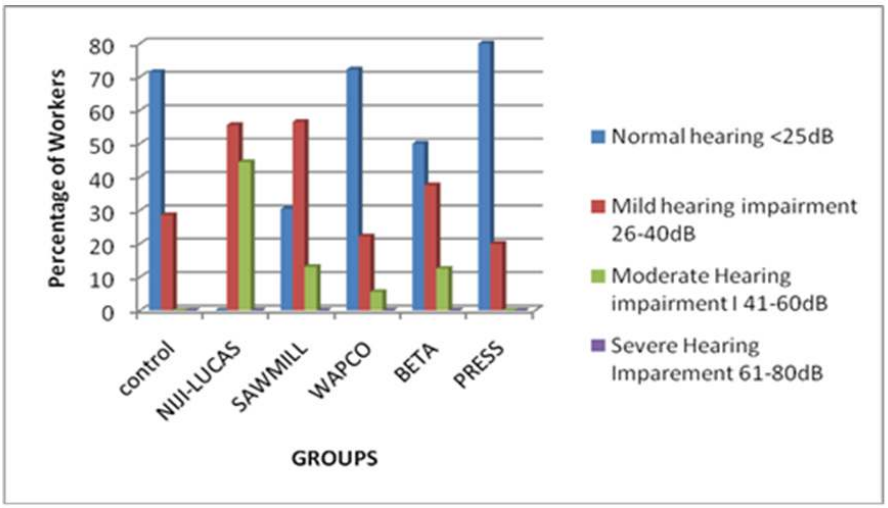

Fig. 6. Degree of right ears hearing Impairment of workers exposed to noise pollution in each industry as compared to control group

Table 12 and Fig. 7 show degree of left ear noise induced hearing Impairment of workers of different age group exposed to noise pollution. The result showed that majority of the workers between ages 31-40 years suffer more noise induced hearing loss than others. Also, as the age group increases, the number of subjects with normal hearing threshold values decreases. This was observed in ages within 41-50 years where number of workers with normal hearing threshold level is lower when compared to those in lesser age range. In age bracket above 50 years, there are no workers with normal hearing value.

Table 13 and Fig. 8 show degree of right ears noise induced hearing loss of workers of different age group exposure to noise pollution. This shows that majority of the workers between ages 31-40 years suffer more noise induced hearing impairment than others. Also, as the age group increases, the number of subjects with normal hearing threshold values decreases. This is marked in ages within 41-50 years where number of workers with normal hearing threshold values is lower when compared to those in lesser age range. There are no workers with normal hearing capability in the age bracket above 50 years.

Table 12. Degree of left ears hearing Impairment of workers of different age group exposed to noise pollution

	20-30 yrs	31-40 yrs	41-50 yrs	50 yrs-above
Normal hearing <25 dBA	17	24	1	0
Mild hearing impairment 26-40 dBA	10	17	9	2
Moderate Hearing impairment I 41-60 dBA	3	7	1	1
Severe Hearing Impairment 61-80 dBA	0	0	0	0
Total	30	48	11	3

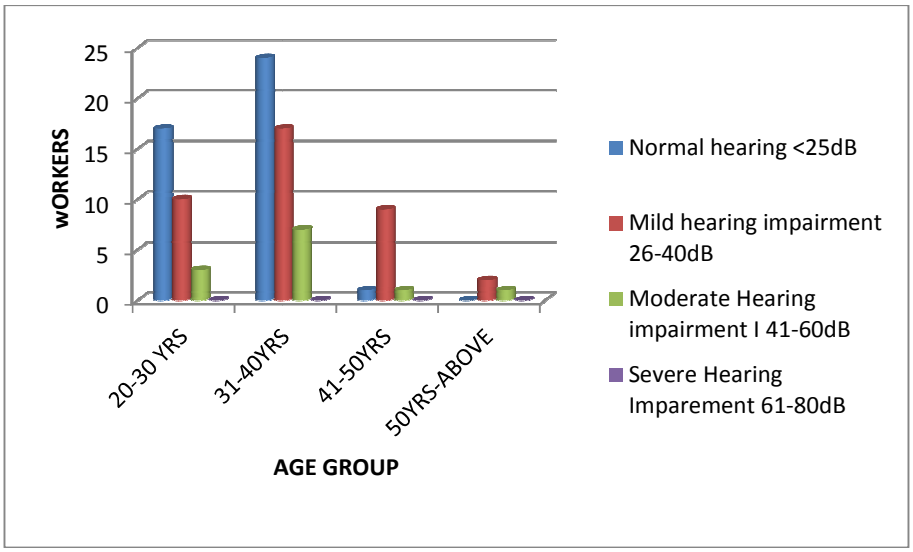

Fig. 7. Degree of left ears hearing Impairment of workers of different age group exposed to noise pollution

Table 13. Degree of right ears noise induced hearing impairment of workers of different age group exposed to noise pollution

	20-30 yrs	31-40 yrs	41-50 yrs	50 yrs - above
Normal hearing <25 dBA	17	22	2	0
Mild hearing impairment 26-40 dBA	10	21	6	2
Moderate Hearing impairment I 41-60 dBA	2	4	3	1
Severe Hearing Impairment 61-80 dBA	0	0	0	0
Total	29	47	11	3

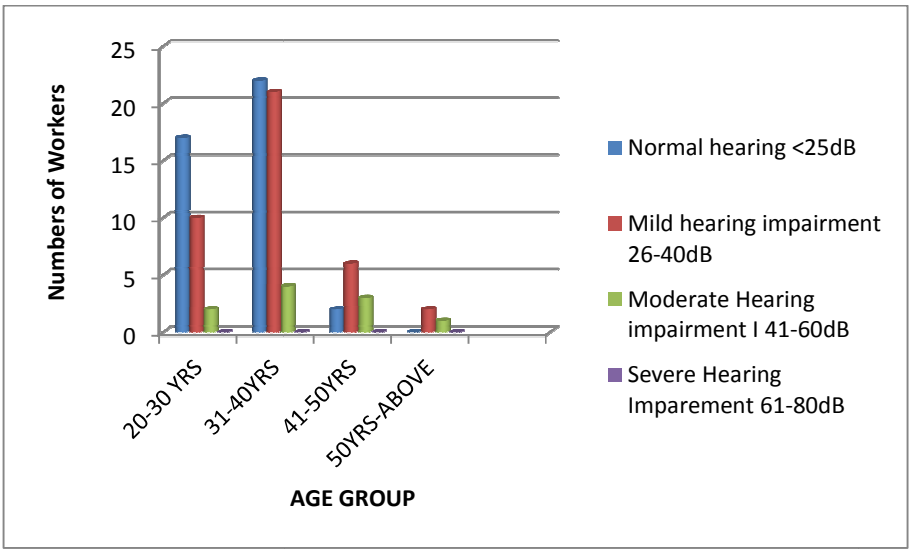

Fig. 8. Degree of right ears hearing Impairment of workers of different age group exposed to noise pollution

4. DISCUSSION

The selected 105 workers aged between 20 and 55 years which consist of the targeted group and the control group. The average age of the subjects is 35 years. The results in the study showed that majority of the subjects are within the age bracket of 31-40 years.

The results also showed the attitude of the subjects towards the use of hearing protective equipment across the industries. 20% of Sawmill workers, 68% of WAPCo workers, 50% of Beta Glass workers, 20% of Printing press workers often use hearing protective equipment and no subject (0%) in Niji Lukas Engineering Company agreed to use hearing protection often. Despite a very high noise intensity of 88.9 -123.1 dBA from the equipment in West African Gas Pipeline Company facility as shown in Table 3, which is in agreement with [16] for the result in Nigeria Agip Oil Company, Omoku Gas plant, WAPCo workers among other industries where audiometric test was conducted recorded the highest percentage (77.8%) of workers with no effect of noise-induced hearing impairment except for subjects in the control group with 85.7%. Only 30.4% of Sawmill factory workers had normal hearing threshold. This is as a result of the workers frequent use of hearing protective equipment at work.

It was also observed that the hearing threshold loss value is increasing with respect to noise intensity level and exposure period to noise. From the results obtained across the industries, higher numbers of subjects who spent 10-12 hrs /day were observed to have suffered noise-induced hearing loss (NIHL) with an exposure to noise level above 85 dBA which is above the standard maximum permissible noise level for human described by the National Environmental Standards and Regulations Enforcement Agency [17]. Some percentage of workers who spend 8-9 hrs/day was also observed to have suffered noise-induced hearing loss because the subjects were exposed to noise without using any personal protective equipment.

5. CONCLUSION

The purpose of this study is to determine the impact of noise pollution on the hearing capability of industrial workers in Lagos State, Southwest, Nigeria. The study was carried out in the following industries: West African Gas Pipeline Company (WAPCo), Badagry; Niji-Lukas Engineering and Fabrication Firm, Isheri-Idimu; Beta Glass Company, Agbara; Alimoso Printing Press and Sawmill Factory, Ibereko – Badagry. Results have shown that noise level in these industries exceeded the limiting value of 85 dBA, except Alimoso Printing press with 83 dBA noise level. The results of the audiometric examination conducted showed that 100% of workers in Niji-Lukas Engineering, 69% of Sawmills workers, 22% of WAPCo workers, 24% of Beta glass workers and 16% Printing press workers exhibit classic noise induced hearing impairment on either of their ears, while 14% of the control subjects exhibited hearing impairment.

However, it was found that there is a significant correlation between the service period of the workers and the duration of exposure with hearing impairment. Also, the study showed that there is a positive relationship between noise-induced hearing loss and use of personal protective equipment on a pure-tone average of hearing threshold level. But there is no significant relationship between workers in the Printing press and the control group.

The results of this study have, therefore shown that industrial noise exposure has a significant impact on the hearing capability of the industrial workers in all age groups as compared with the control group. This result is in agreement with the India cotton ginning industry [18].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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