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# Indonesian timber harvesting workers' knowledge of occupational safety and health

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## Abstract

**Background:** Occupational accidents potentially occur in timber harvesting work. Because this work has a high accident risk, workers' knowledge of occupational safety and health (OSH) is essential. In this study we analysed a group of Indonesian timber harvesting workers' knowledge of OSH, particularly as it relates to operations in natural forests.

**Methods:** We interviewed 30 people who directly undertake timber harvesting work and asked them to answer surveys containing 15 questions related to different aspects of OSH knowledge. Responses were quantified using the Likert scale and validity and reliability tests were performed.

**Results:** The results showed that: 1) worker knowledge regarding the benefits of using personal protective equipment (PPE) was highest compared to the other 14 indicators; 2) workers had less knowledge about timber harvest planning, the meaning of occupational safety and health, safe ways of working and the frequency of work accidents when timber harvesting; and 3) validity and reliability tests showed that this survey was a valid instrument for collecting information on workers' knowledge of OSH.

**Conclusions:** The Indonesian timber harvesting workers surveyed had limited knowledge of the planning of tree felling, timber skidding, and loading, yet they perceive the cognition of OSH, working methods to minimise accidents, and the frequency of work accidents during timber harvesting every year. Ongoing training to improve workers' knowledge of OSH, including correct use of personal protective equipment is important for reducing the risk of workplace accidents. The use of serious games can assist with this training.

**Keywords:** Occupational Safety and Health (OSH); work accidents; timber harvesting; knowledge; forestry workers

## Introduction

Timber harvesting activities both in plantation and natural forests have a high risk of workplace accidents. Nkomo et al. (2018) stated that this high risk of work accidents is influenced by the tools used, operator skills, and knowledge of occupational safety and health (OSH). In the period from 2008 to 2015, Yovi & Yamada (2019) reported that the number of recorded work accidents in the Indonesian forestry sector was 984 per year, which included an average of 46.4 fatalities per year. These accidents occurred across harvesting and collecting forest products, charcoal production, and sap/resin tapping. Logging has a higher risk of work accidents than skidding, loading, unloading, and hauling. It has been identified as one of the most dangerous jobs in many parts the world (Lagerstrom et al. 2019; Occupational Safety and Health Administration US Department of Labor 2024). The dangerous nature of forestry work can be linked to

the environment (rugged terrain, climatic conditions, biological agents, and exposure to noise, vibrations, and exhaust fumes) and to the tools and processed material, i.e. the use of sharp and/or power tools, heavy loads, and heavy machinery (Kaakkurivaara et al. 2022). Nikooy et al. (2019) stated that tree condition has an important role in work accidents in timber harvesting, such as trees stuck with a broken branch and the presence of stumps or dead stems and broken crowns. However, Newman et al. (2018) identified a broader range of factors contributing to workplace accidents which can be grouped into human factors, physical environment, work organisation, and machinery, tools and equipment. Human factors including judgement and decision making, skill and technique, training and education, age, and experience affect human behaviour in the workplace in a way that can affect OSH. Therefore, OSH in forestry work, particularly for timber harvesting is paramount.

There are a variety of work accidents that can occur during timber harvesting, including 1) being hit by a felled tree; 2) hand injuries caused by a chainsaw; 3) hands pricked by thorns; 4) head crushed by a broken branch or twig; 5) falls induced by tripping on tree roots or by sloping ground; 6) dislocated wrist due to incorrect chainsaw operation; 7) eye damage or irritation caused by fine grains of sawdust from creating the undercut and back cut during tree felling; and 8) earache or permanent hearing loss due to the loud noise emitted by chainsaws.

The use of manual tools when timber harvesting, such as chainsaws during logging, is a risk factor for work accidents. Research results show that the highest proportion of work accidents occurred in manual logging work at 51.4% (Landekić et al. 2021; Potočnik & Poje 2017). The risk of work accidents can be mitigated by developing and implementing OSH policies that address the main risk factors. In Indonesia, the government has developed and implemented the Ministry of Manpower Regulation No. 5 which focuses on Occupational Safety and Health in the Work Environment (Ministry of Manpower 2018). For timber harvesting, these regulations cover noise and vibration from the use of felling tools, skidding equipment, loading and unloading, and hauling as well as ergonomic factors. Noise is defined as all unwanted sounds originating from production process equipment or work tools at a certain level causing hearing problems. Vibration is the regular movement of objects in a back, and forth direction from a balanced position. Ergonomic factors are those that can influence activities workers undertake due to a mismatch between work facilities which include work methods, work positions, work tools and lifting loads. Noise control is carried out if levels exceed a threshold value, and these control measures include eliminating noise sources, installing sound dampeners, and using personal protective equipment. Similarly, vibration control is carried out if levels exceed a threshold value, and these control measures include eliminating the source of vibration, replacing tools or work processes that cause vibration, reducing vibration by adding cushions; and using personal protective equipment. Potential dangers from ergonomic factors are caused by work methods, work positions, body posture, design of work tools and workplaces that do not suit the worker's anthropometry, and lifting loads that exceed work capacity. These regulations enable protection for workers and productivity and are intended to create good working conditions for businesses (Ministry of Manpower 2018). More generally, in Indonesia OSH is philosophised as an effort to ensure the integrity and the physical and spiritual perfection for workers in particular and society in general, of works and culture towards a just and prosperous society (Setyawan 2020).

When implementing OSH policies and practices within the timber harvesting workforce, a key initial step is ensuring that workers are aware of and understand these policies and procedures. This is reinforced by the analysis by Kao et al. (2019) who found that safety knowledge is correlated with worker safety attitudes and safety behaviours. Furthermore, Christian et al. (2009) reported that safety knowledge was strongly related to safety performance behaviours. Therefore, this study aimed to analyse the OSH knowledge of Indonesian timber harvesting workers, particularly those working in a natural forest setting.

## Methods

### Study location

This study was conducted in one of the natural forest concessions in Berau District, East Kalimantan Province, Indonesia, namely the PT Inhutani I Sambarata Unit (Figure 1). It is located between 02°15'15" N–117°00'09" E and 02°40'21" N–117°29'25" E. The total area is about 106,020 ha which is dominated by secondary dryland forest (92,330 ha) and primary dryland forest (4,140 ha). The concession has an annual allowable cut of approximately 15,000 $m^3$ from an area of approximately 30,000 ha.

### Data collection and analysis

This study interviewed 30 workers involved in timber harvesting. This group consisted of ten tree-fellers, ten skidder operators and ten timber loader operators. Each worker was asked 15 questions which sought to measure their understanding of different aspects of OSH (Table 1). Responses from each worker were captured using a five-point Likert scale (Table 2), which is widely used to measure attitudes, opinions, and perceptions of a person or group about social phenomena (Hardani et al. 2020). The Likert scale is categorised as an ordinal/interval scale (Yuliarmi & Marhaeni 2019). In this survey, higher scores represented better knowledge. The individual score for each statement was summed up to obtain the respondent's total score.

Prior to analysing the responses from the timber workers, the validity and reliability of the survey to generate usable data were assessed. This assessment determined whether the survey would generate consistent results with repeated measurements (reliability) and achieving precision in the measurements (validity). The validity test aims to determine whether the scale used in

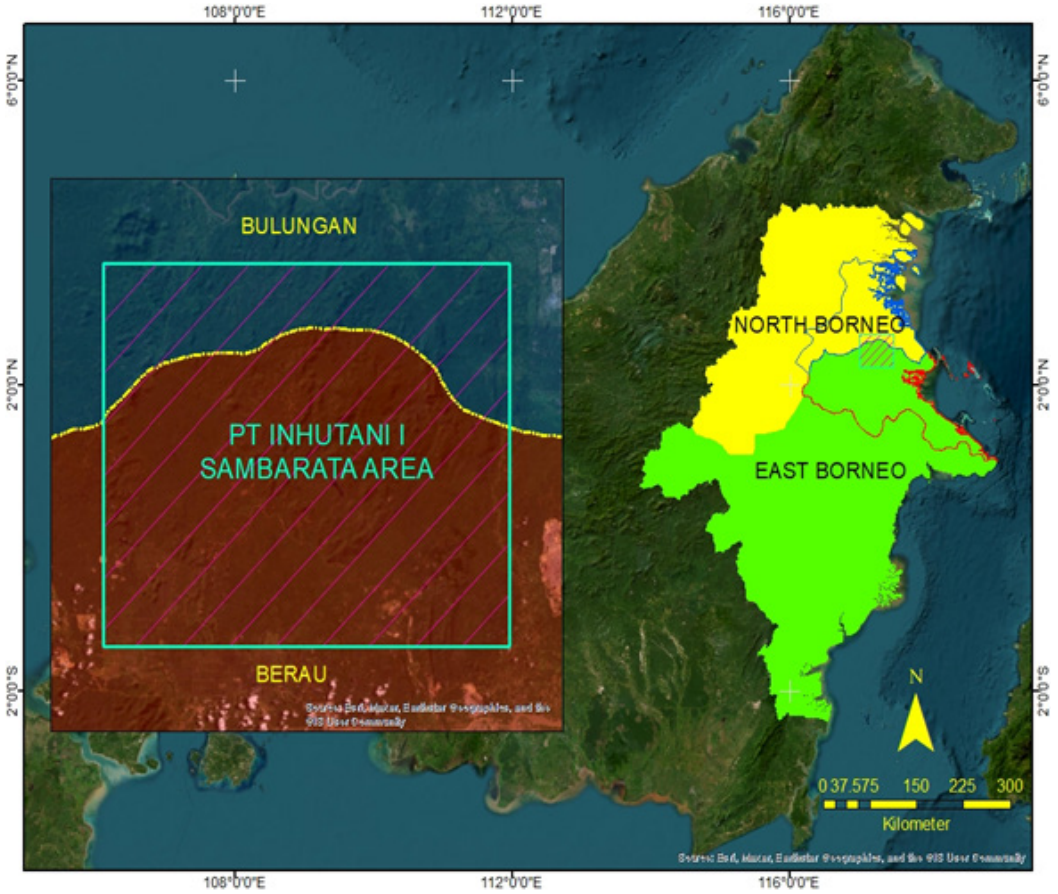


FIGURE 1: The area of PT Inhutani I Sambarata Unit

the questionnaire produces feasible results or not (Dewi 2018). The validity test was conducted by correlating the score of the individual questions with the total score. The question was declared valid if the correlation (r) value was > 0.30 or the significance value was < 0.05 (Hardani et al. 2020). In this study, the r value was computed using SPSS 25 with the criteria test defined as:

- $H_0$ is accepted if r-count > r-table (the measuring instrument used is valid)
- $H_0$ is rejected if r-count < r-table (the measuring instrument used is invalid)

TABLE 1: List of questions used to test the OSH knowledge of timber harvesting workers.

| No | Question |
|---|---|
| 1 | What is your level of knowledge about the planning of tree felling, timber skidding, and loading? |
| 2 | What is your level of knowledge on how to operate equipment for felling, skidding, and loading? |
| 3 | What is your level of knowledge on how to maintain felling, skidding, and loading equipment? |
| 4 | What is your level of knowledge on the meaning of Occupational Health and Safety (OSH)? |
| 5 | What is your level of knowledge regarding the benefits of using personal protective equipment (PPE)? |
| 6 | What is your level of knowledge of the risk of work accidents in felling, skidding, and loading? |
| 7 | How much knowledge have you obtained from OSH training provided by the company? |
| 8 | What is your level of knowledge about the first action to take if the tool you are using cannot operate optimally? |
| 9 | What is your level of knowledge of how to perform first aid in an accident? |
| 10 | What is your level of knowledge of how to operate the tool you are using in difficult field conditions |
| 11 | What is your level of knowledge of how to minimise the risk of workplace accidents? |
| 12 | What is your level of knowledge of the benefits of life insurance? |
| 13 | What is your level of knowledge about PPE provided for workers by the company? |
| 14 | What is your level of knowledge about the different types of PPE that should be used in a particular situation? |
| 15 | What is your level of knowledge about the frequency of work accidents that occur during timber harvesting every year? |

The reliability test is used to determine the consistency of the measuring instrument, whether the measuring device used is reliable, and remains consistent if the measurement is repeated (Dewi 2018). In this study, the reliability test was conducted by computing Cronbach's alpha value using SPSS 25. Cronbach's alpha is used to describe the correlation or relationship between the scale created and all existing variable scales. A questionnaire is said to be reliable or reliable if a person's answers to statements are consistent or stable over time (Ghozali 2016). The closer Cronbach's alpha is to 1, the higher the internal consistency reliability (Hanjaya 2016; Sukmana et al. 2020). The survey was considered to be reliable if the independent and dependent variables have Cronbach alpha values > 0.6.

The overall score for a question was calculated by summing the individual numeric Likert scores given in Table 2. This was also expressed as percentage response by dividing this score by the maximum possible. The average level of knowledge among all the workers for each question was then calculated using the interval ranges given in Table 3.

## Results

### Potential hazards in timber harvesting work

Examples of the risks faced by workers in different stages of timber harvesting work are provided in Table 4. This list is based on feedback from workers and the opinions of the authors. It shows that timber harvesting workers face many potential hazards and risks at each stage of the work. It also highlights the number and breadth of hazards that chainsaw operators are exposed to. These include various work environment risk factors such as noise and body shaking due to tool operation, climatic conditions, lighting, physiology, and workload (Camargo et al. 2021; Marcu et al. 2021; Poje et al. 2019). Unver & Ergenc (2021) reported that chainsaw operators have the highest risk of work accidents with the main sources of risk being the work environment, work techniques and methods, tools/machines used, and worker characteristics. Hutasuhut et al. (2021) and Pradipta (2016) reported that the utilisation of chainsaws during tree felling activity in natural production forests in Indonesia presented multiple hazards and, in some cases, resulted loss of worker life. Therefore, topographical conditions, stands, worker health, condition of tools used, and knowledge of workers become the factors that affect work accidents in timber harvesting works.

### Validity and reliability tests

A validity test was performed to determine the accuracy of the questionnaire to obtain the proper data. The analysis performed was product-moment correlation analysis, namely the correlation between the question items and the total. The questionnaire validity test showed that the r-count was greater than the r-table. Therefore, it can be concluded that all 15 statements are valid, and all these questions can be used to measure workers' awareness of OSH. The reliability test of all 15 instruments in this study yielded a Cronbach's alpha value of 0.777, which means that the instruments used were considered reliable.

### Workers' knowledge level on OSH

The overall frequency distribution of responses (as measured on the Likert scale) from timber harvesting workers to the 15 questions related OSH knowledge is presented in Figure 2. There was variation in the level of knowledge across the 15 questions asked and among individual respondent's answers for a particular question (Table 5). The overall scores for each question showed the workers had superior knowledge regarding the benefits of using PPE (Question 5), the types of PPE (Question 14), and the maintenance of timber harvesting tools particularly felling, skidding, and loading tools/equipment (Question 3). Conversely, some respondents only had basic knowledge regarding timber harvest planning (Question 1), the meaning of OSH (Question 4), how to work safely (Question 11), and the annual work accident frequency (Question 15). However, the respondents' overall knowledge level of OSH is considered good since their responses were mostly classified as "adequate knowledge" and "superior knowledge" rather than "minimal knowledge". Despite this, it is still necessary to hold regular training for timber harvesting workers to improve their knowledge and understanding of OSH.

## Discussion

### Potential hazards in timber harvesting work

Timber harvesting in Indonesia's natural forests is dominated by manual equipment, particularly tree-felling work. Chainsaws are the main equipment that are not only used for tree felling activities but also for delimbing and bucking operations (Dulsalam et al. 2018; Soenarno & Yuniawati 2019). This is different to Europe, North America and Australasia where mechanised timber

TABLE 2: Criteria used for quantifying respondents' answer.

| Respondent answer | Score |
|---|---|
| No knowledge (N) | 1 |
| Minimal knowledge (M) | 2 |
| Basic knowledge (B) | 3 |
| Adequate knowledge (A) | 4 |
| Superior knowledge (S) | 5 |

TABLE 3: The level of respondents' knowledge according to the average value of Likert's scale

| Interval value (%) | Knowledge level |
|---|---|
| 53–60 | No knowledge (N) |
| 61–68 | Minimal knowledge (M) |
| 69–76 | Basic knowledge (B) |
| 77–84 | Adequate knowledge (A) |
| 85–92 | Superior knowledge (S) |

TABLE 4: Hazards and risks of work accidents during the stages of timber harvesting works

| No | Work stage | Hazard and risks |
|---|---|---|
| 1 | Felling | a) Scratches to hands, pricked by thorns, or attacked by a snake when clearing shrubs or understorey trees<br>b) The saw chain breaks/jams causing a hand injury<br>c) Loud noise from the chainsaw<br>d) The sawdust from the chainsaw exhaust could enter the eyes<br>e) The incorrect decision of tree-felling direction could cause a hit<br>f) Being hit by a twig or tree branch<br>g) A faller's body could be punctured by stems/branches that are attached to other trees.<br>h) A faller could trip or slide down into a ravine, even when cutting trees on a gentle slope<br>i) Slipping due to wet ground risks injury, including sprained ankles<br>j) Hands could be cut as a result of mishandling the chainsaw |
| 2 | Skidding | a) The body shakes due to the operation of the skidding equipment<br>b) Operators and skidding equipment could fall into a ravine<br>c) The body could be impaled on a small tree trunk<br>d) Eyes pierced by thorns<br>e) Vulnerable to overturning since the tool fails on uphill and downhill tracks |
| 3 | Bucking | a) Injuries to hands and feet (including cut) due to the chainsaw operation |
| 4 | Loading and unloading | a) Crushed by logs during loading and unloading<br>b) Overturned and fell with the loading and unloading equipment due to the poor tool base and log tumbled from the logging truck |
| 5 | Hauling | a) Slippery hauling road conditions and overloaded trucks conducted fell over to the truck and the driver<br>b) Accidents with other logging trucks due to the lack of traffic signs in the forest |

harvesting is the norm. While the use of mechanical equipment in timber harvesting has advantages in terms of production, worker safety, and minimising waste, the capital investment required is considerable (Bilici et al. 2019; Gülci et al. 2021). However, productivity gains can still be achieved with manual equipment by taking into account several limiting factors, namely stand characteristics, topographical conditions, operator skills, and weather (Contreras et al. 2016; Schweier et al. 2019). Despite this, the use of motor-manual methods in timber harvesting operations puts workers at higher risk of accidents. Previous studies that have either reviewed accident statistics or topics covered in publications on forestry safety have highlighted the risks associated with motor-manual felling (Landekić et al. 2021; Potočnik & Poje 2017).

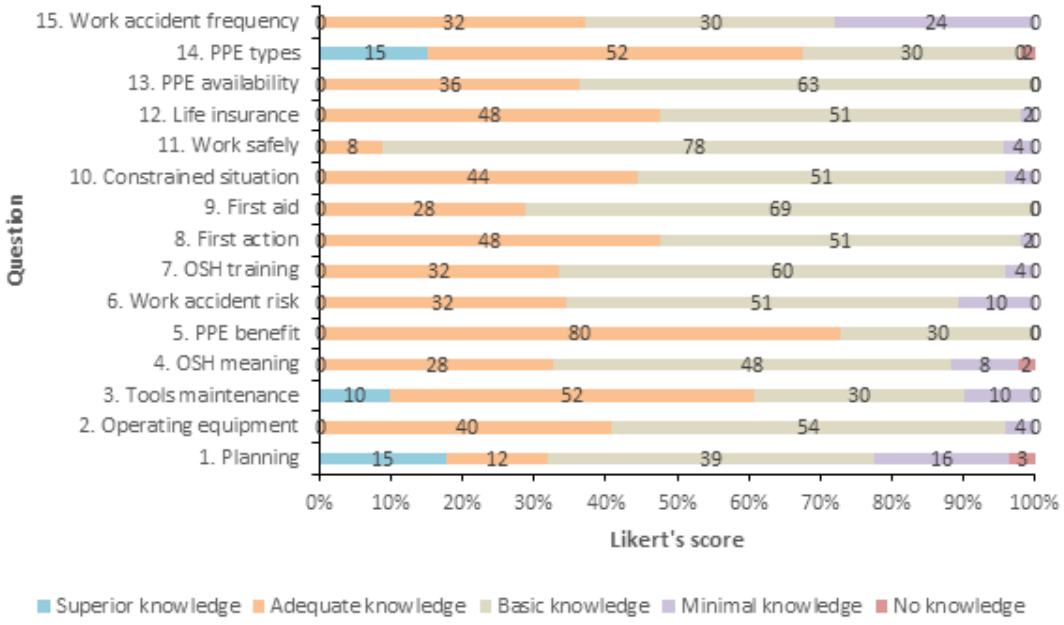


FIGURE 2: Frequency distribution of workers' knowledge

TABLE 5: Summary of the Likert's scale scores from the 15 questions in the survey.

| | Question no | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
| Total Likert score | 85 | 98 | 102 | 89 | 110 | 93 | 96 | 101 | 97 | 99 | 90 | 101 | 99 | 103 | 86 |
| Max | 5 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 |
| Min | 1 | 2 | 2 | 1 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 1 | 2 |
| Average | 2.83 | 3.27 | 3.40 | 2.97 | 3.67 | 3.10 | 3.20 | 3.37 | 3.23 | 3.30 | 3.00 | 3.37 | 3.30 | 3.43 | 2.87 |
| SD | 1.09 | 0.58 | 0.86 | 0.81 | 0.48 | 0.66 | 0.55 | 0.56 | 0.43 | 0.59 | 0.37 | 0.56 | 0.47 | 1.00 | 0.82 |
| Percentage score | 70.83 | 81.70 | 85.00 | 74.17 | 91.67 | 77.50 | 80.00 | 84.17 | 80.83 | 82.50 | 75.00 | 84.17 | 82.50 | 85.83 | 71.67 |
| Knowledge level | B | A | S | B | S | A | A | A | A | A | B | A | A | S | B |

The high risk of accidents in timber harvesting work highlights the importance of increasing forestry workers' knowledge of OSH and implementation of safe working practices. Previous studies have showed that individual workers have different characteristics, behaviours, and abilities, which can positively or negatively affect their performance (Gendek et al. 2018; Pagnussat et al. 2019). One of the essential factors influencing the performance of a chainsaw operator is the acquisition of knowledge in training courses which allows them to gain qualification as a felling operator and to gain experience in timber harvesting operations. This training does not have to simply take the form of lectures and written material. For example, Yovi & Yamada (2015) have developed The Felling Safety Game to raise awareness of the importance of OSH for forestry workers. This game has been trialed with a group of Indonesian forestry workers where it helped improve their knowledge of OSH (Yovi et al. 2016).

**Workers' knowledge levels on OSH**

Workers' knowledge of OSH in logging, skidding, and loading activities should be determined from the outset. It is expected that the greater their concern for OSH, the better their performance. The results of the analysis presented in Table 5 show that workers have good knowledge about the benefits of using PPE (91.7%; Question 5), types of PPE (85.8%; Question 14), and maintenance of timber harvesting equipment (85%; Question 3)). Workers who understand OSH will work with precision, have greater alertness, and follow existing standard operational procedures. Knowledge about OSH can minimise work accidents. Work accidents are caused by unsafe behaviour and working conditions as well as human-related factors such as lack of knowledge and skills.

Results from our study show that respondents' knowledge of the benefits of using PPE is higher than other aspects of OSH. Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimise exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, coveralls, vests, and full-body suits. The research results of Warsito & Wibowo (2022) showed a connection between OSH knowledge and PPE usage on the occurrence of work accidents. Thus, worker knowledge becomes important regarding PPE usage. Some studies also showed that OSH affected worker performance (Elphiana et al. 2017; Maulana 2020; Mzungu & Ngulube 2020). These three reasons for OSH are important as a necessity and need to be implemented in any field of work, namely 1) OSH at work is a fundamental right for every worker; 2) the legal aspect of the government and employers' responsibility to ensure that the work environment is safe and healthy; and 3) from an economic aspect, preventing losses caused by work accidents and damage.

Prabowo et al. (2022) found that occupational safety and health can have a positive and significant effect on work productivity. However, it is necessary to know the basic principles of OSH to achieve this work productivity improvement. One of these efforts has been developed by the OSH Team of the Faculty of Engineering, Yogyakarta State University, Indonesia (Tim K3 FT UNY 2014) who compiled the basic principles of OSH, namely that all accidents could be prevented since accidents have a cause. If the cause of the accident can be eliminated, then the likelihood of an accident can be reduced.

**OSH analysis in the field**

Our analysis shows that Indonesian forestry workers surveyed generally demonstrated a good knowledge of OSH. However, observations of workers in the field found that there were still some who did not wear PPE. During tree-felling activities, some chainsaw operators only used a helmet and boots and did not equip themselves with complete PPE, such as goggles, ear plugs, and gloves. This highlights that while they knew the benefits of PPE, they didn't necessarily have the awareness to protect themselves. Some of the reasons stated for not wearing PPE were the inconvenience of using it because of lack of familiarity, restricted movement, reduced vision because their eyes were covered with glasses that were blurry or dirty, and the reduced ability to hear the sounds indicating a tree was about to fall. These reasons are similar to the those expressed by forest workers in Finland (Vayrynen

1983). There, forest workers, particularly loggers, found that helmets were too hot in summer and too cold in winter. Furthermore, they also stated that the eye protectors become frosted in the winter, there is poor visibility through the protectors when it rains or is dark, and the protectors cause glare in the sunshine. Moreover, Indonesia is a tropical country that has sun all year round. This condition could trigger heat stress in workers as explained by Wästerlund (1998). Thus, the results of these studies highlight the necessity for PPE to be compatible and comfortable. PPE and employee productivity show a positive and significant association, this with correctly designed PPE employees would feel comfortable and increase productivity levels as it would be easier to do their respective jobs (Fatoni et al. 2018; Ikasari et al. 2018).

The results of the questionnaire showed that workers had a poorer understanding of timber harvest planning, relative to their understanding of different aspects of OSH. According to Matangaran (2013), the objectives of timber harvest planning are to: 1) provide guidelines for correct wood harvesting techniques; 2) provide calculations of permitted continuous harvest level; 3) plan harvesting implementation that ensures the safety of workers and the environment; 4) plan work scheduling at each stage of wood harvesting; 5) choose the type and amount of equipment to be used; and 6) provide an estimate of the benefits to be achieved. Low knowledge of workers regarding timber harvest planning can cause risks to OSH because they do not know the target plan for the sustained volume of timber that can be harvested. Wages for logging workers are typically calculated on a piece rate basis, so many workers try to fell as many trees as possible to increase their remuneration. According to Soenarno (2017), under the piece-rate system, loggers are paid wages based on their productivity (i.e. IDR/$m^3$). The desire to obtain additional production that is not in the harvest plan often means workers are not as careful when cutting down trees; this haste can increase the risk of workplace accidents.

Finally, competency and experience and key aspects of OSH. Most of the workers surveyed in this study had only worked for a natural forest company for 3–7 months; previously they had worked for a palm oil company. Even though the Republic of Indonesia Government Regulation Number 50 of 2012 states that workers should work in accordance with the areas of competence they have because if they don't, they are worried about endangering themselves. However, workers' knowledge and skills can be improved through training, thus the company's management competence also has an important role. This is in line with Heilmann & Heilmann (2011) who stated that the competence management in forest company maintenance is two-fold, namely, first, the existing personnel's competence level should be developed and second, the competence of recruits should be taken care of.

## Conclusions

The potential for hazards and risk of work accidents in timber harvesting is high, particularly in timber-felling activities which have a higher risk of work accidents. Factors such as topography, forest stand conditions, workers' health, equipment used, and workers' knowledge affect the risk of workplace accidents in timber harvesting activities. The results of a questionnaire survey on the level of workers' OSH knowledge showed that, in general, their level of knowledge was good, especially their understanding of the benefits of using PPE, types of PPE, and maintenance of timber harvesting equipment. However, there were some workers who had limited knowledge about timber harvesting planning, the meaning of occupational safety and health, safe working methods, and the frequency of work accidents when timber harvesting. Therefore, ongoing OSH training is necessary for timber harvesting workers to reduce the risk of workplace accidents.

## Competing interests

The author(s) declare that they have no competing interests.

## Authors' contributions

YN conducted research activities in the field and designed research ideas; YN, ADS, MHN, & SA processed and analyzed data and wrote and revised the manuscript.

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