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Department of Forest Technologies and Buildings



The Health Implications of Chainsaw Usage on the Forest Workers

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Supervisor:

Ing. Jan Macků, Ph.D.

Author:

Rita Amankona Asuama

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Rita Amankona Asuama

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Thesis title

The Health Implication of Chainsaw Usage on the Forest Workers

Objectives of thesis

The aim of the thesis is to unify the available literary sources about the specifics of wood logging. At the same time, the aim of the work is to evaluate, using the available literature, the influence of work with the chainsaw on the health of workers.

The partial aim of the thesis is, based on the findings of the study of the literature, to propose steps that could lead to the optimization of the relation between the forest – the worker – the saw.

Methodology

The work is based on literary research.

The task is to gather available literary sources in the field of wood logging and its impact on workers' health.

The work will take into account the available literary sources, both historical and modern, in order to be able to follow the trends of the given issues.

The sub-goal will, on the basis of literature studies, propose steps to optimize production.

The proposed extent of the thesis

30 pages

Keywords

chainsaw, forest workers, logging, health

Recommended information sources

- Dvořák, J. Využití harvesterových technologií v hospodářských lesích = The use of harvester technology in production forests. Kostelec nad Černými lesy: Lesnická práce, 2012. ISBN 978-80-7458-028-4
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The Bachelor Thesis Supervisor

Ing. Jan Macků, Ph.D.

Supervising department

Department of Forest Technologies and Constructions

Electronic approval: 8. 3. 2019

doc. Ing. Miroslav Hájek, Ph.D.

Head of department

Electronic approval: 13. 3. 2019

prof. Ing. Marek Turčáni, Ph.D.

Dean

Prague on 26. 01. 2020

Declaration

I hereby declare that this thesis entitled — The Health Implications of Chainsaw Usage on the Forest Workers is my own work and all the sources have been quoted and acknowledged by means of complete references.

February 4th, 2020, Prague

Rita Amankona Asuama

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Abstract

Chainsaw is portable mechanical instrument that is used to perform functions like felling, bucking, pruning etc. This instrument was developed in 1830 and has gone through a lot of design changes due to the risk factors associated with it. The change of the chainsaw design from manual to electric has taken place over the years. The unchecked exposure to hardwood dust is common in forestry workers since they are involved in cutting various trees during a variety of operations. This is a main health hazard and this exposure to hardwood dust is due to the chainsaw usage and cutting. The generation of vibration and noise also has harmful health implications. Although the basic design of chainsaw has undergone a lot of evolution, there still is a gap for improvement in terms of its performance and safety. As this instrument is commonly used in various forestry techniques, especially motor-manual tree felling, the exposure to hardwood dust is responsible for many respiratory disorders. The harmful diseases that have been reported include hearing impairment, digestive issues, nervous system issues, migraines, and other health problems. This research work focuses on identifying and pinpointing the health issues caused by chainsaw usage during wood logging amongst forestry workers. Recommendations for better safety by automating these processes have also been given. Furthermore, the suitable measures and policies for forestry workers have also been discussed with the help of different case studies considered during this research study.

Keywords:

Forestry, Wood logging, Chainsaw, Hardwood dust, Health hazards

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1. Introduction

Hard wood dust is a fine form of wood dust which is produced as a harmful by product of woodwork and poses immense health dangers to the workers involved in forestry. The exposure to hardwood dust is common in forestry workers since they are involved in cutting various trees during a variety of operations. The rampant exposure to hardwood dust is due to the chainsaw usage and cutting specially during conifer pruning, conifer thinning and coppice clear cut. Chainsaw is used in various forestry techniques, for example during motor-manual tree felling and these operations are quite dangerous for forest workers, requiring improvement in these processes (Jonas, 2016). Better safety can be offered by mechanizing and automating these processes. However, different hurdles are created specially working in hilly areas or rocky regions. The main issue which need to be dealt with in order to avoid hardwood dust exposure include the steep terrains. Apart from the hardwood dust, the frequent use of chainsaws in these forestry procedures also leads to exposure to loud noise and vibrations. Other prominent stresses included in these practices also include exposure to harmful exhaust gases (Romankow 2007).

As far as the health implications of hardwood dust is concerned, these fine particles were proclaimed to be carcinogenic by the European Union which was based on the classification of International Agency for Research on Cancer (IARC). The EU directives have set 5 mg m^{-3} as the operational exposure limit of Inhalable wood dust. The range of operational exposure limit for inhalable wood dust varies from 1 to 5 mg m^{-3} for different countries. The chainsaw cutting and processing of the forest wood results in exposure to wood dust which is harmful to the health of the workers. Countermeasures for the prevention from the wood dust should be necessarily taken so that its harmful impact can be reduced. A study on a forest located in the Apennine mountain range of Central Italy was carried out to test the impact of the forest dust. The results of the study showed that the type of chainsaw fuel remained the same while exposure to wood dust varied widely. The treatments that were considered in this study include conifer thinning, conifer pruning, coppice clear cut and sanitary cut (Marchi, 2017).

Furthermore, there is a high risk associated with chainsaw milling and there is a high risk of injury and fatigue while performing the job. The cutting speed can be increased by removing the chain depth gauge however it increases the risks of kickbacks (Romankow, 2007). Wrong posture while dealing with it is another thing that can prove to be hazardous to health. The high noise and vibration levels also result in a harmful impact on the health of workers. The high level of risk on the job should be handled through proper safety measures but unfortunately, there are very few countries where such measures are adopted. The use of chainsaw milling attachments can reduce the risk factor of it but it is rarely used (Jonas, 2016).

Sustainable forest management makes sure that the working conditions for the workers are safe enough to perform the job and necessary prerequisites are taken up by the employee while they are in the field area (Lotfalian, 2012). A good and efficient job can be ensured only when the workers are trained and well instructed. The supervisors and forest managers have the responsibility of making sure that the forest operations are performed by observing safety measures (Jonas, 2016).

The major accidents associated with chainsaws include ax felling and crosscut saw. The major hazardous impacts on the health include deafness due to noise and the vibrations cause Raynaud's disease. Noise is harmful to the health of the ears and excessive exposure to it can result in partial deafness while the long-term exposure to it can result in a complete sense of hearing. The noise level of chainsaw is 106 Db which is unacceptable for the health of the hearing system. The countermeasure that can be taken to resolve this issue can be the use of earmuffs which can reduce the noise levels to 80 Db which can reduce the dangers of deafness (Davis, 1978).

Additionally, the workers face constant exposure to vibrations while handling the chainsaw. This results in fatigue and numbness in and in severe cases it can lead to dis functioning of hands and may also affect the overall blood circulation in the body. Chainsaw workers need to follow the countermeasures to avoid contact with such hazardous diseases. Not taking the right safety measures can impact the health badly (Davis, 1978).

2. Aim of the Thesis

The aim of the thesis is to unify the available literary sources about the specifics of wood logging. At the same time, the aim of the work is to evaluate, using the available literature, the influence of work with the chainsaw on the health of workers. The partial aim of the thesis is, based on the findings of the study of the literature, to propose steps that could lead to the optimization of the relation between the forest, the worker and the chainsaw.

3. Literature Review

This chapter aims at the studies done on wood logging operation and its impact on the environment as well as the health of Foresters. It covers the importance of chainsaw operation and its usefulness in wood logging. The adverse impact and health consequences of hardwood dust have also been critically analyzed and reviewed in terms of human health. Furthermore, this chapter also highlights the consequences of chainsaw usage on the workers.

3.1 Background of Wood Logging

As reported in the literature, wood logging is the process that involves wood cutting, skidding and its loading into the trucks. To make this possible heavy machine are used in the process of wood logging. Basically, the term logging defines the forest management (Addario-Berry, 2014). This is very beneficial for the for the sustained production of timber in the forests. Logging is the process that basically deals with the felling of trees and is mostly used for obtaining timber from forests. The wood product industry is highly dependent on it and is used for various purposes (Addario-Berry, 2014). But this is not its only use, this process is also used to meet the forest management plans and goals.

Kickbacks refers to the outgoing run due to the jamming or resistance of the chain which causes the chain to be pushed towards the operator resulting in serious injuries and can even lead to death. The workers need to be trained as well as the instrument should be further developed for making sure. There are certain cases that have been reported in which the chainsaw operator loses balance and falls on the running chainsaws leading to serious injuries and even death.

The logging process has remained controversial and there has been a lot of debate on it that whether it is legal or not. Many points are raised that this has an impact on the aesthetics of the environment, but it is backed up the importance of logging process. The

negative impact of logging is that it affects the natural habitat as well as the depletion of natural resources. However, the benefit of obtaining wood and the clearing of harmful species in the forest are used to back up the controversial arguments (Rummer, 1995).

3.2 Benefits of Wood Logging in Forestry

Wood logging has several benefits in the field of forestry that have been reported and published in the previous studies. In forestry, wood logging is considered to bring a plethora of advantages for the forest health because due the wood logging operation the harmful and unnecessary species are removed from the forest (Sosman, 1969). It allows the cleaning of the forest from excessive and unbeneficial species of the plants. Weak and overgrown branches that are occupying the forest area and serve no benefits are also removed from the forest as a result of it. As a result, a good exposure of light and air is received by the plants of the forest. these two factors are essential for the growth and development of the plants.

Due the crowded areas of the forest, there is a chance that pathogens can attack and affect the plants. The major reason for the birth of these pathogens is crowdedness. The wood logging also clears such pathogens and the impact of harm can be reduced through this (Sosman, 1969). Wood logging is very useful for obtaining timber from the forests. This wood is used in different areas for various purposes and can help in earning financial benefits (Dimou, 2018). The process of the wood logging enables the ground of forest to flourish as it gives chance to new trees to grow. Specially the short life cycle plants are very beneficial in this wood logging (Dimou, 2018).

3.3 Health Risks from Chainsaw Usage

However, the studies published regarding the process of tree cutting show that this procedure is quite dangerous if the proper precautionary measures are not taken by the foresters while dealing with tree cutting and processing (Sosman, 1969). Over the years a lot of improvements in the chainsaw design have been made but still it has not been ergonomically suitable and safe for use.

Moreover, many repercussions have been associated with the release of hardwood dust produced as a result of the chainsaw usage by the foresters. This hardwood dust which consists of fine dust particles that is very hazardous for the health is released during the wood cutting process (Enarson, 1990). Noise and vibrations are also produced during the wood cutting process which has a very bad impact on the health of the chainsaw workers and is not suitable in the long run. Exhaust gases and the floating particles of the mineral oil also add up to the health hazards. The wood cutting and logging process is very dusty due to the small dust particles released during the process. The fact that these particles are dusty is well known by the forest management authorities. However, there are certain limits that are tolerable for the human body and do not cause any harm.

3.4 Diseases caused due to wood logging and cutting operation

Following are the diseases that result due the wood logging and cutting operations:

- Nasal cavity adenocancer
- Paranasal sinuses
- Pulmonary function changes
- Allergic respiratory responses (asthma)
- Health effects of Mechanical vibrations

- Effect of noise produced by Chainsaw

The description of the cause and cure of the diseases is covered below.

The wood dust released during the chain saw operation is carcinogenic in nature if inhaled over a long time above a specific limit. Strong and regular exposure with cancers of the lungs and nasal cavity have been resulted both in experiments on the people who has occupations which resulted wood-dust exposure and in studies that measured the results of estimated wood-dust exposure (Pérez- Ríos, 2010). The U.S. Occupational Safety & Health Administration defines the measures and safe limits of wood dust that would not lead to diseases or any kind of health risks.

The following operations result in high dust exposures:

- Sawing
- Turning
- Cutting
- Sanding
- Routing
- Dry Dust Sweeping
- Bagging Process from The Systems

3.5 Wood dust results in several risks to worker health

- Breathing problems resulting from the inhalation of the dust from wood cutting. It can lead to Asthma which might also lead to lung cancer if the measures are taken. In some case nasal cavity cancer is also observed due to this.

- If this wood dust is swallowed in any case, then it directly affects the intestines leading to blood infections. The blood infections due to it are serious and can result on negative effects on different parts of the body.
- The exposure of dust with the eyes can cause instant irritation and damage to them
- Human skin also shows sensitivity towards the wood dust if the exposure prolongs. It can lead to skin irritation and ulcers. The skin is badly damaged due to this exposure. In the case of some plant species it has been also found that the wood dust might also lead to skin cancers and dermatitis (Çelik, 2006).

The Figure 1 below shows the diseases that result due to inhalable and repairable dust.



Figure 1. Diseases due to Inhalable and Repairable Dust

(Source: <https://www.dusttool.nl/en/dustco-international-bv-2/>)

Experiencing this dangerous dust of wood can be reduced through design and instrumental modifications, such as incorporating an exhaust system with filters placed at places where dust is produced. The short-term solution for reducing exposure is personal protective equipment, which include respirators.

The rate of respiratory diseases is observed to be high where the respiratory protective equipment is not use. The use of respiratory protective equipment highly reduces the impact of the nasal cancer and sinuses. However, it has been found that the forest management departments of the underdeveloped country cannot afford such equipment for their workers due to which they have to face a high rate of this disease risk (Baran, 2007).

Apart from the chainsaws hazards of having accidents associated with cutting with chainsaw and wood felling there are diseases that are caused due the release of vibration and noise production during the cutting operations (Koponen, 2011). Above a certain limit these vibrations are not considered to be safe and result in diseases. The diseases include deafness because of noise and Raynaud's disease caused by vibration.

In case of long-time excessive noise there may be a total or partial deafness. The ear health is at a very high risk if the operation time is above the normal level. The normal level of noise for most chainsaws is about 106 dB which is allowed medically. If this limit is not followed it can lead to the disease of ear. However, earmuffs can decrease the level of noise produced by the chainsaw to below 80 dB, thereby reducing the harm of deafness in the forest workers.

The high intensity of vibration from chainsaws are transferred to the operator's hands and can lead to fatigue, pain, cyanosis while the severe cases of vibrations exposure result in, Raynaud's disease, which is a disease market with the poor circulation of blood in hands that changes the color of hands to white. Figure 2 given below shows the effects of vibrations on hands. It also leads to the numbness of hands due to which they cannot feel their movement of hands. Also, it results in the loss of control of hands which is caused by the damaging of the nerves of hands (Osman, 2009).

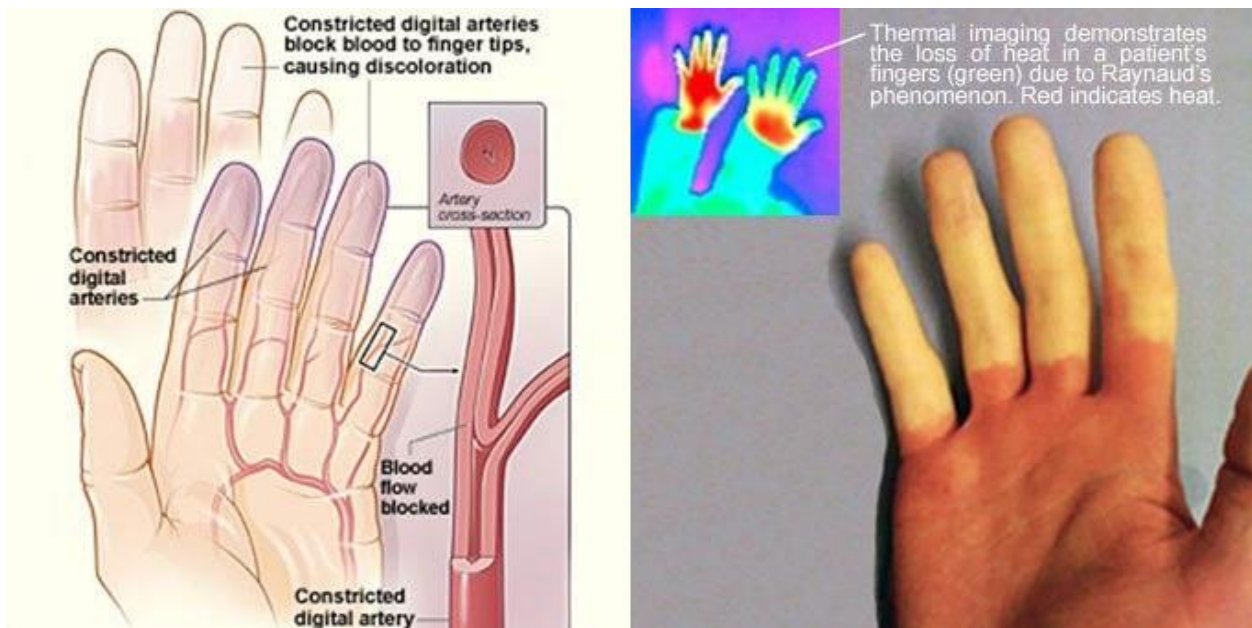


Figure 2. Hand area Affected due to Vibrations

Source: https://www.medicinenet.com/raynauds_phenomenon/article.htm

There are certain ways that are suggested to decrease the incidence of this disease. Safety gloves that are designed according to the standards can result in the reduction of vibrations up to a certain limit but does not reduce the chance of disease unless the time of working hours of the forest workers is controlled.

Due to the increase in health risks due to chainsaw usage and the wood logging operation an organization in UK was set up to deal with the issues related to health. Forest Industry Safety Accord (FISA) was developed by a group of professionals to deal with the monitoring and regulation of health standards as stated by the policies of the Forestry. This organization keeps track of events occurring due to the chainsaw usage and wood logging operation. The aim of this organization is to make the forest workers aware about the standard of health and safety at their workplace. This organization was established due to the increased number of reported cases of accidents and diseases caused by the forest operation.

3.6 Safe Limits for Wood Dust Exposure

In order to test the safe limit, tests are conducted on different samples using different wood types to see what would be suitable. But these manual methods exploit humans during their testing phase which is not a good act. But if these kinds of experiments for testing the levels of wood dust and other factors are done by the analysis of the field of on job forester's so that there is no exploitation of workers (Enarson, 1990). These tests are helpful in devising safe measures of safety so that safe working conditions are ensured, and workers are trained to follow the safety instructions. The results of the experimental testing on the foresters showed that the range of wood-dust exposure on them was between 1 to 3 mg per meter cube during the normal wood cutting operation while the coppicing operation produced less wood dust (Dimou, 2018). In the Table 1 given below, N shows the number of samples on which experiment is done while the % column represents the percentage of the wood produced.

Table 1. Amount of Wood Dust Produced as a Result of Different Operations of Wood Cutting

Wood Dust		≤ 1 mg/m ³		≤ mg/m ³		≤ mg/m ³		≤mg/m ³	
N	Operation	N	%	N	%	N	%	N	%
20	Clear Cut in Coppice	1	5	18	90	19	95	1	5
23	Thinning	11	48	21	91	23	100	0	0
28	Pruning	7	25	25	89	27	96	1	4
29	Sanitary Cut	13	45	29	100	29	100	0	0
10	Total	32	32	93	93	98	98	2	2

Source: Italian Society of Silviculture and Forest Ecology

Through the experiment reported in a study, it was found that different wood cutting operations produced different levels of wood dust. The hardwood is expected to produce more wood dust as compared to soft dust. The maximum amount of wood dust was produced as a result of coppicing and pruning operations. The wood condition also has an impact on the production of wood dust. If the wood is rotten, decayed or wet then it is not s

harmful as hardwood. So, the quality of wood also impacts the levels of wood dust produced (Donahue, 2011).

Another factor that affects the amount of hardwood dust being produced is the species of plant. This amount is determined by the species of plant that is being cut during the operation. This also influences the levels of wood dust in the environment. Some species produce less wood dust while others release more wood dust. So, the impact of wood dust also varies from one plant species type to another (Sosman, 1969).

In a case study carried out in Croatia, there was a proposal passed for the regulation of maximum permissible concentration of hazardous substances that are safe for the health of the individual. The limit for the wood dust particles that are considered suitable for the workers is 3 mg per meter cube. Hence, the foresters while dealing with the wood cutting operations must make sure that the safety measures are being followed in order to overcome the effect produced by the hardwood dust. The major harmful element determined from the studies show that hardwood dust can lead to further diseases if its amount is not controlled (Sosman, 1969).

3.7 Hazardous Gas Detection from Chainsaw Engine

Additionally, the studies reveal that there are certain gases that are released from the chainsaw engine when it is being operated. The two main gases that were found to be released during the chainsaw operation are methane and nitrogen mono oxide (Potočnik, 2017). These were found to be released from 2 conventional chainsaws that include the amateur and the professional one. The experimentations for the testing of various control factors during the chainsaw operations are measured under the real environmental conditions. These experiments are performed under control measures to test the significance of each factor.

Yet another factor reported in the literature is that there are certain gas detectors that can test the levels of gases in the air. During the field operation, such detectors hold great

importance (Potočnik, 2017). These gas detectors tell the amount of gas in the air and can be used to take safety measures if the gas levels are disturbed in the environment. People working in the field can respond to the conditions accordingly.

For the wood cutting areas, the use of smell analyzers can tell that either the working condition is safe or not. These analyzers can be used to collect data of gases produced by the chainsaw during the cutting operation at different conditions (Enarson, 1990). Then the experiment conducting team can process this data by applying statistical tools using the software. This can give them the required findings that can be analyzed to know the trends of the gases produced while performing a different operation on different wood types (Enarson, 1990).

3.8 Evolution of Chainsaw Design

The history of the chainsaw started in the year 1830 by an orthopedist Bernhard Heine. The first and primary design of chainsaw consisted of a specific hand cranked bone saw as shown in Figure 3 given below. This form of handmade chainsaw was meant to be used only during surgical operations. This was the beginning of chainsaw and later in the year 1905, Samuel J. Bens who belonged to San Francisco received a patent for his design of chainsaw.



Figure 3. Preliminary Design of Chainsaw

Source: www.pinterest.com



Figure 4. Modern Chainsaw

Source: <https://www.stihl.com/>

After that, the next chainsaw to be designed was a portable chainsaw, which was developed in the year 1918. The design for a portable chainsaw was then patented by James Shand, which consisted of multiple man saws powered by electricity and supported by

tractors. However, a major drawback of this chainsaw design was its bulky size and its heavy weight, which made it difficult to operate.

Furthermore, in the year 1933, the patent for portable chainsaw was improved by Festo company. Another prominent name in the history and evolution of chainsaw design is Andreas Stihl. He filed for a patent for an electric chainsaw in the year 1926. Apart from that, he also patented the design for a gasoline-powered chainsaw three years later. This design of chainsaw is still known till date. This updated chainsaw design can be seen in Figure 4.

The development of chainsaw has been very important progress in forestry. It is very efficient as compared to traditional blade method. However, still, there is a requirement of further design development of chainsaw due to some of its risks (Axelsson, 1998). Research also shows that the chainsaw type also defines how much-expected gases can be produced due to it. It is beneficial if the gases are not dangerous or their levels are maintained. The foresters should be provided with the chainsaws that are environmentally friendly and not that hazardous for the environment. Catalytic chainsaws are recommended to be used by the chainsaw workers because they are not harmful to the environment (Potočnik, 2017).

In forestry, the portable chainsaw is a basic operational instrument. For efficient performance of chainsaw, it is very important to have the necessary maintenance of the instrument so that greater productivity could be ensured. The lubrication of chain is necessary to protect it from deterioration and for its smooth functioning. To lubricate the chain oils are usually used. Biodegradable oils have better properties as compared to conventional lubrication oils, therefore, they are used nowadays.

3.9 Advantages of Chainsaw

The benefits of the chainsaw can be availed only if the operation of woodcutting is performed under controlled and safe working conditions. If the safety measures are not

followed during the chain saw operation that its quite harmful than being beneficial (Addario-Berry, 2014). Several advantages are served by the chainsaws to the forest workers. A less amount of investment is required for them and a lot of benefits could be earned using them. The ease of accessibility of this equipment is another plus point offered by this equipment as compared to the conventional milling. The conversion into lumber is one of the very beneficial tasks performed it. Forest workers mostly use a chainsaw for the felling of trees with large diameters. Forest workers report that it is less laborious to work on the large forest areas (Addario-Berry, 2014).

In many countries, chainsaw milling is done for obtaining timber from the forests and to export it. There are certain policies that have been developed for chainsaw usage and instructions. Locally this wood is used as fuel by the people. this mostly happens in the backward areas where the need is not being fulfilled and the supply of energy is not available (Addario-Berry, 2014).

The operation that is mainly performed using the chainsaw is the conversion of logs into lumber. First, the trees are cut and then the processing of the tree wood using chainsaws is done. Lumber is produced using the chainsaw from the big logs of wood. The chainsaw equipment is very useful for the processing of the wood logs. It can be used to convert the wooden logs into other forms that are usable. Some of the converted products can be directly moved to the market. (Addario-Berry, 2014).

The property of shorter decomposition time of the biodegradable oils makes it favorable for the environment. For the functioning of chainsaws and making the chainsaw operation smooth, the biodegradable oils are a basic element (Stanovský et al., 2013). However, the risks that occur during the logging operations cannot be supported by any point. The logging process has been one of the riskiest jobs. It's the responsibility of forest management to handle such risks.

3.10 Case studies regarding Accidents During Wood Logging

The Australian state enterprise provides a briefing about the number of accidents occurred during the period 2000-2009. A total of 1077 cases were reported in the forests of Australia and the severity of these events ranged from head-neck injuries to the loss of body parts while the chainsaw cutting was being performed. The most serious cases resulted from the wood logging operations when incidents of wood felling occurred. However, it was found that the rate of these accidents decreased when the workers were trained (Tsioras, 2014).

A study on the wood logging accidents in Swedish Industry of forests showed that several cases of severe cases injuries resulted because of using the traditional saws but the mechanization of the chainsaw method resulted in a decreased rate of such accidents. This showed that chainsaw mechanization was an important progress made in this field.

Table 2 below shows the types of injuries that have occurred during different operations. Their occurrences are mainly covered in this table. Felling and Trimming are activities that are most reported.

Table 2. Summary of Accidents by Activity and Injury During 1985-1991 in New Zealand

Operation	Type of Injury					Overall	Percentage of total
	Laceration	Fracture	Bruising	Multiple	Other		
Felling	180 (14)	63 (39)	118 (8)	30 (37)	61	452 (18)	27.3
Trimming	357 (12)	14 (34)	41 (6)	6 (7)	36	454 (12)	27.5
Landing work	120 (14)	53 (43)	88 (6)	13 (23)	85	359 (15)	21.7
Breaking out	39 (5)	34 (29)	63 (6)	14 (29)	64	214 (12)	13.0
Other	52	25	27	9	61	174	10.5
Total	748 (12)	189 (37)	337 (7)	27 (29)	307	1653 (14)	-
Percentage	45.3	11.4	20.4	4.4	18.6	-	100.0

Source: Logging Industry Research Organization, Rotorua, New Zealand

A study was conducted in the field to see the performance of a manual harvesting system with the help of a chainsaw in a Caspian hardwood forest. A selective cut was made on a 42-hectare tract having an average slope of 30%. Felling time for one tree was influenced by diameter and distance. The gross production rate was 20.6 m³ per hour by one person and the net production rate was 26.1 m³ per hour by one person. The cost of one unit using the gross rate was 1.05 USD/m³ and the unit cost considering the net production rate was 0.81 USD/m³. Diameter at breast height (D) and distance among harvested trees (L) were taken as the significant variables and the model used in the study was the time expenditure model. Figure 5 and Figure 6 given below depict the graphs reflecting the effect of tree diameter and distance between trees on the felling time.

Statistical analysis was conducted using data collected from the field. The regression of the data was run to find out the results. The significant diameter of the tree and distance among the trees was tested as well as their relationship with the cycle time. Following were the results that were obtained from regression (Behjou, 2009).

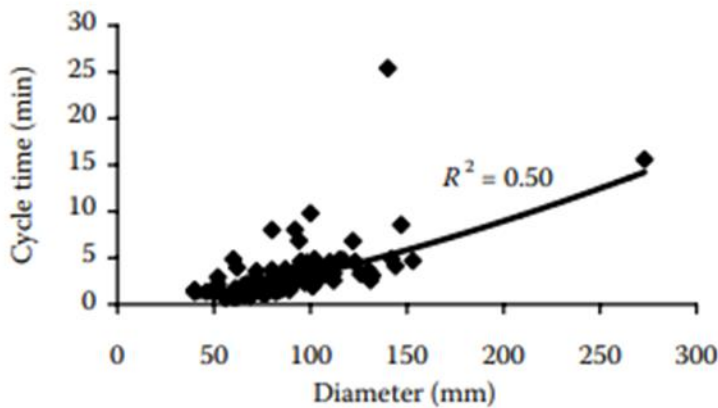


Figure 5. Effects of Tree Diameter on Felling Time Per Cycle

Source: Behjou et al., 2009

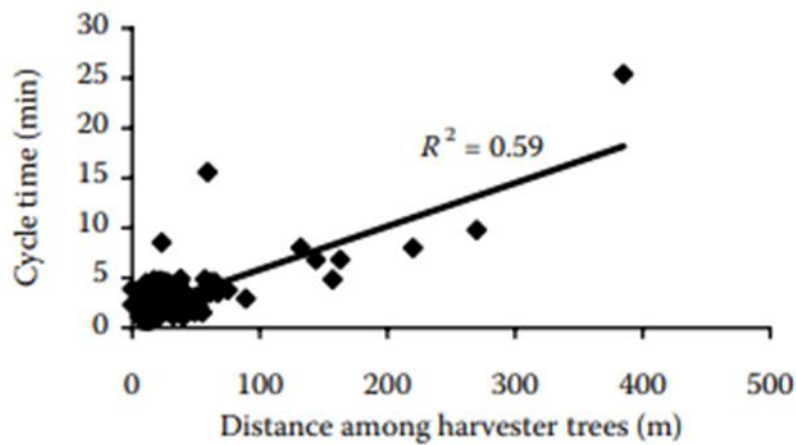


Figure 6. Effects of Distance Among Harvested Trees on Felling Time Per Cycle

Source: Behjou et al., 2009

Results of the study can be used for the comparison of the production and cost of other harvesting systems used and this might prove to be beneficial for the loggers to decide which system to choose through which their productivity can be improved and also the circumstances of harvesting time. The limitations of this experiment were the mechanical and technical delays that might have an impact on the values (Behjou, 2009). Logging is a perilous task. A survey was conducted in the US to know about the profession that is the most dangerous. Data was collected about this field which is summarized in the Figure 7 below:

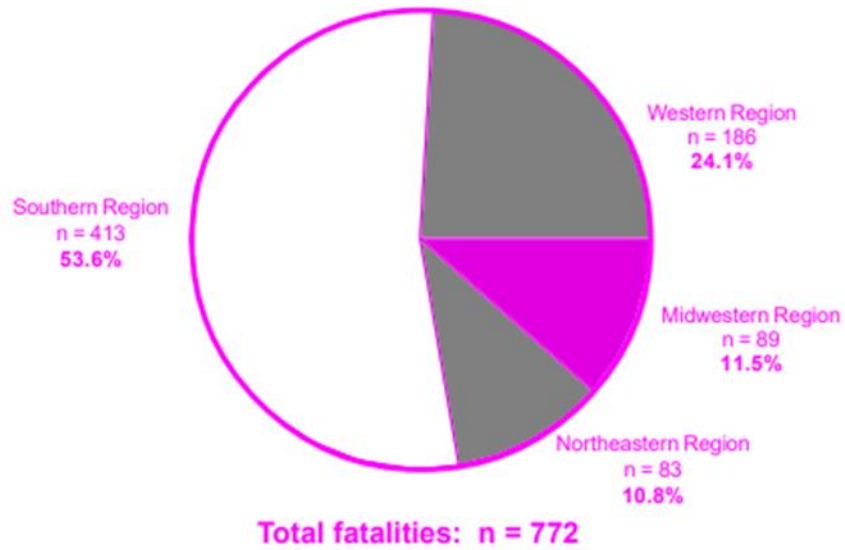


Figure 7. Logging Fatalities in the United States by Region

Source: US Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 1998

This chart shows that the highest number of fatalities was reported in the Southern Region. Another survey on the logging employment percentage showed that it was maximum in the southern region. Figure 8 below shows the results of this survey:

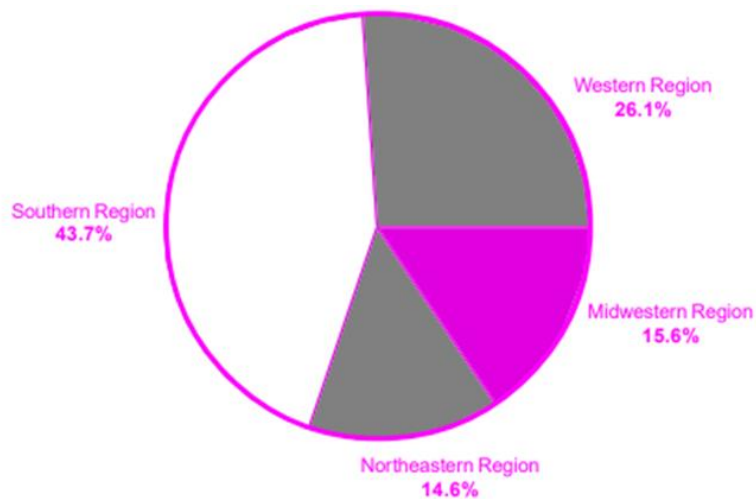


Figure 8. Logging Employment Percentage by Region

Source: US Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 1998

This survey was conducted to know about the trends of fatalities that have occurred due to the logging activities. It was found that the trend of fatalities has increased over the years. However, it was found that due to the training and safety measures observation by the forest workers many non-fatal injuries were reported. But still, it could not be completely controlled.

In the recent years, a study conducted by New Zealand’s Forest Management showed that the trimming and felling of trees during the wood logging incidents resulted in most of the accidents. This is shown by Table 3 given below. About 50% were reported during this operation. A trend of an increase in such accidents was reported over the years and the reason that was figured out for such events is the increase in the number of inexperienced groups.

Table 3. List of Laceration Injuries that Resulted from the Wood Logging Operations

Location of Laceration	Number	% of Total
Head	72	9.6
Eyes	22	2.9
Arm	82	11
Hand	216	28.9
Upper torso	18	2.4
Lower torso	6	0.8
Upper leg	57	7.6
Lower leg	98	13.1
Foot	167	22.3
Other	10	1.3
Total	748	100

Source: Logging Industry Research Organization New Zealand

The time of this accidents of wood logging was between 9 to 10 am. These working hours were the dangerous hours for the wood logging process.

In order to deal with such injuries, the policy for wearing personal protective equipment was passed. It is basically used to ensure the workers safety while performing

their job on field. The use of these personal protective equipment reduces the incidence of such events (Enez, 2014).

The injuries discussed above were the result of the wood logging process. There are some other injuries as well that resulted due to the wood dust that was produced during the activity performed during the chainsaw usage. Wood dust produced during the process has resulted in several risks and diseases (Crowe, 1982).

The Figure 9 below shows the recorded injuries in specific parts of the body during the logging operation. This shows the health implications on chainsaw workers.

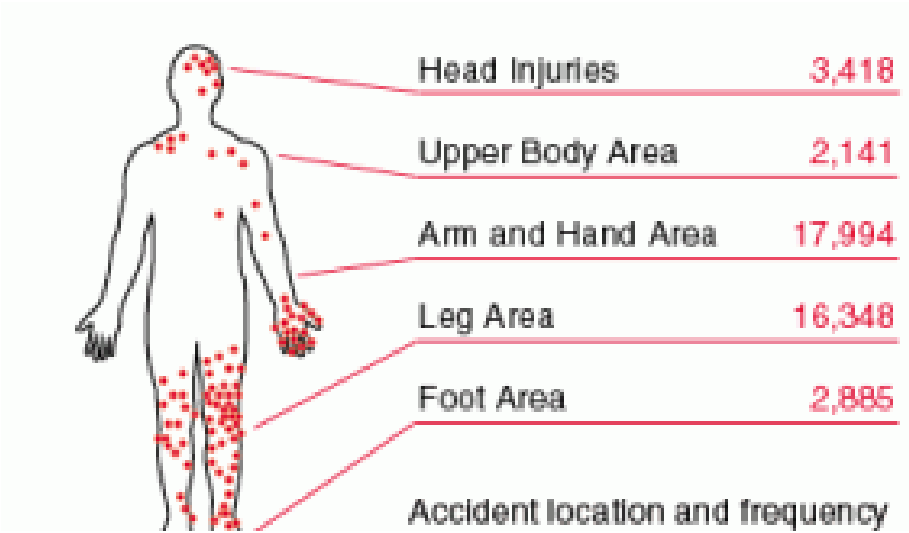


Figure 9. Recorded Injuries in Specific Parts of the Body by Logging Operations

Source: US Product Safety Commission

Through an analysis of previous policy on wood logging, it was found that Liberia’s wood logging industry was imposed with sanctions that did not allow it to develop its wood logging industry. The reason that caused the sanctions to be imposed in the country was the inappropriate and unregulated manner by which the activity was conducted.

The activity of chainsaw cutting during the wood logging was banned to illegal activity of the people being observed. This happened due to the lack of monitoring and policy regulation by the forest management authorities in Liberia. People started

performing this activity illegally without taking proper measures which resulted in several health risks and deadly accidents. They used that wood to earn revenues from it which was not a legal way to do this activity.

To deal with this the government authorities developed a regulatory mechanism. The government encouraged the people to invest in this area so that its expansion can be made possible. This prevented from the illegal act of wood logging (Shaffer, 2005). While the area where still a gap has been left is providing safety measures for performing the chain saw job appropriately with reduced risks. The need of optimization of the regulatory processes is still there because lot of health risks are being resulted due to the wood logging process. Also, the systems improvement from Manual to Mechanized is required so that the incidence of such events could be reduced.

There are certain laws and policies that have been developed to regulate the process of good logging and make sure that no illegal procedures against the standard operating procedures are carried out. The laws act introduced in some countries include the US Lacey Act, EU timber regulation and Australian Illegal Logging Prohibition Act 2012. These acts have been developed to reduce the level of health risks that were increasing in the rate because the standard operating procedures were not being followed (Randall, 2009).

The Figure 10 shows that the among the deadliest jobs of 2013 the wood logging stands on top.

America's Deadliest Jobs

Fatal occupational injuries per 100,000 full-time workers (2013)

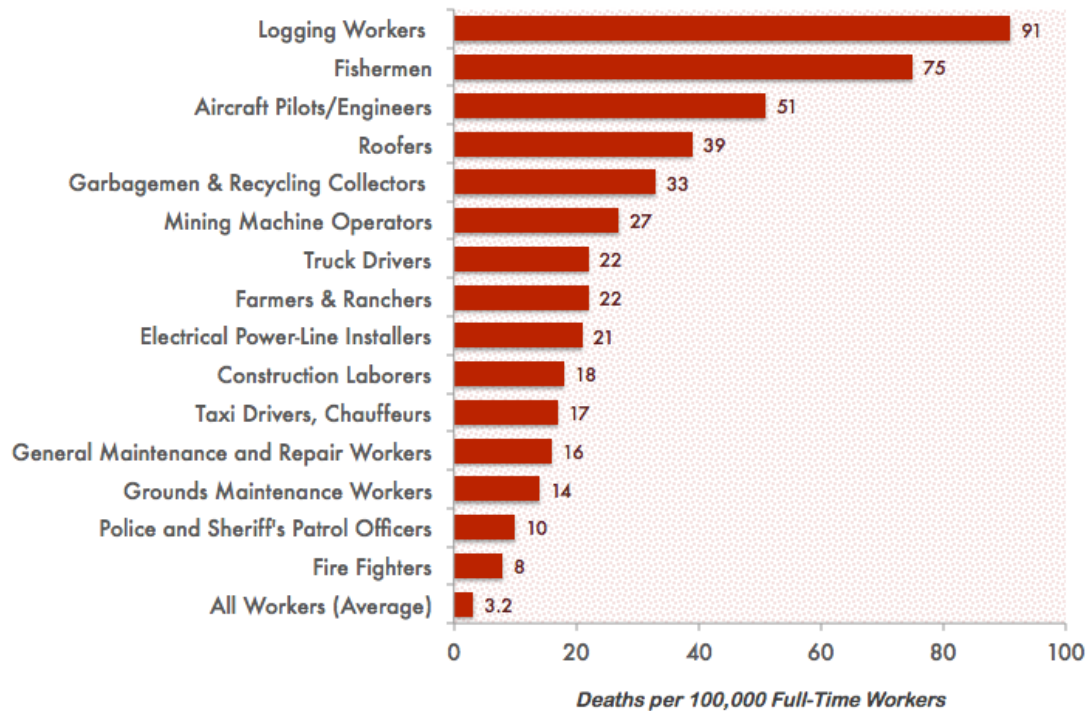


Figure 10. Wood Logging as Deadliest Job of 2013

Source: ANANDTECH

The reason of this being on the top is that no regulatory rules for the health and safety rules. In countries where these rules are present, the reason that accidents result is not following the rules. Not following the rules results in accidents and injuries which make this job deadly.

The Figure 11 below shows the personal protective equipment that need to be used while performing the wood logging job. This can help to reduce the deadly effects that might result due to the wood logging risks.

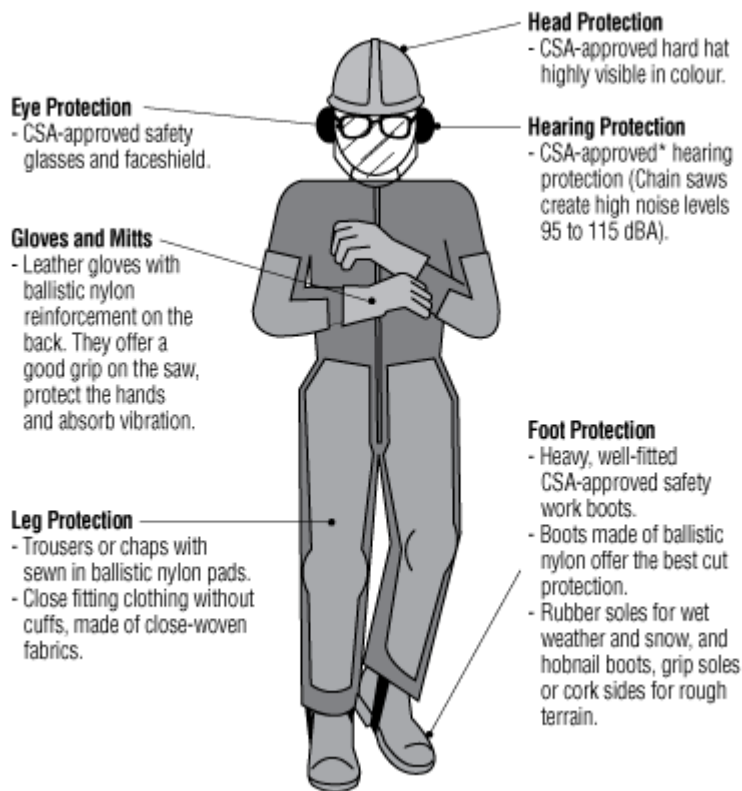


Figure 11. Personal Protective Equipment for Safety of Forest Workers

Source: Canadian Center for occupational health and safety

The help risks due to wood logging can be reduced by using the personal protective equipment. This was by the Canadian Health and Safety Center for the workers using the chainsaw equipment during the wood cutting operation. It was found that the risks of injuries were highly reduced as a result of it but due to the lack of resources of the forest management authorities of some countries, the risks are still not controlled.

3.11 Risk Assessment and Policy Making by Forest Management

Risk Assessment is the process that analyses and evaluates the risks as well as the harms of the forest operations. This is done to make improvements in the safety measures if

there is any lag in the procedures related to safety. The improvements can reduce the risk of fatalities rate and improved production rate (Bordas et al., 2001).

According to the health and safety work act 1974 the organizations that employ more than 4 people need to make sure that the risk assessment of job is done by the supervisors of every area. Writing down the risk assessment is also promoted under this act. This act has been signed irrespective of the size of business. Risk assessment is subjective and dependent on the type of job being performed. The goal of a good risk assessment approach is that people on a worksite know what to do and how to perform the job safely. They should also be aware of the possible hazards at a job (Bordas et al., 2001).

Providing the information and instructions about health safety and technical training is the job of supervisors. They must give clear instructions and adequate training to their employees about the risks they may face and the measures to adopt for the control of the risks. They should be guided on how to follow any emergency procedures. It is very important to meet the training needs and supervision of the new recruits and trainees as they mostly include young people who are more vulnerable to accidents (Bordas et al., 2001).

A study was conducted to find out the satisfaction level of the workers performing this job. In this study, a survey was conducted to about the perceptions of the participants about the role of forest management and their handling with the operations of the forestry. The participants were asked what were the risks that they have observed the most on the job. Based on their answers some variables were analyzed that were perceived as the points of risk by the workers. The satisfaction level of the supervisors about the job SOPs as well as the worker's performance was also analyzed. However, less work was done to know about non-safety measures. When the results of the study were analyzed it was found that there was a contradiction between the responses of workers and the supervisors (Bordas et al., 2001).

The management response showed that the job safety and satisfaction levels are being met positively for the workers performing the job on sight. But the study showed that

the perceptions of the workers about job safety and satisfaction were negative. The results show that the management should work to improve the communication gap with their workers so that they can know what the perceptions of the workers about their job are. The management should also work to improve the satisfaction levels of their employees and make sure that the job safety requirements are being met (Michael et al., 2005).

The Swedish forestry department conducted a study to analyze the health and safety risks on chainsaw operators and wood logging machine operators. The study aimed to check the impact of increased mechanization of the instruments on the risks during the job. The frequency rate of the chainsaw operator's accident was 63% while it was 17% for the wood logging machine operators. It was found that the mechanization of the chainsaw instrument resulted in a decrease in the risk rate of chainsaw accident by 10%. This has been a significant improvement by the Swedish forestry due to its research in the areas of ergonomics (Axelsson, 1998).

Health hazards were decreased due to the adoption of health and safety measures, especially the disease due the chainsaw vibration was notably found to be reduced among chainsaw operators. Repetitive stress injuries (RSI) was also found to be reduced by taking proper on job safety measures. The Swedish forestry made an efficient progress as compared to the other countries where the stats have been found to be increased over the years. Standards for the ergonomic developments and safety measures were set up by the forestry department of Sweden for the other countries which have been a very significant contribution (Axelsson, 1998).

For performing any work with a chainsaw, the worker should ensure that the risks of the task have been monitored and controlled and the operator is trained to do the job. Also, the operator wears the required personal protective equipment (PPE) for the job. They should be provided with the training to either stop the engine or applies the chain brake in case of the saw not being used (Bordas et al., 2001).

All the safety measures need to be implemented by the supervisors and the forest management authorities should also play their role in this matter. Although the formulation

of the policies has the major role in this field and the safety measures play a secondary role but still a lot of improvements have been resulted in this area by them and have reduced a great number of risks.

3.12 General Safety Measures and Recommendations for Forest Workers

The general safety measures that the forest workers should take include wearing facemasks, sunglasses and Hi-Vis jackets. Wearing the appropriate shoes is also essential for the workers in the field area. Lose and long dresses can result in serious hazards so the cloths fitting should be according to the standards of safety (Montorselli et al., 2010).

Moreover, the general safety guidelines for forest workers state that the dress of the forest workers should have close body fitting. Hearing protection should be worn by the forest workers to reduce the risk of diseases caused due to noise (Montorselli et al., 2010). The chain should be handled and adjusted safely to avoid any kind of hazards. Not adjusting the chain can lead to kickbacks which result in fatal injuries. Fumes and dust inhalation can be controlled by wearing masks (Montorselli et al., 2010).

In order to operate a chainsaw, it is important for the worker to be physically and mentally composed. This is because the job requires present mindedness and activeness otherwise serious hazards can result (Montorselli et al., 2010). People with disabilities or any kind of medical prescription by the doctor that restricts the task efficiency should not be allowed to perform the job. This is because these things can affect the ability of the workers to operate the chainsaw (Bordas et al., 2001).

There are some conditions in which operating the chainsaw is highly prohibited. These conditions include diseases like strokes, arthritis, diabetes, heart diseases, vertigo, giddiness, etc. These diseases affect the mobility and alertness of the workers. Their physical strength and vision is also affected by these diseases. The chainsaw job requires efficiency from the workers which can be achieved by dexterity and good balancing

abilities of the worker. The operators must make sure that they meet the health standards of the job (Bordas et al., 2001).

Therefore, it is evident from the detailed analysis of different literary studies that there has been a gradual evolution which has been observed in the history chainsaw cutting and wood logging. Moreover, there is a pressing need to optimize these procedures in forestry and to devise policies which can lessen the health implications of these operations on health of foresters.

4. Methodology

The work is based on literary research. The task is to gather available literary sources in the field of wood logging and its impact on workers' health. The work considers the available literary sources, both historical and modern, in order to be able to follow the trends of the given issues. The sub-goal will be based on literature studies, propose steps to optimize production.

5. Results

The result of various studies and the data analyzed from the journal articles provides a lot of insights about the wood logging operation using chainsaw. Also, the health implications on the chainsaw workers for performing the wood cutting using the chainsaw was also studied through the existing literature.

Most of the studies from the existing literature showed that the use of chainsaw is one of the riskiest jobs in the world and the deadliest accidents have been reported among the chainsaw workers. I found a lot of work done related to the accidents and risks for performing this operation while very little work has been done for the formulation of the policies for the regulation of forest operations.

There are a lot of diseases that might be caused due to the chainsaw operation. Nasal cavity cancer and asthma are caused due to the wood dust produced during the chainsaw operation. The vibrations and noise of the chainsaw instrument if experienced over a long period of time can cause very serious risks to health. Also, if the chainsaw is not maintained properly or not handled rightly then it can lead to serious accidents and even death.

A lot of controversies about the usage of chainsaw and cutting of timber have therefore been emerged. To provide counter argument for the controversies very less work has been done. However, a lot of work can be found on the health implications on chainsaw workers due to the usage of chainsaw for wood cutting. Many statistics on the number of causalities and risk of accidents have been found in the existing literature.

In addition to this, health and safety trainings and instructions related policies can be found to reduce the risk of accidents among the chainsaw workers. But there are no standard fixed operations manuals for the workers using chainsaw. Therefore, a lot of work needs to be done in this field so that some consolidated policies and standard operating procedures are developed.

6. Discussion

This chapter covers the discussion of specific health diseases that result from the chainsaw operation. Apart from the risk factors of operations these diseases also come under health implications of chainsaw. The safe limits and control measures policies for these diseases are also covered in this chapter.

Forest policies are developed to provide a guideline to the management of forest. National and local authorities must come together for the development of standard policies to be followed. Each country has its own regulatory process for the development of authorities. Policies provide a legal and regulatory mechanism to run the operations of forest according to the safe standards.

Policy development is highly influenced by the political climate of a country or the area within which an area of land is located. In some cases, it has been found that individuals become advocates for this course of action. In other cases, these individuals work as researchers investigating the means of policy scenarios and their impact on forest management (Wiggins, 2004).

These individual efforts are not enough to meet the demand of the forest management. This is because forests operate on a large scale and organizations need to take proper action to deal with the situations. The integration and coordination of regulatory authorities can lead to the development of standard policies. The current rate of the accidents in the forests have resulted to the lack of concrete policy formulation. Although there are standard health and safety measures that have been developed to reduce the risks but without the implementation of these standards by the regulatory bodies it is not possible to reach the health safety objectives (Boscarino, 2009).

To analyze the health implications and incidents that occur due to chainsaw usage, the forest management makes summaries of such events to know the trends of the events occurrence. The logging companies are responsible to prepare summaries of such events at regular intervals. The record of data is collected directly from the field and is then entered

into the computerized data base. The data is then processed and analyzed. After the processing of data summaries of the accidents reported due to wood logging are reported to the concerned forest management organization. The role of these organizations is to develop measures that would avoid any accidents in future (Addario-Berry, 2014).

The results of the trends about the kind of injuries resulting due to specific operation being performed can be analyzed to know the root cause of such events. Also, the record of the number and types of the injuries is also maintained by the forest management authorities. The reason behind collecting the data and then processing it in software is to get the various risks trends of the operation. Record keeping of the past events is done to know about the patterns of these events. The objective of doing this is to plan and adopt measures that would help to avoid such events in future. The training of workers required to bring improvement in the existing alarming figures is done to avoid accidents in the future. The processes of performing job and the equipment are modified depending upon the need of time. These modifications and changes are important to deal with the issues like these (Peters, 1991).

If the same procedures and equipment are being used, then there is no chance of improvement in the trends of such accidents. It is the responsibility of the forest management authorities to take necessary steps for the safety of their workers. The trend analysis is also useful in decreasing the number of such events in future. A drop in the number of such events is success for the forest regulation authorities. However, this is possible only if the required actions are taken on time otherwise the same cases might occur in future as well (Lefort, 2003).

7. Conclusion

Chainsaw is an important development in the field of forestry and is a good mechanization of the old blade using method. The wood cutting in the forests have been highly facilitated due to it. Along with these benefits there are some drawbacks of the instrument as well. Due to its improper use, several fatalities have been reported over the years. The risk assessment by the forest management has not been effective in this area therefore it has led to several fatalities in different countries over the past years. This research work mainly sought to give more insight on the effect of chainsaw usage on the health of forestry workers, measures that can be adopted to reduce these harmful effects which includes the use of personal protective equipment (PPE) and the significance of providing training and workshops periodically for workers in forest enterprises. At the end all objectives set for this bachelor thesis were met.

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