Available online at www.elixirpublishers.com (Elixir International Journal)

Medical and Health Science

Elixir Medical and Health Sci. 99 (2016) 43018-43025

ISSN: 2229-712X

Health Effects of Noise Exposure among the 'Juakali' Workers: A Case Study of King'orani "Jua Kali" Artisans in Mombasa County, Kenya

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ARTICLE INFO

Article history:

Received: 4 September 2016;
Received in revised form:
1 October 2016;
Accepted: 5 October 2016;

Keywords

NIHL,
DB,
OSHA,
Hazard,
Artisan,
Threshold.

ABSTRACT

The informal (*Juakali)* sector in Kenya lack occupational health and safety services and workers unknowingly exposed to health hazards. Worldwide, occupational noise is a significant cause of adult onset-hearing loss and 16% of disabling hearing loss in adults. . The aim of the study was to identify the health effects of noise to the *Juakali* artisans in King'orani area by identifying key sources of noise, assessing hearing threshold levels, examining auditory health effects of noise and the prevalence of noise induced hearing loss. This was through administration of a structured questionnaire, noise level measurements, and pure tone eudiometry to stratified, randomly selected subjects. Data was coded cleaned and analyzed using SPSS version 21.0. Out of 124 participants involved in the study, prevalence of NIHL was 59.7% with 31.5% having mild, 18.5% moderate, and 5.7% had severe, and 4% had profound impairments. The level of impairment increased with the duration and level of exposure to noise above 90 dB. Those involved in operation of pneumatic tools were the most affected compared to those involved in other activities as food vendors and hawkers. Exposure level and duration was greatly associated with auditory effects such as Tinnitus, headache, poor concentration, and sleep disorders. In conclusion NIHL, headaches, tinnitus, poor concentration and sleep disturbances are related to prolonged exposure to high level of noise above 90dB with a positive correlation coefficient of 0.248 at $p<0.05$. Therefore, review of OSHA 2007 to effectively regulate the informal sector, awareness campaign on effects of noise exposure, establishment of Hearing monitoring canters, special subsidies and provision of PPEs will be able to arrest the otherwise forgotten irreversible disability causing Hazard the *Juakali* artisans are exposed to.

Introduction

In Kenya, the informal sector encompasses a range of economic units in urban areas with low levels of organization. Developing countries Kenya included rarely monitors the activities of informal sector and the working conditions of those employed; therefore, protection of the health and safety of workers in this sector is big challenge that requires an integrated approach to safety and health promotion (Theuri, 2012). Physical hazards including noise are associated with inadequate safety and health standards and are evident in the informal sector, whose workers do not have necessary awareness, technical means, and resources to implement safety and health measures. Due to lack of formal employment in Kenya up to 8 million (75%) of workforce are in the small-scale enterprises and the informal sector while only 2.8 million are in the formal sector (Theuri, 2012). Physical hazards are factors in the environment that can harm the body without necessarily touching it. They are the hazards that affect physical safety and include Noise, vibrations, extreme temperatures, and many others. Work related noise is one of the most common occupational hazards that are associated with irreversible hearing impairment. Noise is undesired sound or unwarranted disturbance within a useful frequency band; however, it is present in every human activity either occupational (workplace) or environment that include residential, community (Concha- Barientos *et al.*, 2014).

Noise pollution or disturbance is excessive noise that may harm the activity or balance of human life. A high level of occupational noise remains a problem in all regions of the world. Occupational hearing loss is the most common work related illness. In USA, 30 million workers are exposed to hazardous noise annually (NIOSH, 2014). In Germany 4-5 million (12-15% of the workforce) are exposed to noise levels defined as hazardous (Barientose *et al.*, 2004). Smaller enterprises are likely not to have effective noise control measure due to lack of adequate/ insufficient knowledge of the effects of hazardous noise on hearing, hearing loss and quality of life, believing that control cost too much or it will not happen to me and other cultures that resist change (perri-Timmins and Oliver Granger, 2010).

Traumatic noise exposure may cause an immediate hearing loss in some cases but most occupational hearing losses occur too gradually that workers are unaware they are losing their hearing. The rate of hearing loss growth is greatest during the first 10 years of exposure (NIOSH, 2008). The *Jua Kali* sector in Kenya is facing enormous health challenges that are threatening its very existence. The noise that the artisans are exposed to each day is far much beyond the recommended levels and some have already loosed sense of hearing totally (Kass FM, 2014).Levels of occupational safety and health in Africa are low compared with the rest of the world. This is because in sub-Sahara Africa public health problems are so massive that occupational health is sub-ordinate (spee, 2006). More than 90% of *Juakali* related activities generate noise above the recommended 90 dB, they include panel beating more than 100dB, Compressor used in Panel beating 90-100dB, Pneumatic tools majority produce sound greater than 90dB (Gerges *et al.,* 2006)

Noise is one of the most common physical hazards associated with some detrimental health effects. Noise induces hearing loss that occurs through excessive wear and tear to the delicate inner ear structures causing damage to the ear by progressive consequences. High levels of occupational noise remains a problem in all regions of the world; in the USA, 30 million workers are exposed to hazardous noise. While 242 million dollars spent annually on workers compensation for hearing loss disability (NIOSH, 2014).

Noise induced hearing loss is a well and long recognized occupational hazard; however mechanisms influencing attitudes towards noise hazards and prevention of hearing loss as a result are poor (Foluwasayo *et al.*, 2005). The gradual, uncertain, and hidden course the hearing loss among the informal sector workers takes, do reduce the priority in noise control as a safety and health issue. In the developing countries, noise induced hearing loss is the most common of occupational injuries. it is associated with social isolation, impaired communication with co-workers and family, decreased ability to monitor the work environment (warning signal, equipment sound), increased injuries (from impaired communication and isolation), expenses for workers' compensation and hearing aids, loss of productivity and decreased self esteem(Concha-Barientos *et al.,* 2008).

Efforts to address occupational health problems in these countries receive very little attention by health service planners due to inadequacy of data and long latency periods (Cauntley *et al.,* 2015). King'orani area of Mvita sub County hosts the largest number of *Juakali* artisans in Mombasa County. The artisans including mechanics, spray painters, metal fabricators, scrape dealers, motor vehicles body builders, and many others. Survey done randomly by RBA and OED in 2011 shows *Jua Kali* artisans in Mombasa had the highest exposure level to noise hazard and had the highest level of disabling hearing loss.

The needs for healthy and safe working environment is a fundamental pre-requisite for sustainable development and protect vulnerable groups and poor who are the majority in the informal sector (Buhlebenkosi *et al*., 2013). For sound to be perceived, it must exert a shearing force on the stereocillia of the hair cells lining the basilar membrane of the cochlea. When excessive (sound force) can lead to cellular metabolic overload, cell damage and cell death.

Noise induce hearing loss therefore represents excessive wear and tear on the delicate inner ear structures hence noise induced damage to the ear has a progressive consequences that are considerably more spread than are revealed by conventional threshold testing (Fernandez , 2008). Hearing impairment is the most frequent sensory deficit in human population. Globally, over 275 million people are affected and 80% of them are in low and middle income countries. In developing countries occupational noise accounts for about 3.8 million Noise induce hearing loss which represents a much heavier burden in developing countries than in developed regions of the world (Chandambuka *et al.,* 2013).WHO defines disabling hearing impairment in adults as permanent hearing threshold level of 41 decibels or greater. This is based on unaided hearing threshold in the better ear and as averaged over the 0.5, 1, 2, and 4 frequencies (Health Australia, 2008).

Table 1. Showing grades of hearing impairment. Source: Health Australia.

Grade	Hearing Level	Impairment
0	< 25 DB	None can hear whispers
1	26-40 DB	Slight can hear words at 1 meter in raised voice
2	41-60 DB	Moderate can hear words in a raised voice
3	60-80 DB	Severe- can hear words if shouted into the ear
4	> 80DB	Profound cannot hear shouted words

The objectives of the OSHA 2007 On Noise control and hearing conservation were to set limits for noise exposure and requirements for noise control and hearing conservation programs to prevent noise induced hearing loss in workplaces. Permissible noise levels set were that no worker should be exposed to noise levels above 90dB (A) for more than eight hours in a duration of twenty-four hours. worker should not be exposed to noise level of 140 dB (A) at any given time and where noise is intermittent, noise exposure should not exceed the sum of the partial noise equivalent to continuous sound level of 90 dB (A) in eight hours duration within any twenty four hours duration. Where noise in workplace exceeds 85dB (A), an effective noise control and hearing conservation has to be put in place (Kimani, 2012).

Materials and Methods

Research design

The purpose of this study was to ascertain noise production and its effects on hearing capabilities and auditory health effects of *Juakali* artisans in king'orani area. The research employed a cross-sectional study design. A research design according to Kothari (2014) is a conceptual structure within which research would be conducted aimed at providing for the collection of relevant evidence with minimal expenditure of effort, time, and money. Creswell (2013) defines research designs as plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis. According to Levin Kate (2006), cross-sectional study design is used when the researcher is interested in investigating exposure to risk factors and outcomes as well as estimating the prevalence of the outcome within relatively a short time in a population or a subgroup within a population in respect to an outcome and set of risk factors.

Study population

Mugenda and Mugenda (2003) define a target population as a complete set of numbers with some common observable characteristics. Sekaran and Bougie (2011) defines a target population in terms of numbers, geographical boundaries, and time. In this study, the target population was the "*Juakali* artisans working in the garages, shades, and open spaces within the king'orani area of Mvita Sub County. The artisan involved in the research should be those who have been in the locality for at least one year.

Sampling frame

Study sample was obtained from *Jua Kali* artisans working in areas producing or associated with noise production. They were categorized into the experimental group (Panel beaters, drillers, spray painters, mechanics, grinder operators, welders, exhaust repairers). None exposed which included those engaged in activities with minimal noise production or safe levels of sound (water vendors, food vendors, hawkers, clients to the artisans,) within king'orani area who will be the control group.

Sample and Sampling technique

Representative sample was calculated using Atchleys formula (Saunders and Thornhill 2009).

$$n = \frac{Z^2 P(1-P)}{d^2}$$

n= deserved sample size

p- Proportion in target group or prevalence estimated to have the measured character

Z-reliability co-efficient or standard normal deviation at the required confidence level

d - Is the level of statistical significance or degree of freedom

z= reliability co-efficient (1.96)

p= prevalence (50%)

d= degree of freedom (0.05)

$$n = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2}$$

The required sample was

n = 384

However, since target population was way below 10,000 the final sample estimate (nf) was calculated using

$$n_f = \frac{n}{1 + n/N}$$

Where

N, is the estimated population (212) and n, actual sample size.

$$\frac{384}{1 + 384/212}$$

(nf) final sample was = 136

Table 2. Sample population of the exposed group.

Occupation	Population	Sample
Mechanics	55	32
spray painters	58	34
Panel beaters/welders	99	58

Table 3. Sample population of the control group.

Occupation	population	Sample
Food Vendors	34	11
Hawkers	32	10
Clients	12	5

Sampling was through stratified random sampling where each stratum consisted of different disciplines within the *Juakali* artisans and the control group. The 136 who constituted the main sample size were those exposed and active *Juakali* workers who were also selected for questionnaire administration. The other participants that were only involved in audiometric tastes as the control group; were randomly sampled from food venders, hawkers, and clients to the *Juakali* workers. This is because they had minimal exposure to noise hazards. They were 82 in number(38.7% of the target population) . 12 participants changed their mind and withdrew from the study during questionnaire interview, otoscopic and audiometric examinations: these participants were categorized as non-respondents as the little information they had provided could not be subjected to analysis

Instruments

The researcher used structured questionnaire, audiometers, to collect data. The structured questionnaire was important, as it gave respondent freedom to express their views objectively and collection of social demographic information, health history, and views of respondents. Observation by the researcher captured other key information left out by the respondent but key to the objectives of research. The researcher used sound level meter IEC61672-1 class to measure noise level generated by different machines and equipments operated. Audiogram MON 650A was used to determine hearing threshold of the participants

Data collection methods

Collection of data was through three processes. One was through the questionnaire. Trained research assistants assisted the respondents to complete the questionnaire during face-to-face interview. The structured questionnaire captured social demographics, health history and current complains in relation to exposure to noise hazard. Audiometric test (pure tone eudiometry), were done on the exposed group (experimental group) and the control group to determine the hearing threshold at difference frequency bands and the findings recorded. The workplaces noise levels was measured using sound level meter and their sources to establish the levels of noise and those within the range of being exposed and forming the experimental group. Those operating outside the maximum exposure limit including food vendors, hawkers painters, had less exposure with limited duration formed the control group.

Hearing evaluation

Hearing evaluations were done in four stages. Stage 1 involved briefing the participants on procedures they were to be taken through and likely duration of each. Stage two involved physical examination of the ear for any physical and anatomical defects that could affect hearing ability using otoscope. Stage three involved pure tone eudiometry where the participants were ushered into a soundproof room for hearing thresholds (audiograms) evaluation. The audiograms were done beginning with the best ear at different frequencies of 1000 Hz, 2000 Hz, 400 Hz. Hearing threshold was determined by getting satisfactory response by reducing levels of the tone in 10 dB then increasing with 5 dB until the subject gives response at the same level while twice in descending or ascending sound level adjustments. The research involved human subjects as the main source of Data. Therefore all the details, intentions , objectives and procedures were subjected to ethical committee review for approval, after which the research participants were fully informed of all the details of research and there after allowed to make informed decision on whether to take part or not. The details of research participant remained secured and findings kept confidential. Collected data were coded, cleaned, tabulated, and analyzed using SPSS version 21.0 to determine frequencies, means, standard deviations, Chi square and Pearson's correlations among the variables of interests. Presentation is through percentages, tables, frequencies, bar charts and graphs. The main objective of the study was to determine level of exposure to noise hazard and health effects associated with the exposure. Those with auditory health effects, referral to Coast general hospital for rehabilitation and follow up was undertaken. The study findings were shared with Operation Ear drop a nongovernmental organization that has been spearheading rehabilitation and creating awareness on the effect of noise. After the study, the researcher also shared finding including sources of hazardous noise, risks of prolonged exposure to noise, available control mechanism, and general health promotion in relation to occupational noise hazard with King'orani *Juakali* artisans.

Results and Findings

The targeted sample size was 136 participants, however 124 out of the 136 took part in the study to conclusion while the 12 withdrew midway during questionnaire administration and a number declined to take part in otoscopic and audiometric examination. Therefore the 12(8.82%) constituted non respondents while response rate stood at 124(91.18%) which is statistically reliable in giving significant findings

Social demographics

For the purpose of this study, social demographics provided the basis of the measurement of the key variables. Table 4 gives a summary of the key demographics parameters of importance to this study.

Table 4. Showing social demographics of the participants.

Variable	Characteristic	Frequency	Percentage
Gender	Female	17	13.7
	Male	107	86.3
Age in years	10-20	4	3.2
	21-30	48	38.7
	31-40	44	35.5
	41-50	24	19.4
	More than 50	4	3.2
Level of Education	No education	4	3.2
	Primary Education	56	45.2
	Secondary education	40	32.3
	Tertiary education	24	19.4

Majority of the participants were Male at 86.3 percent and female at 13.7 percent. This indicates that this is a male dominated field as shown in table 4. Age is a significant observation as it has a major contribution on duration at workplace and exposure period as well as experience. Most of the participants age was between 20 to 50 years; where those aged 21 to 30 years were 48(38.7%), 31-40 were 44(35.5%) ,and few were between the age of 10 to 20 years 4(3.2%) and above 50 years (3.2%) as shown in table 4. Education level is vital in any discipline as it provides basis of creating understanding and awareness among those involved. Majority of the participants 45.2%(56) had attained primary education level, 32.3(40) had secondary education while only 19.4%(24) had formal training and those who had no formal education were 3.2%(4). This indicates that majority of the king'orani *Juakali* workers have no background knowledge of health and safety provided during formal professional trainings as shown in table 4

Nature of work and noise production

Table 5. Showing Nature of workstations used by *Juakali* artisans in King'orani area.

	Frequency	Percent	Valid %	Cumulative %
Open air	84	67.7	67.7	67.7
Over head shades	12	9.7	9.7	77.4
Workshop	8	6.5	6.5	83.9
Open air and shades	12	9.7	9.7	93.5
Open air, shades and Workshop	8	6.5	6.5	100.0
Total	124	100.0	100.0	

67.7% of the activities and work was carried out in open air while 9.7% under overhead sheds, 6.5% done in workshops while 16.2% was in both overhead, open air and workshop as shown in table 5. This is a clear indicator of occupationally poor work environment, lack of mechanism of controlling noise generated within the workstations and other potential hazards.

Sources of Noise

Most of the noises generating activities within the kingorani *Juakali* sector are mechanical. Majority of the workers undertook more the one activity and hence activities are in clusters. . They included Panel beating/drilling/welding 38.5 %(48), Grinding/ spray painting 19 %(24), panel beating /spray painting 16 %(20), Motor vehicle repairs/ sandblasting 26 %(32) indicated in table 6. However, these activities took place in the same environment and majority of the artisans in the workstations exposed to the noise generated by most of these activities at ago.

Table 6. Showing activities associated with noise generation.

Activity	Frequency	Percent	Valid %	Cumulative %
Paneling, drilling, welding	48	38.7	38.7	38.7
Grinding, spray painting	24	19.4	19.4	58.1
Paneling, spray painting	20	16.1	16.1	74.2
Auto services, Sandblasting	32	25.8	25.8	100.0
Total	124	100.0	100.0	

Noise level measurement

Table 7. Showing levels of noise in dB generated by artisans' activities.

Activity	Noise level in dB(A)
Grinding	94.6
Drilling	98.5
Welding	89.9
Spray painting	103.8
Motor/mechanical service	106.8
Sandblasting	89.8
Panel beating/ Fabrication	104.6

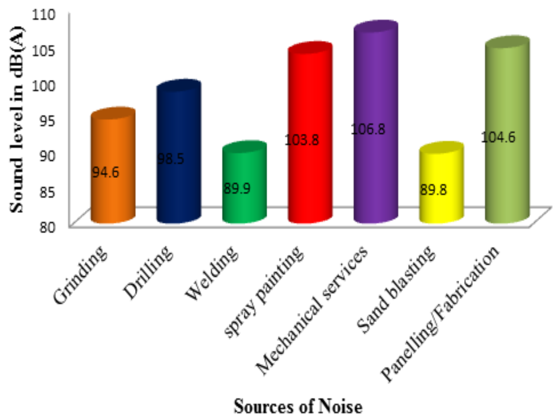

Figure 1. Highlighting levels of noise generated by artisans' activities.

Nearly all activities carried out by *Juakali* artisans generated noise at significant levels of; grinding 94.6 dB, drilling 98.5 dB, welding 89.9 dB, spray painting 103.8 dB, mechanical and automotive services 106.8 dB, Sandblasting 89.8 and Panel beating 104.6 dB. The noise generated by the activities above in figure 14 produced noise above 85 dB, with mean of 99.6±4 with STD of 0.794, which is above the maximum allowable limits hence exposing the artisans to Hazardous effects.

Noise exposure level

Exposure levels were high as most of the Artisans 55.6 %(69) had noise exposure of 101 to 110 dB and 30.6% (38) with noise exposure level of 91 to 100 dB While at 81 to 90 dB 12.1% (15). Those with exposure level below 80 dB were 0.8 % (1) with exposure level 70 to 80 dB and 0.8% (1) with exposure level below 70 dB respectively shown in table 8 and figure 2. The measurement categorizations were done based on activity one was undertaking during noise measurement and usual daily work performed by the study subject.

Table 8. Showing exposure levels and frequency among the study participants.

Level of exposure	Frequency	Percent	Valid %	Cumulative %
less than 70 dB	1	.8	.8	.8
70-80 dB	1	.8	.8	1.6
81-90 dB	15	12.1	12.1	13.7
91-100 dB	38	30.6	30.6	44.4
101-110 dB	69	55.6	55.6	100.0
Total	124	100.0	100.0	

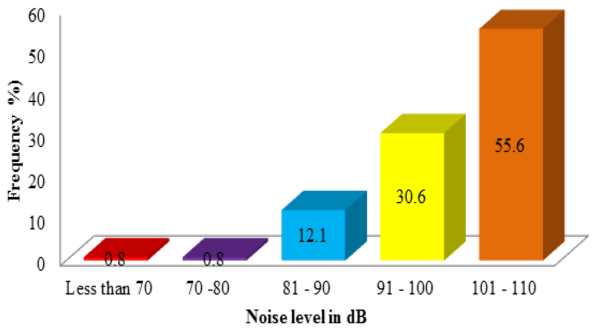

Figure 2. Showing noise levels and frequency of exposure by the artisans in kingorani area.

Duration of exposure

Table 9. Showing duration of exposure frequency in years by the artisans.

Period in years	Frequency	Percent	Valid %	Cumulative %
Less than 1 year	8	6.5	6.5	6.5
1 - 10 years	46	37.1	37.1	43.5
11- 20 years	44	35.5	35.5	79.0
21- 30 years	20	16.1	16.1	95.2
More than 30 years	6	4.8	4.8	100.0
Total	124	100.0	100.0	

The duration of exposure to noise was based on the number of years the artisan have been working in the same environment while carrying out similar activities and they were, less than 1 year 6.5%(8), 1-10 years 37.1% (46), 11-20 years 35.5 %(44), 21-30 years 16.1% (20) and more than 30 years 4.8% (6) with standard deviation of 0.99. as shown in table 9.

Daily exposure duration

Daily sustained exposure to noise measurement was important, because it plays a key role in determining the overall exposure and outcome (effects of exposure). Most of the respondents spent more than 8 hours at the workstation 83.9 %(104), while 9.7 %(12) spend between 5-8 hours and 6.5 %(8) spend less than 1 hour with Standard deviation of 0.77

Nature of noise generated

Table 10. Showing nature of noise generated by the work activities of artisans.

Noise description	Frequency	Percent	Valid%	Cumulative %
Normal	4	3.2	3.2	3.2
Loud	16	12.9	12.9	16.1
Very Loud	24	19.4	19.4	35.5
Very loud/ ,irritating/Deafening	44	35.5	35.5	71.0
Irritating and Deafening	24	19.4	19.4	90.3
Painful and deafening	12	9.7	9.7	100.0
Total	124	100.0	100.0	

Noise description by the study subjects was important as illustrated how they discern noise produced by the activities they carry out. This also indicated if they view it as health hazard as

Medical history

Majority of the respondents, 87.1%(108) had no prior noise exposure, while 12.1%(15) have previous exposure for period less than 1 year, while only 1 respondent had exposure for a duration of 1- 5 years. 13.7% (17) of the respondents had prior history of ear infection as shown in table... out of which all fully recovered without complication following treatment. Those with history of trauma to the ear were 16 (12.9%) out of which they recovered fully As shown in table...Use of ear protectors was almost absent as 93.5% (116) having never used while only 6.5% (8) having rarely used as show in table 11 . Due to poor infrastructure, PPE use is the more realistic way of controlling exposure to noise by the artisans

Health effects

Table 11. Showing noise effects experienced by the artisans.

Effect experienced	Frequency	Percent	Valid%	Cumulative%
Hearing impairment	24	19.4	19.4	19.4
Tinnitus, Headache	36	29.0	29.0	48.4
Hearing, Tinnitus	24	19.4	19.4	67.7
Hearing, concentration	8	6.5	6.5	74.2
Tinnitus, loss of sleep	12	9.7	9.7	83.9
Tinnitus, concentration, Hearing	20	16.1	16.1	100.0
Total	124	100.0	100.0	

As shown in table 11, Study subjects experienced varied symptoms and health related problems after spending considerable time at the working area with considerable levels of noise. This included Hearing impairment 19.4%(24) Headache with ringing ears 29%(36) Ringing ears, Hearing impairment and headaches (19.4%)(24) Concentration deficiency 6.5%(8), Loss of sleep and ringing ears 9.7%(12) and a combination of Hearing, concentration, ringing ears 16.1%(20)

Hearing ability

Table 12. Highlighting communication and hearing abilities of the artisans.

Hearing ability	Frequency	Percent	Valid %	Cumulative %
Spoken communication in low tones	24	19.4	19.4	19.4
spoken communication one on one	64	51.6	51.6	71.0
only hears when one shouts	28	22.6	22.6	93.5
Affected with background noise	8	6.5	6.5	100.0
Total	124	100.0	100.0	

As illustrated in table 12, Majority of the respondents' communication and hearing ability deficiencies, was due to exposure to high levels of noise. 19.4%(24) of the respondents were able to here communications in low tone and whispers, 51.6%(64) were able to hear communication one on one, 22.6%(28) were able to here when one shouted or raised voice, and 6.5%(8) were unable to here whenever there background noise

Hearing Evaluation

Otoscopy

Table 13. Highlighting the findings during otoscopic examination.

Observation	Frequency	Percent	Valid %	Cumulative %
Normal	88	71.0	71.0	71.0
Foreign body	12	9.7	9.7	80.6
Wax impaction	16	12.9	12.9	93.5
Narrowed auditory canal	8	6.5	6.5	100.0
Total	124	100.0	100.0	

Before pure tone audiometric tests, all respondents underwent otoscopic examination for any anatomical and physical defects that affect hearing process. as indicated in table 13 those with physically Normal ears were 71 %(88), foreign bodies 9.7 %(12), wax impaction 12.9 %(16), Narrowing of auditory canal 6.5 %(8).

Audiometric examination

Table 14. Showing categorized hearing thresholds of respondents.

Level of impairment	Frequency	Percent	Valid %	Cumulative%
Normal sound below (25 dB)	50	40.3	40.3	40.3
Slight (26-40 dB)	39	31.5	31.5	71.8
Moderate (41-60 dB)	23	18.5	18.5	90.3
Severe (61-80 dB)	7	5.7	5.7	95.2
Profound (Over 81 dB) loss	5	4	4	100.0
Total	124	100.0	100.0	

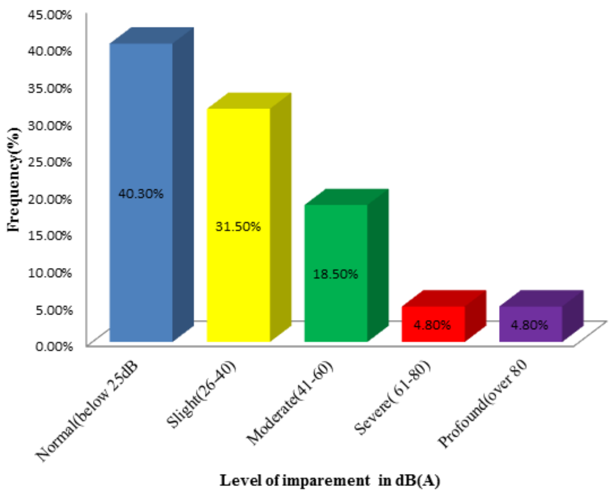

Figure 3. Showing categorized levels of hearing impairments of the artisans.

As shown in table 14, A total of 124 audiograms were studied out of which, 40.3%(50) were able to pick sounds below 25 dB, 31.5 % (39) of the respondents had slight impairment where the threshold was 26-40 dB. Moderate impairment of 41-60 dB 18.5 %(23), severe impairment (61-80 dB) was 4.8 %(6) and profound impairment (over 81 dB) 4.8%. When compared with noise exposure level and overall duration of exposure, there was chi square significance level of 0.641 and 0.131 respectively at p values less than 0.05.

Discussion

Despite noise being a major occupational hazard among those working in *Juakali* sector, practices show there is low level of awareness. Average age was 36 ± 2.81 with standard deviation of 0.889. Considering that majority of the workers in *Juakali* sector start at an early age, the average age of the artisans has a direct link to exposure duration average of 16±2.76 years with STD of 0.996. This average duration of exposure is a long period that greatly contributes to NIHL. This was similarly found by the study done by Musiba, z. (2015) among Tanzanian miners at Msasani peninsula as well as Faluwasayo *et al*., (2005) among steel rolling mills workers in Nigeria where exposure period of more than 10 years to noise above 90 dB increases one's risk to NIHL. Most of the *Juakali* artisans had not undergone tertiary level of training and relied heavily on job training. This contributed to low level of awareness and lacked information on the risks associated with certain activities they are involved. This makes them vulnerable to exposure to hazards like noise, as observed by Theuri (2012) who indicated that most of the informal sector workers lack basic education and therefore equally are deficient in knowledge of hazard management.

During the assessment of, key sources and level of noise, as indicated in table 6, 7, Most of the activities carried out by the artisans generated noise levels way above the OSHA 2007 allowable limit of 90 dB maximum of 8 hours daily. According to Gerges *et al*., (2006), most informal sector activities such as welding, drilling, operation of pneumatic equipments, generate noise above 85 dB. Artisans had exposure to noises above 90 dB for more than 8 hours daily. 55.6% of the respondents had exposure to noise above 101 dB generated by their daily activities, which is 10 dB above the allowable limit. There was significant association between exposure level and auditory effects with chi square value of 0.951, Hearing impairment chi square value 0.641 at $p<0.05$ significant level. Majority of whom had worked for more than ten years at exposure level above 90 dB (56.4%); and had developed hearing impairment (Ranging from mild to severe). 59.6% had hearing threshold shift, (ranging from mild to severe as shown in table 14). This was found in the study by NIOSH (2008) where NIHL is gradual and more common among those who were exposed to noise for over 10 years. Similarly, Chandambuka *et al*., (2013) also found that exposure to noise levels above 90dB for duration more than 10 years contributed greatly to high prevalence of NIHL among the mineworkers of Zambia.

During the study there was significant association between noise exposure level and duration with hearing impairment, The Pearson's chi square of 0.641 significant at $p< 0.05$ level and positive correlation coefficient of 0.248 on hearing ability and 0.279 on hearing impairment, significant at $p< 0.05$. This shows that the artisan had a prolonged exposure to noise levels above 90dB, and this contributed to them developing NIHL with other auditory health problems. Therefore, the null hypothesis rejected. This was also in the study done by Fernandez (2008) which showed that prolonged exposure to noise causes progressive wear and tear of the delicate inner ear attendant NIHL

80.7% of the respondents reported to suffer from other auditory effects (ringing ears, headache, concentration, loss of sleep) which depend on prolonged exposure and the level of noise generated There was strong association between level of exposure, duration of exposure and auditory effects with chi square value of 0.663 significant at 0.05 level. The daily hours spent at workplace had strong association with these effects especially headache ringing ears concentration, with chi square value of 0.825 significant at 0.05 level. Similarly, in Msasani peninsula Daresalam, Musiba (2012) found that there was high prevalence of NIHL among those with exposure period of more than 10 years compared to those less than ten years.

Occupational health and safety practices were absent and the awareness of some of control measures available. Use of ear protectors was not in practice except 6.5% who used them on rare occasions.

Conclusion

The main objective of this study was to identify the health effects of noise exposure among the *Juakali* artisans of king'orani area Mombasa County. It sought specifically to identify sources and level of Noise, hearing thresholds of the *Juakali* artisans, asses' auditory effects, and prevalence of noise induced hearing loss. The research therefore established that:

1. Most of the artisans work activities generated hazardous noise above allowable limit of 90dB
2. 59.6% of the respondents had hearing threshold level shift with hearing impairment due to prolonged exposure to noise level above 90dB. The majority had moderate to mild impairment
3. Noise exposure levels contributed to artisans developing auditory effects such as headaches, ringing ears, poor concentration, and sleep disturbances.
4. The prevalence of Noise induced hearing loss was 59.6% with majority having mild to moderate impairment at 62%
5. The *Juakali* sector lack any occupational health and safety initiative therefore the workers are overtly exposed to hazards
6. There was a positive correlation coefficient of +0.279 between duration of exposure and NIHL. The longer the duration one is exposed to high level of noise, the higher chance of development of hearing impairment.

Recommendation

The informal sector workers (*Juakali*) are exposed to numerous hazards without any control and preventive effort. Noise is among the commonest hazards with debilitating irreversible effects. Therefore, serious prompt interventions need to be established and they include

1. Regular training and awareness programs on the effects of exposure to noise and prevention mechanisms
2. Government sponsored personal protective equipments provision at an affordable cost
3. Review of the OSHA 2007 act to exhaustively regulate and protect those working in the informal sector considering that over 75% of workers are in the informal sector
4. Provision of regular, free, hearing screening services to the informal sector workers to ensure early detection and prevention of serious auditory health effects caused by noise exposure.
5. Establishment of specialized Noise induced hearing loss, rehabilitation and management centers at all county, and sub county hospitals
6. Setting up of a mandatory medical fund/insurance scheme that will cater for the rehabilitation and compensation to those affected especially disabling hearing loss.
7. Further research to be done to establish proper affordable PPE that can be utilized by the *juakali* artisans in reducing debilitating effects of Chronic noise exposure.
8. Development an infrastructural master plan, that ensures steady development of healthy, safe working environment for all workers (Both in the informal and formal sector) in long term.

Acknowledgement

First, I would like to thank JKUAT MSA CBD Campus for providing an enabling environment during the preparation of this Thesis. The guidance advanced by my supervisors Professor Robert Kinyua and Dr. Rahma Udu not only made it possible for successful process but timely. The continued support and advice by course coordinator Miss Mary Kerich did provide the basis of Thesis development.

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