Assessment of Cumulative Trauma Disorders among Workers in Southwest Nigeria Sawmilling Industry

Hezekiah O. Adeyemi* and Emmanuel I. Udoh
College of Engineering and Environmental Studies
Olabisi Onabanjo University
Ago Iwoye, Ogun State, Nigeria
**ahacoy@yahoo.com*

Date received: December 8, 2015
Revision accepted: January 19, 2016

Abstract

This study assessed Cumulative Trauma Disorders (CTDs) among workers in Southwest Nigeria sawmilling industry. The aim was to ascertain the prevalent types, and likely occurrence of the injury among the group of workers. Sixteen sawmilling factories were studied. Physical observation method was used to assess job demands, methods and workplace safety. Questionnaires were completed among 267 workers through written interview. This measured subjective injury and/or prevalence of CTDs symptoms on different body regions. Sound and vibration meters were used to measure noise and vibration levels of 64 machines respectively. Calculated mean values of measurements were compared with the recommended standards. The statistical analysis was done using Non-parametric Chi-Square tests on SPSS application. Low back, shoulder and wrist/hand were the leading regions of the body where pains were reported by interviewed workers. Among the risk factors capable of contributing to CTDs occurrence, standing for long hours, forceful griping, forward bending, hand twisting and wrist deviation were reported. The statistical analysis results established associations between some two or more prevalent risk factors capable of leading to CTDs. Workers may be prone to De Quervain's disease, Degenerative joint disease and Lumbosacral strain among others which may affect their musculoskeletal, vascular and nervous systems.

Keywords*:* sawmilling, industry, tasks, workers, injury, CTDs, pains

1. Introduction

Cumulative trauma disorders (CTDs) are injuries of the musculoskeletal and nervous system sustained over a long period of time that may be caused by repetitive task, forceful exertions, vibrations, mechanical compression or sustained or awkward positions which causes pain and discomforts in a human body (NJDHSS, 2003). Cumulative indicates the injuries that developed gradually over period of weeks, months, or even years as a result

of repeated stresses on a particular body part. The word trauma signifies bodily injury from mechanical stress. Disorders refer to physical ailment or abnormal condition (NOISH, 1989).

Epidemiological studies have shown that in the genesis of the CTDs, three sets of risk factors are considered; (1) Physical factors - e.g., sustained or awkward postures, repetition of the same movements, forceful exertions, hand-arm or all-body vibration etc.; (2) Psychosocial factors - e.g., work pace, autonomy, monotony, work/rest cycle, task demands etc.; (3) Individual factors - e.g., age, gender, professional activities, etc., (Bruce and Bernard, 1997; Buckle and Devereux, 2000; Nunes, 2012). Cynthia (2004) however highlighted in Table 1, some names of CTDs and factors that can lead to their occurrences.

Table 1. CTDs disorder names and their risk factors

Disorder name	Actions contributing to disorder
Carpal tunnel syndrome	Rapid, often-repeated finger movement, wrist deviations, pinch grip vibrations of 10 to 60 Hz.
Degenerative joint disease	Trauma, faulty posture of the back, emotional stress.
De Quervain's disease	Combined forceful gripping, hand twisting.
Elbow tendinitis	Repetitive forceful exertions of forearm, rotations around elbow joint.
Facet slipping	Going beyond the limit of sudden movements in the back flexion and extension.
Ganglionic cyst	Force exertion.
Lumbosacral strain	Faulty alignment, standing for long periods unguarded, forward bending.
Rheumatoid arthritis	overuse or repetitive trauma to the joints.
Sciatica	May be due to some mechanical factor of compression or tension.
Vibration Syndrome	Vibrations magnitude between 2.5 m/s^2 and 5.0 m/s^2 limit value, grip force, feed force.
Wrist tendinitis	Forceful ulnar deviation and thumb pressure, repetitive wrist motion, forceful wrist extension and pronation.

(Source: Cynthia, 2004; HS, 2005).

Sawmilling is a task requiring physical activities with various hazards inherent to it. Human involvements (manual handling) are reported common in sawmilling operations hence workers in the industry are at risk of various workplace hazards (Njinaka *et al.*, 2011). According to Aina (2006), sawmilling is the process of converting log from the forests into lumber using variety of machines like band saws, re-sawing machines etc. A

sawmill worker performs combination of duties such as: unloads logs from trucks or lorries, rolls logs from deck to log or carriage, rides log carriage of head saw and adjusts position of logs on carriage to cut planks of required thickness, straightens lumber on moving conveyors, straightens edges of rough lumber, using saw etc. (Adeoye *et al*., 2015).

Noise pollution and machine vibrations are reported causing serious injuries among workers in many industries (Department of Environment and Conservation, 2006) sawmilling industry not excluded. Noise-related hearing loss was listed as one of the most prevalent occupational health concerns for more than 25 years. Since 2004, the Bureau of Labor Statistics has reported that nearly 125,000 workers have suffered significant permanent hearing loss as a result of repeated exposures to loud noise. Similarly long-term whole-body vibration, according to Richard and Michael (2002), has been associated with an increased risk of degenerative lumbar spine injuries, central nervous system disturbances, and possibly damage to the digestive and genital/urinary systems. Frequency of vibration and some of its effects on the human body are highlighted in Table 2. The National Institute for Occupational Safety and Health (NIOSH) however recommended that all workers exposures to noise should be controlled below a level equivalent to 85 dBA for eight hours to minimize occupational noise induced hearing loss (USDHHS, 1989). NIOSH has no specific quantitative exposure limit that will eliminate the risk of developing hand-arm vibration syndrome in all workers exposed to hand-arm vibration from all type of vibrating tools and/or machinery (USDHHS, 1989; Safe Work Australia, 2015). However, Health and Safety (2005) set a daily exposure limit value of 5 m/s^2 A(8) which is the average (A) exposure over an eight-hour (8) day. This is equally presented in Figure 1.

Table 2: Frequency of vibration and its effects on the human body

Range	Effects
Below 1 Hz	Motion sickness
3.5 to 6 Hz	Alerting effect
4 to 10 Hz	Chest and abdomen pain
Around 5Hz	Degrading manual actions
7 to 20 Hz	Communication problem
8 to 10 Hz	Back ache
10 to 20 Hz	Intestine and Bladder pain
10 to 30 Hz	Degrades manual and visual controls
10 to 90 Hz	Degrades visual actions

Sanders and McCormick (1993); Helmut and Alan (2011); Bovenzi,(1998); Bridger, (1995); Shivakumara and Sridhar, (2010).

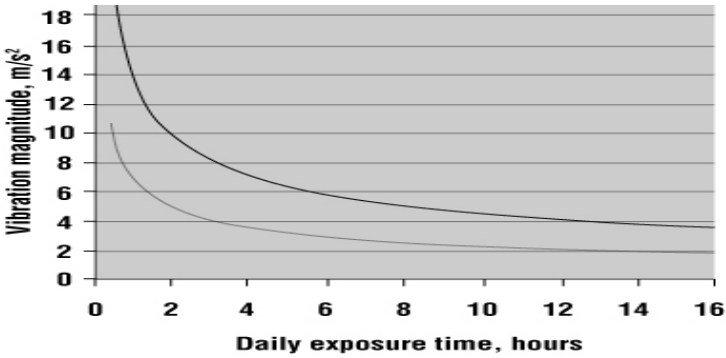

Figure 1. Vibration magnitude and recommended daily exposure time (CCOHS, 2008)

Work-related injuries among workers across industries had been widely reported with various human body regions affected. However, stating the CTDs name prevalent or likely in those industries are uncommon. Beyond mentioning the workers' body region(s) affected or likely to be, this study aimed at ascertaining the name of disease related to CTDs prevalent or likely among workers in sawmilling industry. The objectives are to:

i. determine the commonly reported pains, and risk factors capable of causing CTDs, among the group of workers.
ii. find out the contributions of noise and vibration level of different machines to workers reported injuries.
iii. find out the type(s) of CTDs prevalence or likely among the group of workers.

The following research questions are raised to assist the research:

i. Do the reported risk factors contribute to CTDs occurrence?
ii. Are the reported pains related to CTDs symptoms?
iii. Which type(s) of CTDs are prevalent or likely among the group of workers?

1.1 Hypotheses

H0: There is no significant association between the prevailing risk factors among the workers and the risks factors capable of leading to CTDs occurrence.
Ho: There is no significant association between the reported pains and CTDs symptoms

H0: There is no significant association between two or more CTDs risk factors prevalence among the workers that may lead to a type of CTDs.

2. Materials and Methods

2.1 Study Site and Task

A research survey was adopted for this study which involved sixteen (16) sawmilling industries located in Lagos, Abeokuta and Ibadan all within the south west Nigeria. These study areas were selected because Southwestern zone of Nigeria comprises mainly of the rainforest vegetation belt. Active logging take place in this part of the country (Kehinde and Awoyemi, 2009). The task assessed included the ones carried out on wood log cutting machine, circular cutting machine, planning machine, wood band saw machine, wood spindle machine, wood edger machine and wood screw machine.

2.2 Work Demands and Methods Assessment

Physical observation method was used to assess job demands and workplace safety. Techniques at which workers performed their tasks were followed. Among conditions checked included; job physical demands, noise pollution, biomechanical risk factors such as forceful gripping, hand twisting, wrong postures, machine and/or work vibrations, forceful exertions, wrist deviations and load lifting. Observation method has lead to some of the most important scientific discoveries in human history. It involves engagement of brains as well as eyes and ears, organizing data so that sense can be made of them (Fox, 1998). Machine noise level was measured using sound meter while machine vibrations were measured using a vibration meter.

2.3 Semi-Structured Interviews

Questionnaires were completed among 267 workers through interviews with the use of a modified version of Nordic questionnaire reported by Kuorinka *et al.*, (1987). It measured subjective injuries (past or present) on their different body regions by written response and assessed the symptom(s) and/or prevalence of CTDs among the group of workers. All potential volunteers agreed, and consents were taken in written form to have the interview conducted after they were informed that their participation was

voluntary. The purpose of the study and the confidentiality of the information provided were emphasized. The interview was conducted at their break period and lasted approximately 15 minutes for each subject.

2.4 Noise and Vibration Assessments

Since most vibrating machines and/or tools produce noise, a vibration-exposed worker is likely to be exposed to noise at the same time (Canadian Center of Occupational Health and Safety, 2008). Noise and vibration levels of 64 machines including 12 log cutting machines, 9 circular cutting machines, 10 planing machines, 9 wood band saw machines, 8 wood spindle machines, 9 wood edger machines and 7 wood screw machines, were measured with sound and vibration meter respectively. Measurement of hand-arm vibration can be difficult and complex (Safe Work Australia, 2015). ISO 5349-1 (Standard Australia, 2013; Edwards and Holt, 2006) which specified general requirements for measuring hand-transmitted vibration exposure was followed. Worker daily exposure to vibration was measured by a formula known as an A (8) value. This is the average (A) exposure over an eight-hour (8) day (Health and Safety, 2005). The magnitude of the vibration was taken into account and how long each subject was exposed to it. The rate of vibration of a tool and/or machinery was measured in metres (m) per second (s). Noise level of all machinery was measured in dB by placement of microphone and tripod following the procedures highlighted by Environmental Protection Agency (1991). All measurements were carried out by trained personnel and the readings were recorded at least three times for each machine to ensure accuracy. Average values of each round of measurement were computed.

2.5 Data Analysis

Descriptive statistics procedure and non-parametric Chi-Square tests were conducted to analyze the recorded data using SPSS package. Chi-square is a versatile Statistics test used to examine the significance of relationships between two (or more) nominal-level variables (Vicki, 1979). The Chi-Square results determined whether to accept or reject null hypothesis. When the test result showed $p<0.05$, the null hypothesis was rejected, and the alternate accepted. This means that the relationship was significant. When $p>0.05$ the null hypothesis was accepted which indicated a no significant relationship.

3. Results and Discussion

3.1 Workers' Response to Interviews

Two hundred and sixty seven (89%) of the total three hundred (300) workers who participated in the study from sixteen (16) sawmilling industry completed the questionnaire. Among others, common job title assessed included cutting machine operators (21.7%), circular cutting machine operators (23.6%), planing machine operators (23.6%) and bandsaw operators (10.2%) and manual material handling workers(19.5%). All subjects have spent not less than four (4) years on their current job. The demographics of the workers who participated in the study are presented in Table 3. The average age of the workers is about 45 years most of which were 9years on the current job.

Table 3. Statistic of the demographic information of workers studied in 16 sawmilling industries

Descriptions	**Age**	Work hours	**Years of Working Experience**
Mean	45	8.7	8.5
Mode	36	9	7.0
Std. Deviation	4.2	0.5	0.63

3.2 Reported Work Related Pains

Two hundred and nine (209) respondents representing 75.7% reported to have suffered pains in the last 12months, 147 (55.1%) in the last 1 month and 157 (58.8%) in the last 7days. All reported pains lasted for 24 hours with incurred medical bills. About 70% of this group of workers stated that the pains suffered prevented them from doing their normal works.

From Figure 2 and in descending other, 274 (99.3%) complained of Low back pain (LBP), 230 (83.3%) complained of shoulder pain, 166 (60.1%) reported wrist/hands pain, 92 (33.3%) complained pains in their ankle/feet, 83 (30.1%) complained of hip/thighs pains. Other reported pains included kneels (18.5%), neck (16.7%), upper back (14.1%), fingers (6.7%) and chest (5%).

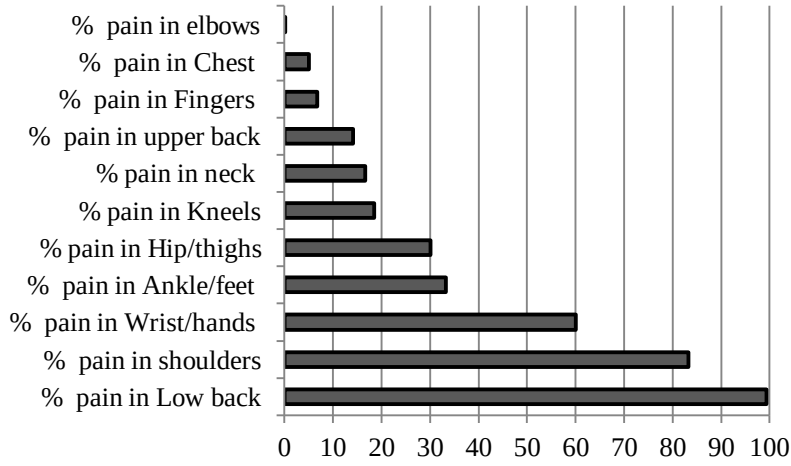

Figure 2. Reported work related pains among workers in the studied sawmilling industries

3.3 Reported Psychosocial Aspect of the Work

In their opinion, 267 (96.7%) of the workers see their job schedule as risky. 258 (93.5%) rated the job as dangerous and 157 (56.9%) said the work is excessive. However, 186 (67.4%) stated that they did not enjoy sufficient time of rest. As part of the measures adopted to ease the difficulties attached to the job, 254 (92.0%) assisted each other one way or the other, most especially in load lifting. 191 (69.2%) would not like to continue doing the job, if they had alternative. Among reasons for this, 253 (91.7%) mentioned that their supervisors/managers had no concern about their safety. For instance, 187 (67.8%) mentioned that there was no health care service and/or safety training provided at work.

3.4 Risk Factors Prevalence in the Work

As represented in Figure 3, 266 (96.4%) reported that the work required forceful gripping (FG), 133 (48.2%) said the work demanded hand twisting (HT), 273 (98.9%) mentioned that the work needed standing unguarded (SU) for long period of time. 174 (63.0%) also complained of frequent forward bending (FB) and 242 (87.7%) reported that they were daily exposed to high level of vibration (HV) from machinery. In the same manner, 234 (84.8%) reported forceful exertions (FE), while 104 (37.7%) reported wrist deviation (WD).

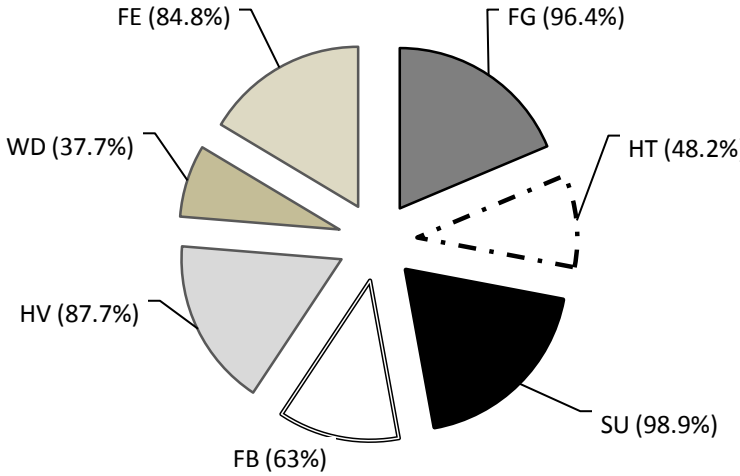

Figure 3. Reported risk factors' prevalence among workers in the studied sawmilling industries

3.5 Degree of CTDs Symptoms among Workers

From Figure 4, 161 workers representing 58.3% had experience of finger movement in the course of carrying out their jobs. 179 (64.9%) reported emotional stress and 183 (66.3%) experienced pains at the base of their thumb. Those who reported pain over the thumb side of the wrist were 198 (71.7%) while 92 workers (33.3%) experienced loss of feelings with their fingers.

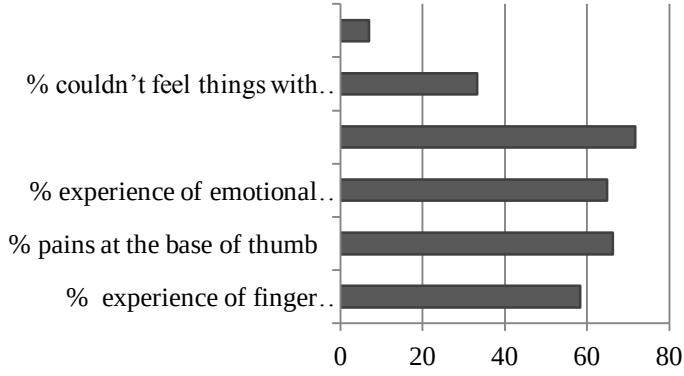

Figure 4. Prevalence of CTDs symptoms among workers in the studied sawmilling industries

3.6 Test of Hypothesis

Result of statistics test for significant relationship between two or more risk factors based on the reported problem of the workers, the combination of which are capable of leading to a CTDs disorder type or the other are shown in Table 4.

According to Table 4, forward bending and emotional stress experienced by the workers was significant going by the rejection of the null hypothesis because the p value was less than 0.005. Hence there was a relationship between the set of workers who complained of emotional stress and those who reported frequent forward bending at work. With the result, Chi-square = 12.505 and p = .000, the null hypothesis in this case was rejected meaning that there was a relationship between those who reported emotional stress and those who had pains on their body regions. With the Chi-Square value of 5.862 and p value of 0.015, there was a relationship between workers who experienced forceful gripping at work and those who suffered pains over the thumb side of their wrist. Association between those who reported working with vibrated machines and the workers who had experience of loss of feeling with their fingers was equally significant (Chi-square = 5.621, p = .021).

Table 3. Result of statistics analysis conducted to test for significance between two or more risk factors capable of leading to CTDs

Risk factors descriptions	**Non-parametric Chi-Square Test**		
	Value	**Asymp. Sig.**	**Decision**
Forward bending at work and emotional stress	3.705	0 .044	Significance
Emotional stress and pain on body regions	12.505	0.000	Significance
Forceful gripping and hand twisting	6.342	0.011	Significant
Forceful gripping and pain over thumb of wrist	5.862	0.015	Significance
Work/machine vibration and loss of feeling with fingers	5.621	0.021	Significance
Excessive vibration at work and workers finger movement	1.587	0.208	Not Significant

3.7 Assessment of Noise Pollution

The average result of noise pollution for all evaluated machines grouped into seven (7) are shown in Table 5. On the average, 87.43±7.5 dB was recorded with an average of 7.23±5.2 percentage deviation from the recommended standard.

Table 4. Result of the measured average noise level of 64 machines grouped into seven (7).

Subject	Noise Measurement			
	Machines Description	**Ave. Max. NL (dB)**	**RS NL* (dB)**	**% Deviation from RS**
1.	Wood log Cutting machine	95	85	-11.8
2.	Circular Cutting machine	92	85	-8.2
3.	Planning machine	87	85	-2.4
4.	Band saw machine	96	85	-12.9
5.	Spindle machine	85	85	0
6.	Edger machine	75	85	11.8
7.	Screw machine	82	85	3.5
	Average	**87.43 7.5**	**85**	**7.23 5.2**

*(USDHHS, 1989), Ave=average, Max. =maximum, RS=recommended standard, NL= Noise level.

Figure 5 shows comparison between the average measured machine noise level compared with the recommended standard values. As observed, two machines (28.6%), Edger and Screw, met with the recommended standard. The rest (71.4%) were however either equal or above 85dB. Four (4) out of seven groups of machine (60%), the wood log cutting machine, the circular cutting machine, the planning machine and the band saw were above 85dB and deviated from the standard by 11.8%, 8.2%, 2.4% and 12.9% respectively. The band saw machine is the highest deviated from the standard, while the Edger machine recorded the lowest level of deviation.

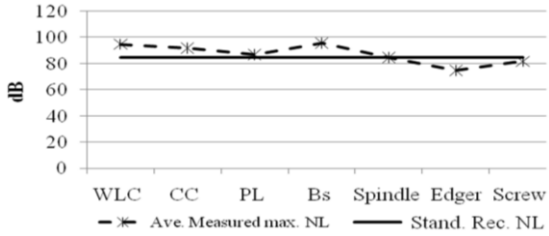

Figure 5. Comparison between measured average noise level (dB) and standard recommended exposure noise level (dB) of 64 sawmilling machines.

Table 6. Result of the measured average vibration level of 64 sawmilling machines.

Vibration Measurement			
Machines Description	**Ave. Max. VEV (m/s^2)**	**RS Max. VEL (m/s^2)***	**% Deviation from VEL**
Wood log Cutting machine	5.8	5	-16.0
Circular Cutting machine	5.2	5	-4.0
Planning machine	4.5	5	10.0
Band saw machine	6.8	5	-36.0
Spindle machine	4.2	5	16.0
Edger machine	3.7	5	26.0
Screw machine	2.8	5	44.0
	4.71 1.4	**5**	**5.71 27.4**

*(HS, 2005), Ave=average, Max. =maximum, VEV= Vibration Exposure Value, VEL=Vibration Exposure Limit.

3.8 Vibration Assessment

Table 5 shows the average vibration level of 64 measured machines. The table also shows the maximum Health and Safety Standard recommended vibration limit of 5 m/s^2 for workers. On the average, maximum vibration level of all the machines was 4.71 ±1.4 m/s^2. 5.71±27.4 was however recorded as percentage deviation from the maximum recommended standard.

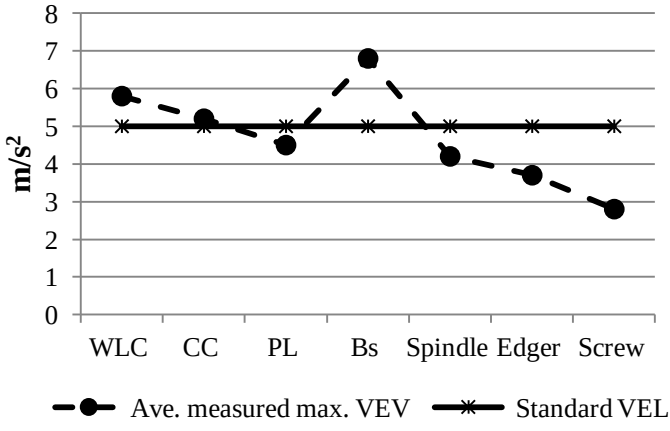

Figure 6. Comparison between average measured machine vibration and the recommended vibration exposure limit value of $5m/s^2$

Figure 6 compared the measured average vibration level of seven categories of machines with the recommended exposure limit value of $5m/s^2$. As

observed from the figure, the average measured values of 3 groups of machine representing 42.9% are above 5m/s^2. This included; Wood log Cutting, Circular Cutting and Band saw machines. Average measured values of the remaining four (4) categories of the machines, representing 57.1% were below 5m/s^2.

3.9 Discussion

Standing for long hours unguarded is common among sawmilling workers. Most of the jobs are equally carried out in forward bending postures. According to Cynthia (2004), lumbosacral strain, a CTDs type of diseases, is caused by combination of three factors; faulty alignment, standing for long hours unguarded, and forward bending. Lumbosacral pertains to the lumbar vertebrae and sacrum. With the prevalence of two of these risk factors i.e. standing for long hours unguarded and forward bending, the concerned workers may be prone to lumbosacral strain.

As evidence in the statistics test, the high prevalence of LBP among the workers might be as a result of the combined effect of awkward positions during work and also lifting of heavy log of wood. Studies have revealed a relationship between LBP and the specific motion patterns during forward bending (Silfies, 2005). Hence measures to reduce the awkward posture and manual handling of workpiece become necessary. Carrying of log of wood for instance could be done using lifting devices, wheel transporting device like wheel barrows or trolleys could be used to transport log of woods. Work shift and adequate rest may also help to reduce the prevalence of these two risks factors and prevent occurrence of such disorder among the workers.

As noted in this study, most sawmilling works require forceful gripping of tools and/or workpiece. As earlier reported, 58.3% suffered from finger movement while 14.2% experienced pains in their fingers regions. This might be as a result of the effect of forceful gripping, which according to Kroemer (1989) may lead to pain over the thumb of wrist. As confirmed by statistics analysis, there is a relationship between workers who reported forceful gripping and those who suffered from finger movement. According to CUE (2015), forceful gripping exertions of hand rely on muscle contractions in forearm, and muscle forces are transferred to fingers via tendons. The affected workers may be exposed to high risks of hand and wrist related problems, such as Tendonitis – a cumulative trauma disorders type which is usually caused by repeated or forceful exertions associated with repeatedly tensed tension in contact with a hard surface (Kroemer,

1989). These risk factors can also contribute to occurrence of De quervains disease (Cynthia, 2004), a disorder which occurs when the tendons around the base of thumb are irritated or constricted and can lead to pain over the thumb side of the wrist (AAOS, 2013). In this case hand glove can be provided for use during work, this will help reduce the effect of forceful gripping on the palm and fingers.

Noise pollution as well as machine vibrations were widely reported by the workers as common in the industry. This study noted that the noise level of about 71% of the total machine assessed were above the recommended standard of 85dB. This might lead to any of the hearing related injuries or loss. The supervisor/mangers however should make available necessary personal protective equipment to reduce the effects of noise pollution from these machines. Continuous exposure to excessive vibrating tool and/or machines according to WorkSafeNB (2013) will result in constriction of blood vessels in the hands and arms, thus reducing or cutting off blood supply to fingers and hands. The reduction in blood supply will cause numbness, blanching and tingling effects. Statistics analysis conducted in this study confirmed a relationship between workers who complained of excessive vibration and those who reported experience of loss of feeling with their fingers. Those workers (33.3%) who complained of these disorders may be among those who work daily with machines like wood log cutting machine, circular cutting machine and band saw with measured vibration exposure values above the recommended exposure limit of 5 m/s^2. Other factors may have also contributed to the disorder. Mandatory rest periods for vibratory tool and/or machine operators and ergonomics training on how to handle equipment and machinery could help to reduce the effect of this disorder among the affected workers.

4. Conclusions

This study assessed Cumulative Trauma Disorders (CTDs) among workers in Southwest Nigeria sawmilling industry. Arising from the major findings the following points are drawn;

1) Low back (99.3%), shoulder (83.3%) and wrist/hands (60.1%) were the leading pains among the workers.
2) Forceful gripping (96.4%), hand twisting (48.2%), standing unguarded (98.9%) for long period of time, forward bending (63.0%), excessive

vibrations (87.7%), forceful exertions (84.8%) and wrist deviation (37.7%) were the various actions which contributed to CTDs disorder among the group of workers.

3) CTDs symptoms prevalent among the workers included finger movement (58.3%), emotional stress (64.9%), pains at the base of thumb (66.3%), pain over the thumb side of the wrist (71.7%), loss of feelings with fingers (33.3%) and pains in the fingers region (6.9%).

4) The statistics analysis results established associations between some two or more prevalent risk factors capable of leading to CTDs. These included; (1) forceful gripping and hand twisting, (2) forward bending and emotional stress and (3) standing for long periods unguarded and forward bending.
5) Sawmill workers may be prone to De Quervain's disease, Degenerative joint disease and Lumbosacral strain among others, which may affect their musculoskeletal, vascular and nervous systems.

5. References

Adeoye, O.A., Adeomi1, A.A., Abodunrin, O.L., Olugbenga-Bello, A.I., and Abdulsalam1, S.T., (2015). Awareness of occupational hazards and health problems among sawmill workers in Osun State, Nigeria International Journal of Research and Review, 2(1), 1-14.

Aina, O.M, (2006). Wood waste utilization for energy generation. Proceedings of the international conference on renewable energy for developing countries, from http://www.udc.edu/docs/cere/Aina.pdf.

American Academy of Orthopaedic Surgeons, (AAOS) (2013). De Quervain's Tendinosis, from www.orthoinfo.aaos.org.

Bovenzi, M., (1998). Exposure-response relationship in the hand-arm vibration syndrome: an overview of current epidemiology research. International Archives of Occupational and Environmental Health, 71, 509-519.

Bridger, R.S., (1995). Introduction to Ergonomics. Mcgraw-hill International Editions. pp. 318-9.

Bruce, P., and Bernard, M.D., (1997). Musculoskeletal Disorders and Workplace Factors: A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. National

Institute for Occupational Safety and Health, from www.cdc.gov. Accessed on September 12, 2015.

Buckle, P., and Devereux, J., (2000). Work-related neck and upper limb musculoskeletal disorders, Journal of European Agency for Safety and Health at Work, 33, 207-217.

Canadian Centre for Occupational Health and Safety (CCOHS), (2008). Vibration - health effects, from http://www.ccohs.ca/oshanswers/phys_agents/vibration/vibration _effects.html.

Cornell University Ergonomics (CUE), (2015). Hand Tool Design and Musculoskeletal Disorders, from http: //www.occmed.oxfordjournals.org.

Cynthia, L.R., (2004). Designing, implementing, and justifying an ergonomics program in: Maynard's industrial engineering handbook (MIEH). Ergonomic technologies corporation. NewYork, from www.digitalengineeringlibrary.com.

Department of Environment and Conservation (DEC) (2006). Assessing vibration: a technical guideline, from www.environment.nsw.gov.au/noise.

Edwards, D.J., and Holt, G.D., (2006). Hand-arm vibration exposure from construction tools: results of a field study. Construction Management and Economics, Vol. 24(2), 209-217.

Environmental Protection Agency (EPA), (1991). A guide to the measurement and analysis of noise. Publication 280, from www.epa.vic.gov.au.

Fox, N.J., (1998). How to use observations in a research project. NHS Executive, Trent, U.K.

Health and Safety (HS), (2005). The control of vibration at work regulations. No. 1093, from ww.legislation.gov.uk.

Helmut, W.P., and Alan, G.M., (2011). Whole-Body Vibration Building Awareness in SH&E. Professional Safety, from www.asse.org.

Kehinde, A.L., and Awoyemi, T.T., (2009). Analysis of economic efficiency in sawnwood production in Southwest Nigeria, Journal of Human Ecology, 26(3), 175-183.

Kroemer, K.H.E., (1989). Cumulative trauma disorders: Their recognition and ergonomics measures to avoid them. Applied Ergonomics, 20(4), 274-280.

Kuorinka, B., and Jonsson, A., (1987). Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics, 18, 233-237.

New Jersey Department of Health and Senior Services (NJDHSS), (2003). Cumulative Trauma Disorders in office workers, from www.state.nj.us.

Njinaka, I., Uhumwangho, O.M., Edema, O.T., Dawodu, O.A., and Omoti, A. E., (2011). A comparison study of conjunctiva disorders in technical and administrative sawmill workers in Nigeria, Malays Journal of Medical Science., 18(3), 43-48.

National Institute for Occupation Safety and Health (NOISH), (1989). Cumulative Trauma Disorders in the workplace, Journal of Occupational Safety and Health, 32, 91-231.

Nunes, I.L., and Bush, P.M.C., (2012). Work related musculoskeletal disorders assessment and prevention, from www.intechopen.com.

Richard, N., and Michael, Y., (2002). Task-based assessment of occupational vibration and noise exposures in forestry workers. American Industrial Hygiene Association Journal, 63, 617–627.

Safe Work Australia (SWA), (2015). Guide to measuring and assessing workplace exposure to Hand-Arm vibration, from www.swa.gov.au.

Sanders, M.S., and McCormick, E.J,. (1993). Human factors in engineering and design. 7th edition. Mcgraw-hill International Editions, 627-34.

Shivakumara, B.S., and Sridhar, V., (2010). Study of vibration and its effect on health of the motorcycle rider, Online Journal of Health and Allied Sciences, 9(2), 1-4.

Silfies, S.P., Squillante, D., Maurer, P., Westcott, S., and Karduna, A.R., (2005). Trunk muscle recruitment patterns in specific chronic low back pain populations. Clinical Biomechanics, 20, 456–73.

Standard Australia (SA), (2013). Mechanical vibration-measurement and evaluation of human exposure to hand-transmitted vibration. ISO 5349.1:2013, from www.bookwebs.org.

U.S. Department of Health and Human Services (USDHHS), (1989). Occupational exposure to hand-arm vibration, from www.cdc.gov.

Vicki, S., (1979). Statistics for the Social Sciences. Little brown & Co (T). Ventura, CA, U.S.A.

WorkSafeNB, (2013). Hand-arm vibration syndrome, from www.worksafenb.ca.