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Addressing Occupational Ergonomics Issues in Indonesian Forestry: Laborers, Operators, or Equivalent Workers

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Abstract

This study addresses occupational ergonomics issues in Indonesian forestry (work conditions, workers' characteristics, occupational safety, occupational health, and job satisfaction) to acquire a comprehensive perspective in understanding the actual problems facing the operations. Direct observation, interview, questionnaires, and secondary data analyses were carried out to acquire all of the required information. A total of 191 frontline forestry workers (chainsaw operators, helpers, manual hauling workers, skidder/tractor operators, logging truck drivers, and nursery workers) participated in this study. The study shows that various techniques of forest operations (labor-intensive to semi-mechanized systems) have been applied in Indonesian plantation forests, both short and long-rotation, as well as in natural forest management. Most of the workers were non-permanent workers, who receive a low wage, work under a straight piecework system, have a high dependency on the forestry work to make a living, and exhibit poor comprehension of the concept of hazard control. The fatality rate was recorded as 1.3 deaths/10^6 m^3 log, but this may be even higher as this rate only represents data taken from formal forestry workers. An intense physical dimension of fatigue occurs among workers involved in forest operations, with the highest prevalence of musculoskeletal disorders in the upper back, lower back, neck, shoulders, and arms. This study reveals eight variables that influenced job satisfaction, i.e., wage, type of contract, accessibility, health services, living facilities, work equipment, training, and social facilities.

Keywords: forest operation, OSH, accidents, MSDs, CFSI, fatigue, job satisfaction

1. Introduction

Work in the forest brings significant pressures to forestry workers. These job stressors relate negatively to job performance (Arshadi and Damiri 2013) and are detrimental not only to the individual health and work productivity (Karasek and Theorell 1990) but also to occupational safety (Potočnik et al. 2009, Lindroos and Burström 2010, Tsioras et al. 2014). According to the reports, the accident rate in this industry has been significantly higher when compared with other sectors (Klun and Medved 2007, Shalini 2009, Albizu-Urionabarrenetxea et al. 2013).

Indonesian forest operations also face the same situation. Indonesian frontline forestry workers (especially laborers, operators, or equivalent workers) suffer from excessive physical workload (Yovi et al. 2005, 2006). The excessive workload threatens workers with severe musculoskeletal impairment (Bovensi et al. 1991), causing disability, long-term downtime (Kahraman et al. 2016), and low work productivity (Yovi et al. 2006). The excessive physical workload can also lead to fatigue (Lerman et al. 2012), poor decision-making (Shappell and Wiegmann 2000), and poor behavioral motor performance (Neu et al. 2011), which leads to error and accidents (Reason 1990).

Indonesia also faces competence problems amongst forestry workers, which is evident in the knowledge aspects, i.e., general safety, safety management, chainsaw operation and maintenance, and safe tree felling (Yovi and Yamada 2015, Yovi et al. 2016). Given that »person« is one of three main areas where a hazard may develop (Makin and Winder 2008), a worker with a low level of competence has a high probability of

Table 1 Distribution of respondents (2016–2017)

Profession	Personal data		Accidents data	CFSI*	SNQ**	Job satisfactions
	General data	Financial data				
Chainsaw operator	52	49	5	19	52	52
Forest inventory worker	9	1	8	7	9	9
Helper	8	0	8	7	8	8
Logging truck driver	19	10	8	7	19	19
Manual hauling worker	60	53	5	40	60	60
Nursery worker	33	17	7	29	33	33
Skidder/tractor operator	10	0	10	5	10	10
TOTAL	191	130	51	114	191	191

*Cumulative Fatigue Symptoms Index
**Standardized Nordic Questionnaire

showing unsafe work behavior, which ultimately leads to increased occupational safety and health (OSH) risk.

In the context of Indonesian OSH policy, there is also an issue regarding OSH protection for forestry workers. The Indonesian government has ratified several ILO conventions related to OSH, productivity, and well-being. A technical safety regulation on felling and log transportation was issued in 1978 (Regulation of the Indonesian Republic of Ministry of Manpower, Transmigration and Cooperation Numbered PER.01/MEN/1978). The latest issues on OSH and workers' well-being have been explicitly stated in the Indonesian mandatory sustainable forest management (SFM) policy (Regulation of the Directorate General of Sustainable Management of Production Forests Numbered P.14/PHPL/SET/4/2016) (Yovi and Nurrochmat 2018). However, OSH protection of forest operations has remained weak and stagnant (Yovi and Yamada 2015, Yovi et al. 2016, Yovi and Nurrochmat 2018).

In a broad spectrum, ergonomics plays a key role in moving towards sustainable forest operations (Marchi et al. 2018). In this context, ergonomics information, in the form of research evidence, will serve as an essential reference or an enlightenment factor that should help policymakers, as well as decision-makers, to understand the existing problems (Kemm 2006) and to formulate suitable public policy that will affect a large number of people (Orton et al. 2011). Unfortunately, comprehensive reports related to the characteristics of workers, the OSH status (fatigue, musculoskeletal disorder/MSDs, occupational accidents), and job satisfaction of forestry workers in Indonesia are not available. Therefore, this study aimed to investigate work conditions, workers' characteristics (including wage, payment system, consumption patterns, and perception of occupational accidents and hazard control), and OSH. Job satisfaction was also discussed in this study as it corresponds positively to the commitment to safety management policies (Gyekye 2005).

2. Methods

In total, as many as 191 frontline forestry workers (laborers, operators, or equivalent workers) participated in this study (Table 1). Data was collected in 2016–2017. The data were taken from forest management units representing three common types of forest management units in Indonesia, i.e., natural forest management (5 forest management units), industrial plantation forest management (short-rotation, 1 forest management unit), and plantation forest under right-to-use management (*hak pengelolaan*; long-rotation plantation forest, 5 forest management units). A total of 130 questions were given to each respondent, asking for general information and financial conditions (wage, payment system, and consumption patterns), exploring the respondents' perception of accidents and job satisfaction, and investigating the status of occupational health (fatigue and MSDs).

The following statistical tests were used: Pearson product-moment correlation coefficient (for normally distributed data, ratio scale), Spearman's rank-order correlation coefficient (for not normally distributed data, ratio scale), and Somers' Delta (Somers' *D*) test (for not normally distributed data, ordinal scale or bi-

Table 2 Description of questions in the Cumulative Fatigue Symptom Index* (CFSI, Kosugo et al. 1992)

Type of fatigue	Number of questions	Aspects of symptoms
Physical dimension of symptoms		
General fatigue	10	Carelessness, feeling weak, dizzy, tiring eyes, backache, tired legs, and bad sleep quality
Chronic fatigue	8	Too sleepy, feeling tired all the times, lacking energy, and not recover from the previous fatigue
Physical disorders	7	Loss of appetite, difficulty in falling asleep, problem with the digestive system, diarrhea, and heavy head
Mental dimension of symptoms		
Depressive feeling	9	Feeling gloomy, hate their self, enjoy nothing, no fun in their life, and tend to be a loner
Feeling of anxiety	11	Feeling of worry, uneasy, restless, poor concentration, and feeling inferior.
Decrease in vitality	9	Impatience, laziness, low ability to give full attention to work, troublesome, loss of vitality (languish), and dull mind
Social dimension of symptoms		
Irritability	7	Sensitive to get angry, tense, irritated for no reason, and feeling to beat someone up
Unwillingness to work	13	Dissatisfaction with their work, monotonous feeling, and bad relationship with boss or colleagues

* Adopted from English version of CFSI (Yoshimura and Acar 2004)

nary variable). The Pearson correlation coefficient and Spearman's correlation test present a good estimation of the actual degree of association (Göktaş and İşçi 2011), while Somers' *D* test has been widely used to measure strength and direction association between variables distinguished into dependent and independent variables (Newson 2001).

2.1 Work Conditions, Workers' Characteristics, and Perception of Occupational Accidents

Considering that the targeted respondents were at laborer, operator, or equivalent level, most of whom were not willing to read lengthy questionnaires, data and information related to work specifics, workplace characteristics, and workers' characteristics were obtained through direct observation, face-to-face semi-structured interviews, or short questionnaires, which were then verified by using gray literature either in the form of documentation or the forest management unit official reports. The perception of the forestry workers on work accidents and hazard control strategy in their workplace was captured by interviewing forestry workers who had experienced occupational accidents or near misses (near hits).

2.2 Occupational Accidents

The number of accidents and fatalities were recalculated from the raw data obtained from the Indonesian Public Agency for Social Security (*Badan Penyelenggara Jaminan Sosial*; BPJS).

2.3 Occupational Health Disturbances

2.3.1 Fatigue

Fatigue was measured by using the Cumulative Fatigue Symptoms Index (CFSI, Kosugo et al. 1992). The CFSI is a self-reporting questionnaire (dichotomous, »yes« or »no« answer) covering three dimensions of fatigue (physical, mental, and social), which are further classified into eight subgroups (74 questions) (Table 2). The associations among the variables were tested by using the Somers' *D* test. In this study, an Indonesian version of the CFSI questionnaire was constructed based on the English version of CFSI (see: Yoshimura and Acar 2004).

2.3.2 Musculoskeletal Disorders

A body map based on the Standardized Nordic Questionnaire (SNQ, Kuorinka et al. 1987) was used to examine occupational health in terms of MSDs. Respondents were asked to mark the map to indicate their musculoskeletal pain experiences.

2.4 Job Satisfaction

In this section, the analysis was directed to verify the impacts of wage, type of contract, accessibility, health services, living facilities, work equipment, training, and social facilities on job satisfaction. A questionnaire, consisting of nine (short but clear) questions (closed-ended questions with a five-point scale format-ordinal modified from Likert scale) was developed. Perception of general satisfaction, wage,

Fig. 1 Common practices in long-rotation plantation forests in Java Island Indonesia

and type of contract (permanent, temporary) was described as »very dissatisfied, dissatisfied, neither, satisfied, or very satisfied«, while perception of work facilities (tools and equipment), living facilities (housing, sanitation), health services, training facilities, and social facilities (sport facilities, prayer room) was described as »very poor, below average, average, above average, or excellent«. Questions about accessibility were stated as »very poor, poor, acceptable, good, or very good«.

3. Results

3.1 Nature of Work Conditions, Workers' Characteristics, and Perception of Accidents

3.1.1 Nature of Work Conditions

The business license for timber utilization in the natural forest has been granted to 19.3 million ha out of 68.8 million ha of Indonesian total forest production area; the annual timber production in 2016 was 5.4 million m^3 (MoEF 2017). Indonesia applies selective cutting; thus, only commercial tree species with ≥40 cm in diameter (for permanent production forest) or ≥50 cm in diameter (for limited production forest) are allowed to be harvested in this forest. Felling is carried out using a chainsaw, and the conventional method (simple notch and back-cut technique) is common. Various forest machines are used for skidding, loading/unloading, and log transportion (Table 3).

Indonesia has also developed plantation forests. This intensively managed forest plantation is the leading forest industry in Indonesia. MoEF (2017) has granted a business license for timber utilization in the form of a plantation forest to a total of 10.8 million ha area. This industrial plantation forest is mostly located in Sumatra, Kalimantan, and Papua islands (fast-growing species: e.g., acacia, eucalyptus). Annual timber production from this plantation forest was 32 million m^3 in 2016 (MoEF 2017). Similar to harvesting

Table 3 Types of forest operation in the observed forest management units

Felling	Skidding	Debarking	Loading/unloading	Transporting
Natural forest, dominated by Dipterocarpaceae (located in Kalimantan, Papua, Sulawesi, Maluku, and Sumatra)				
Large chainsaw (36 inches bar length)	Tree-length skidding by using crawler tractor or wheel/track skidder (winch attached)	Debarking is performed in landing	Wheel/track loader (grapple and crane attached)	Logging truck, flat raft or pontoon (controlled by tug boats)
Short rotation industrial plantation forest (small log diameter, big scale industry, e.g., plantation forests in Sumatra, Kalimantan, Papua)				
Medium or large chainsaw (20–36 inches bar length)	Short wood skidding by using excavator (grapple and crane attached), forwarder, skidder	In some cases, debarking is carried out manually over standing tree (right before felling), and then finished by using excavator grapple before skidding	Excavator (grapple and crane attached)	Logging truck (above ground transportation), barge transport/ pontoon ship (water transportation), or combination of logging truck and barge/pontoon
Long rotation plantation forest (large log diameter, mostly in Java Island)				
Large chainsaw (36 inches bar length)	Cut to length, manual hauling	Debarking is carried out manually in felling site, landing, or in log yard	Manual loading	Light-medium truck (equal to Class 3 or 4 US truck class)
Short rotation plantation forest (small log diameter, micro or small scale industries)				
Medium chainsaw (36 inches bar length)	Cut to length, manual hauling	No debarking	Manual loading	Light-medium truck (equal to Class 3 or 4 US truck class)

in natural forests, timber harvesting in these short-rotation plantation forests is carried out in the form of semi-mechanized forest harvesting (Table 3).

On Java Island, a state-owned forest company has intensively managed 1.8 million ha of plantation forest (dominated by long-rotation species, e.g., teak, Indonesian rosewood, mahogany). In this forest, the intensive labor system has become the backbone of the forest operations for decades (Fig. 1).

3.1.2 Workers' Characteristics

The age of forestry workers involved in this study averaged 39 years of age (±10 years). Approximately 53% of workers were older than the average. Work experience averaged 12 years (±9 years), and the number of dependent family members averaged 4 persons (±1 person). About 89% of workers had lower than high school education. Out of 130 respondents, who answered the financial-related questions (Table 1), 49% stated that forestry work was the only source of income, while the rest (51% of respondents) had alternative financial support (which, on average, accounted for 20% of the total household income). Financial data showed that 49%, 45%, and 5% of respondents spent as much as 27–49%, 50–74%, and >75% of total income on food, respectively (average spending pattern was 53%; Fig. 2). The lower-income households had a higher food spending rate than the relatively higher-income households (Spearman's correlation test, rs=–0.579, p=0).

Despite their poor financial condition, smoking behavior was found in 69% of respondents (from the entire survey). With an average of 12 cigarettes per day, the expenditure for cigarettes can reach USD 27 per month, which is 17% of a household's monthly total income.

3.1.3 Workers' Perception of Work Accidents and Hazard Control

The majority of respondents agreed that accidents are »shocking«, »sad«, but quite »common«. As stated by worker A, a manual hauling worker: »... accidents are events caused by work activities that are essentially undesirable. One of my friends has been in an accident and suffered serious injury and is in miserable condition. Of course, I do not want that to happen to me. However, it is a »normal« occurrence if you work in this industry...« Similar to other manual hauling respondents, he wore personal protective equipment (PPE) improperly while at work (Table 4). The other 21% of respondents also stated a similar opinion and showed the same work behavior.

A statement of worker B, a logging truck driver, represents another general description of the workers' perception of an accident: »... as long as we work carefully, we can avoid accidents…« The statement be-

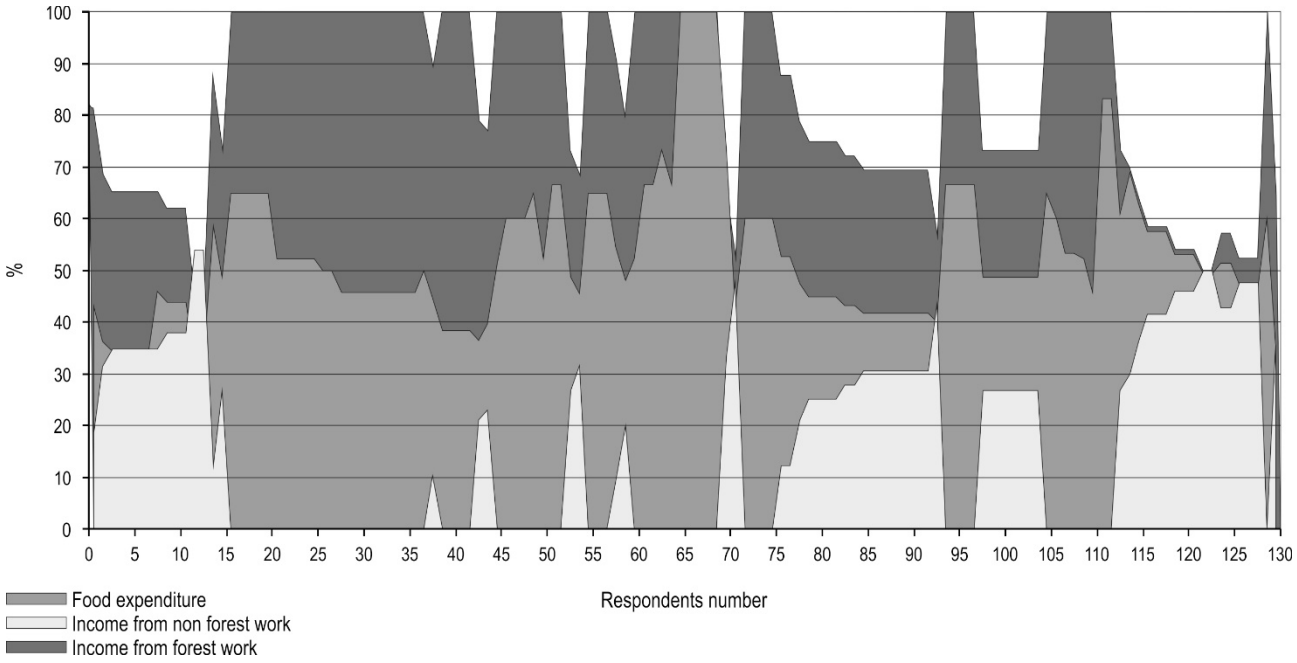

Fig. 2 Distribution of sources of income and food expenditure among 130 respondents in the survey

comes very interesting because some of them did not maintain a safe driving distance. In regard to manual hauling workers, we found that they prefer to carry 60 kg of logs using no manual lifting devices. The workers said that the use of such lifting devices would consume more working time and result in decreased wages.

Further, worker C, a chainsaw operator who wears no safety shoes, safety trousers, eye protection, and ear protection during work stated as follows: »… Cutting work is hard and dangerous work, and accidents are unwanted. In my opinion, I will be able to prevent work accidents if I wear PPE properly....« This statement represents the perception of 86% of respondents,

Table 4 Overview of occupational accidents: accident type, personal protective equipment (PPE) used, and respondents' opinion about hazard control strategy

Workers	Type of accidents	Cause of accidents	PPE used during accidents	Respondents' opinion on hazard control strategy*
Chainsaw operators	Slipped while cutting, almost hit by a tree, bee stung, and hit by a machete while cleaning bush shrubs	Careless, slippery road	Rubber boots, helmet, gloves	Wearing PPE, being alert to the work environment, being careful, preparing an evacuation route
Helpers	Chainsaw is struck by a fallen tree, hit by sling, bee stung	Careless	Rubber boots, glove	Being alert to the work environment, being careful
Logging truck drivers	Crashed into another car, rolled over	Slippery road, careless	Safety shoes	Wearing PPE, being careful, obeying traffic signs, praying before start work
Manual hauling workers	Slipped, hands or feet wedged in logs, crashed by logs	Slippery log, careless	Helmet	Wearing PPE
Nursery workers	Falling off the motorbike	Slippery road	Helmet, rubber boots	Wearing PPE
Skidder/tractor operators	Tractor overturned because failure on the brake system	Slippery road	Safety shoes	Wearing PPE, not to work when tired

* Listed in sequent from the most effective to the least effective

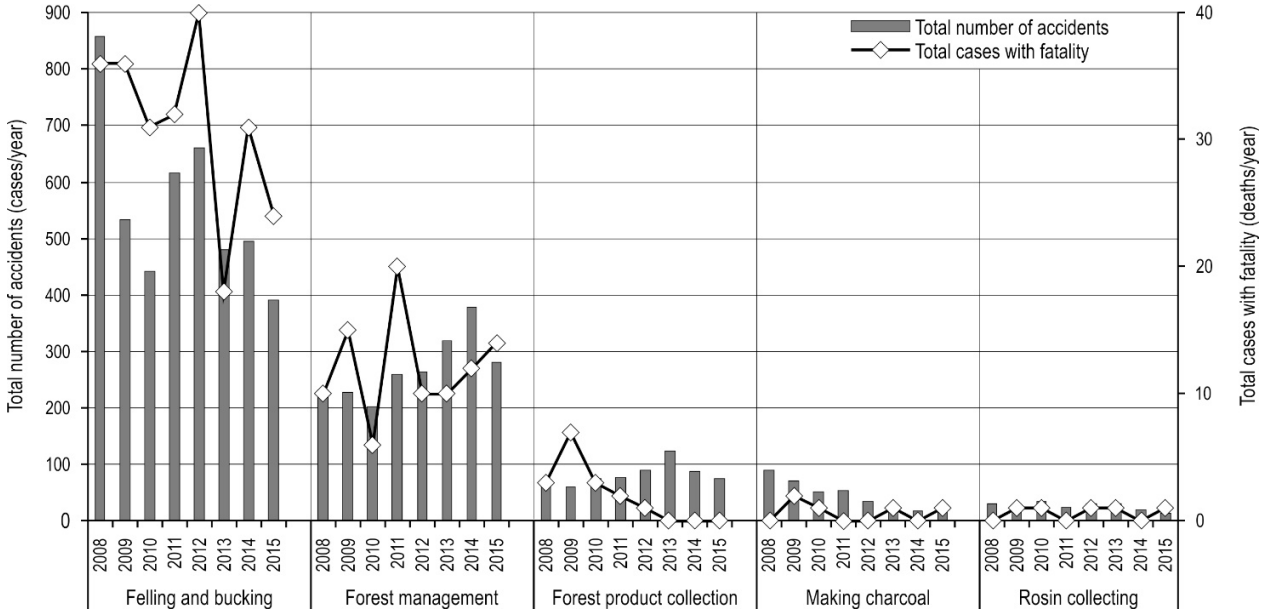

Fig. 3 Number of accidents and fatalities in forestry works in 2008–2015. Data were obtained from the Indonesian Public Agency for Social Security (*Badan Penyelenggara Jaminan Sosial*, BPJS) and were recalculated

who admit PPE is a critical instrument in avoiding accidents because PPE gives one a good ability to »control the hazards«.

3.2 Occupational Accidents

3.2.1 General Description

The 2008–2015 national data taken from BPJS show that forestry works (consisting of cutting, forest management, collecting forest products, making charcoal, and collecting resin) contribute to 984 accident cases annually resulting in 46.4 fatalities annually. Among different categories, felling and bucking contribute the most significant number of accident cases and fatalities annually (Fig. 3). The data also shows a decrease in the annual number of both accidents and fatalities in 2008–2015.

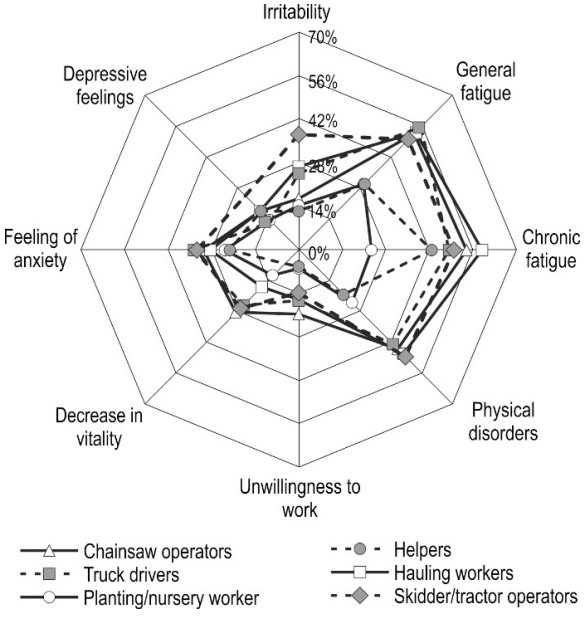

Fig. 4 Cumulative Fatigue Symptom Index of forestry workers

3.3 Status of Occupational Health

3.3.1 Fatigue

In general, the complaint rate of cumulative fatigue among manual hauling workers and chainsaw operators was more intense when compared to that of other workers (Fig. 4). Most workers mention the feeling of discomfort in the morning, suffering stiffness, and feeling sleepy throughout the day, indicating chronic fatigue, which is a physical dimension of fatigue (Kosugo et al. 1992). Other symptoms of the physical dimension of fatigue (general fatigue and physical disorders) were also detected. The Somers' *D* test shows that the physical, mental, and social dimensions of fatigue reciprocally influence each other in a positive direction (see Table 5). This relationship indicates that the factors triggering fatigue in forestry work overlap in physical, mental, and social aspects.

3.3.2 Musculoskeletal Disorders

In line with the CFSI results, manual hauling workers have the most intense MSDs. MSDs were associated

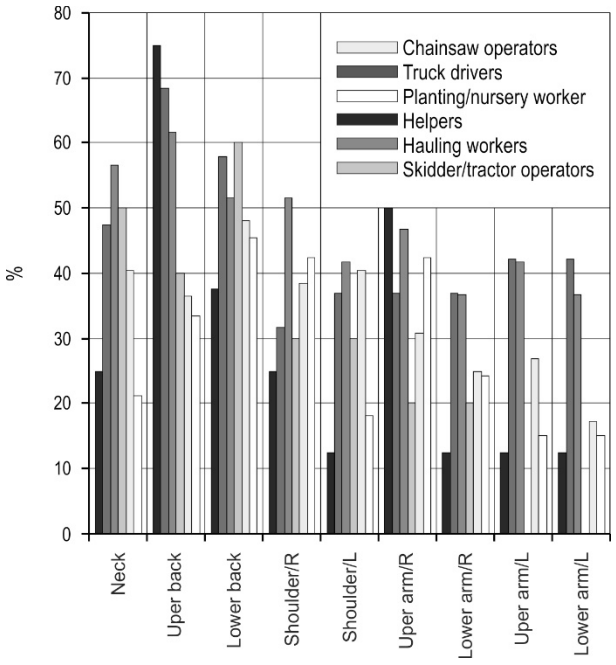

Fig. 5 Distribution of musculoskeletal disorders among forestry workers

with physical fatigue (Somers' *D* test, d=0.231 for physical dimension of fatigue as dependent variable, d=0.209 for MSDs as dependent variable, p<0.0005). The MSDs were found in 18 body parts, with the most intense pain in the upper back, lower back, neck, shoulders, and arms (Fig. 5).

Detailed economics-loss data caused by fatigue and MSDs in the Indonesian forestry sector are not available; however, there is evidence that fatigue and MSDs inflict not only health problems that result in low quality of life, but are also significantly detrimental to economic well-being. In the United States, fatigue may cost as much as USD 9.1 billion annually (Reynold et al. 2004), while MSDs cost USD 2.6 billion (Bhattacharya 2014). In Columbia, Piedrahita (2006) estimated that the total loss due to MSDs in the country was USD 171.7 million (equal to 0.2% of the country's 2005 GDP).

3.4 Job Satisfaction

The questionnaire was valid (Pearson Product Moment Correlation test shows the p-values of the Sig. 2-tailed for all nine questions <0.01) and reliable (Cronbach's Alpha value=0.873). Data were not normally distributed, but monotonic relationships between general job satisfaction and the existing eight independent variables (wage, type of contract, work facility, living facility, health service, training facility, social facility, and accessibility) existed. The Somers' *D* shows that job satisfaction was influenced by the eight variables (see Table 6).

4. Discussion

4.1 Work Conditions, Workers' Characteristics, and Perception of Occupational Accident

Besides the labor-intensive system (a combination of chainsaw+manual hauling for felling+skidding), the chainsaw+skidder (or equivalent machinery) combination is massively applied in Indonesia. Several studies

Table 5 Output of correlation test: Somers' *D* directional measures for physical, mental, and social dimensions of fatigue

	d Value	Asymptotic standard errora	Approximate Tb	Approximate significance
Physical*mental dimension				
Physical dimension dependent	0.355	0.062	5.655	0.000
Mental dimension dependent	0.344	0.061	5.655	0.000
Physical*social dimension				
Physical dimension dependent	0.356	0.067	5.255	0.000
Social dimension dependent	0.335	0.064	5.255	0.000
Social*mental dimension				
Social dimension dependent	0.410	0.065	6.323	0.000
Mental dimension dependent	0.397	0.063	6.323	0.000

a) Not assuming the null hypothesis
b) Using the asymptotic standard error assuming the null hypothesis

Table 6 Output of correlation test: Somers' D directional measures for job satisfaction

Variables (job satisfaction dependent)	Value	Asymptotic standard error[a]	Approximate T[b]	Approximate significance
Health service*Job satisfaction	0.728	0.033	18.357	0.000
Accessibility*Job satisfaction	0.708	0.043	15.642	0.000
Living facility*Job satisfaction	0.631	0.046	12.075	0.000
Tools and equipment*Job satisfaction	0.587	0.049	11.233	0.000
Training facility*Job satisfaction	0.568	0.049	11.249	0.000
Wage*Job satisfaction	0.551	0.049	11.043	0.000
Social facility*Job satisfaction	0.480	0.059	7.912	0.000
Type of contract*Job satisfaction	0.425	0.073	5.880	0.000

a) Not assuming the null hypothesis
b) Using the asymptotic standard error assuming the null hypothesis

have proven that the chainsaw+skidder combination poses a higher risk to safety and health (Potočnik et al. 2009, Potočnik and Poje 2017); thus, the combination of chainsaw+manual hauling potentially triggers a severe impact on the workers' safety and health.

Compared with the provincial or municipal minimum wage set by the Indonesian government (Government Regulation Numbered 78 of 2015 on Remuneration), total income of 76% of respondents slightly exceeds the minimum monthly wage. For reference, the minimum wage ranges from IDR 1,337,645 (equal to USD 100) for Yogyakarta up to IDR 3,100,000 (equivalent to USD 231) for Jakarta (average currency rate in 2017). However, since a worker should support 3–5 family members, the wage rate is not yet comparable to the decent living needs. This is indicated by the fact that the average spending rate for food consumption was 53%, which is even more than twice the typical low-income household spending pattern (Castner and Mabli 2010). The situation becomes complicated when the issue of health and lifestyle is taken into discussion. Wasting 16–17% of total monthly income on tobacco is a significant cost for low-income households. This rate is higher than the estimated tobacco cost in low-middle-income countries (Eriksen et al. 2012).

In addition to the high dependency on the forest to make a living, as much as 71% of respondents were non-permanent workers (working for a specific length of time or specific production target) and paid under a straight piecework system. The fact that the manual hauling workers perceived safety procedures as a time-consuming additional work that may reduce their work output should be seen as an indication that the current piece rate system provokes unsafe work behavior that threatens the workers' safety (Johansson et al. 2010).

This study also shows that the lack of knowledge of the concept of hazard control potentially increases hazards (Makin and Winder 2008). In this study, most of the workers rely mainly on PPE to prevent accidents (see Table 4), whereas the hierarchy of hazard control has positioned PPE as the least effective action (NIOSH 2018). An obvious example can be seen in the case of the skidder/tractor accident caused by brake failure (see Table 4). Instead of preventive actions, e.g., carrying out regular maintenance, operators listed PPE as the primary strategy to avoid accidents. Another example is that manual hauling workers considered wearing PPE as effective in protecting their toes/hands from being pinned down by rolling logs. Based on the accident types, improving the working techniques (e.g., using lifting devices such as a portable winch or improving workers' skill by conducting training) is the proper strategy to overcome this hazard. In the case of chainsaw operators, it is a fact that the legs are the most commonly injured body part (Bentley et al. 2002, Lilley et al. 2002); thus, it is not wrong to consider safety trousers as a strategy to avoid accidents. However, the operators failed to understand that safety trousers cannot provide 100% protection to the legs from chainsaw cut accidents, as there are many factors, e.g., cut angle, trousers' material, chains type, and chain sharpness that influence the threshold of stopping speed in the protection mechanism (whether the chain stops or clogs, or if there is a cut-resistant mechanism) (Arteau et al. 1996). Therefore, using PPE as the first attempt at hazard control is inappropriate thinking because PPE alone cannot be relied upon to control hazard.

4.2 Status of Occupational Accidents

Chainsaw is the most common machine used for cutting (Table 3) and has been documented as the cause of most fatalities in Indonesia (Fig. 3). A similar tendency has also been revealed in other countries (Thelin 2002, Wilhelmson et al. 2005, Potočnik et al. 2009). In 2008–2015, the average annual fatality rate in forestry work accidents was 1.3 death/10^6 m^3 log, and the average annual round wood production was 35.4 million m^3 (MoF 2012, MoEF 2017). The death toll is lower than that of Austria and Switzerland (Klund and Medved 2007). However, it should be noted that 97% of the data shown in Fig. 3 were taken from formal forestry workers only, whereas the majority of front-line forestry workers (e.g., chainsaw operators, skidder/tractor operators, helpers, logging truck drivers, manual hauling workers, and nursery workers) are informal workers. This fact indicates that there is a high probability that the actual accident and fatality rate in forestry works is higher than the given figure.

4.3 Status of Occupational Health

The CFSI and MSDs analysis confirmed that the practices of labor-intensive and semi-mechanized forest operations in Indonesia had caused a negative impact on the operators' health. In half-day work, one group of hauling workers (usually consisting of four workers, labor-intensive system) should load approximately 4.5 m^3 of large logs onto a truck using only simple aid tools (e.g., pole, turning hook, or skidding tong, see Fig. 1). This fact implies that, on average, a worker is burdened with more than 1 ton of load per day. In terms of chainsaw operation, cutting a small diameter of trees scored 12 on ergonomics risk level (REBA score, which means »very high risk: immediate change is required«) (Yovi and Pradjawati 2015) and burdened the chainsaw operator with heavy physical workload (Yovi et al. 2006). Thus, the risk level is possibly higher for a larger diameter of trees (carried out in the natural forest), as larger diameters demand longer duration of awkward posture. Teak-stand clear-cutting, a part of a labor-intensive forest operation that still exists in Indonesia, is even harder. Teak is a high-value tree species so that the cut is made to be as low as possible to minimize logging waste. As a result, chainsaw operators should maintain an awkward posture (see Fig. 1) for a longer duration, which results in higher physical workload (Yovi et al. 2005) and hypothetically greater ergonomic risk level. As for logging truck drivers, they have to sit (in a forced and monotonous position) for an extended duration through uneven and bumpy forest roads. In an observation site, it was a 75 km driving distance with a driving speed (loaded) of 18–25 km/hr. Hence, the manual hauling workers, chainsaw operators, and truck drivers are burdened with excessive physical activity, which resulted in severe MSDs (Bovensi et al. 1991, Ohlendorf et al. 2017) and intense physical fatigue (Lerman et al. 2012).

4.4 Job Satisfaction

Forestry work leaves little room for error; on the other hand, the Indonesian forestry workers face complex problems. Therefore, supports are required. This study shows that improvement in health services, living facilities, working tools, training, and social facilities, together with the type of contract, wage, and accessibility, will boost the workers' job satisfaction, which will lead to better safety protection, as workers with higher job satisfaction tend to be more committed to safety than dissatisfied workers (Probst and Brubaker 2001, Baring et al. 2003, Gyekye 2005).

In terms of training facility improvement, regular-based designed training is recommended, as the designed training has been effective in reducing occupational accidents in forestry work (Potočnik et al. 2009). The recommended topics for the training are handling emergency conditions and safe work practices. In accordance with the training, open access to the OSH information is required. A safety education learning tool could be implemented for this purpose (Yovi and Yamada 2015, Yovi et al. 2016).

In addition to improving knowledge and skills, workers must also be equipped with tools fit for the job, e.g., equipping hauling workers with lifting aid tools to avoid excessive physical workloads. Furthermore, based on the current conditions, having a regular health examination or providing an emergency kit for every unit/workgroup is an example of recommended health facility improvement.

Eliminating a contract labor system in forestry works is not straightforward. Therefore, mutual benefit between the forestry business owner/manager and the workers reflected in the equality of bargaining power of rights and responsibilities and written in an employment agreement is compulsory (Yovi and Nurrochmat 2018).

Another strategy in improving the quality of workers' life is by increasing wage/salary rate per output; the impact will likely be more effective if the current payment system adopts differential piecework system, one which gives higher rewards to workers who observe good safety practices. This payment system revision is also a more effective and protective strategy in hazard control than wearing PPE (NIOSH 2018).

5. Conclusions

This paper presents the basic information describing actual occupational ergonomics-related problems in Indonesian forestry work. This study states that the »traditional« technology (labor-intensive and semi-mechanized harvesting) still plays a role as the backbone of forest operations in Indonesia. This technology level correlates with a high risk to occupational safety (high fatality rate) and health disturbances (fatigue in physical-mental-social dimensions and intense MSDs). In addition to having a high financial dependency on forest work, most of the workers are low-income and non-permanent and paid under a straight piecework system that provokes unsafe work behavior. Due to the lack of knowledge of the concept of hazard control, the situation becomes even more complicated. Improving the working techniques (equipping workers with proper devices), increasing wage rate per output (which is then followed by improving the payment system), and improving workers' knowledge (and skill) of safety and health protection should be considered as alternative exit strategies to overcome the problems. Improvement in these three aspects, together with improvements in health services, living facilities, and social facilities, as well as accommodating better mutual benefits between the workers and business owner/manager in employment contract, and ensuring better workplace accessibility, will increase the workers' job satisfaction, which, in turn, will increase occupational safety and health awareness among the forestry workers.

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6. References

Albizu-Urionabarrenetxea, P., Tolosana-Esteban, E., Roman-Jordan, E., 2013: Safety and health in forest harvesting operations. Diagnosis and preventive actions. A review. Forest Systems 22(3): 392–400. http://dx.doi.org/10.5424/fs/2013223-02714

Arshadi, N., Damiri, H., 2013: The relationship of job stress with turnover intention and job performance: Moderating role of OBSE. Procedia-Social Behavioral Sciences 84: 706–710. http://dx.doi.org/ 10.1016/j.sbspro.2013.06.631

Arteau, J., Arcand, J.-F., Turcot, D., 1996: Factors influencing the performance of chain saw leg protective devices and its measurement. In: Johnson, J.S., and Mansdorf, S.Z. eds. Performance of Protective Clothing. 5th Volume. ASTM STP 1237. West Conshohocken, PA: American Society for Testing and Material, 70–84 p.

Baring, J., Kelloway, K.E., Iverson, R., 2003: High quality work, job satisfaction, and occupational injuries. Journal of Applied Psychology 88(2): 276–83. http://dx.doi.org/10.1037/0021-9010.88.2.276

Bentley, T.A., Parker, R.J., Ashby, L., Moore, D.J., Tappin, D.C., 2002: The role of the New Zealand forest industry injury surveillance system in a strategic ergonomics, safety and health research programme. Applied Ergonomics 33(5): 395–403. http://dx.doi.org/10.1016/S0003-6870(02)00037-6

Bhattacharya, A., 2014: Costs of occupational musculoskeletal disorders (MSDs) in the United States. International Journal of Industrial Ergonomics 44(3): 448–454. http://dx.doi.org/10.1016/j.ergon.2014.01.008

Bovensi, M., Zadini, A., Franzinelli, A., Boroni, F., 1991: Occupational musculoskeletal disorders in the neck and upper limbs of forestry workers exposed to hand-arm vibration. Ergonomics 34(5): 547–562. http://dx.doi.org/10.1080/00140139108967336

Castner, L., Mabli, J., 2010: Low-income household spending pattern and measures of poverty [Online]. Available at: https://fns-prod.azureedge.net/sites/default/files/Spending-Patterns.pdf (Accessed: 25 April 2018).

Eriksen, M., Mackay, J., Ross, H., 2012: The Tobacco Atlas. 4th ed. Atlanta: American Cancer Society.

Göktaş, A., İşçi, Ö., 2011: A comparison of the most commonly used measures of association for doubly ordered square contingency tables via simulation. Metodološki Zvezki 8(1): 17–37.

Gyekye, S.A., 2005: Workers' perceptions of workplace safety and job satisfaction. International Journal of Occupational Safety and Ergonomics 11(3): 291–302. http://dx.doi.org/10.1080/10803548.2005.11076650

Johansson, B., Rask, K., Stenberg, M., 2010: Piece rates and their effects on health and safety – A literature review. Applied Ergonomics 41(4): 607–614. http://dx.doi.org/10.1016/j.apergo.2009.12.020

Kahraman, T., Genc, A., Göz, E., 2016: The Nordic Musculoskeletal Questionnaire: Cross-cultural adaptation into Turkish assessing is psychometric properties. Disability Rehabilitation 38(21): 2153–2160. http://dx.doi.org/10.3109/09638288.2015.1114034

Karasek, R., Theorell, T., 1990: Healthy Work. Stress, Productivity, and the Reconstruction of Working Life. New York: Basic Books Inc.

Kemm, J., 2006: The limitations of 'evidence-based' public health. Journal of Evaluation in Clinical Practice 12(3): 319–324. http://dx.doi.org/10.1111/j.1365-2753.2006.00600.x

Klun, J., Medved, M., 2007: Fatal accidents in forestry in some European countries. Croatian Journal of Forest Engineering 28(1): 55–62.

Kosugo, R., Fujii, H., Hirata, A., 1992: Subjective assessment of workload. Revision of the Cumulative Fatigue Symptoms Index. Journal Science of Labour 68: 489–502.

Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sørensen, F., Andersson, G., Jøgensen, K., 1987: Standardized Nordic Questionnaire for the analysis of musculoskeletal symptoms. Applied Ergonomics 18(3): 233–237.

Lerman, S.E., Flower, D.J., Gerson, B., Hursh, S.R., 2012: Fatigue risk management in the workplace. Journal of Occupational and Environmental Medicine 54(2): 231–258. http://dx.doi.org/10.1097/JOM.0b013e318247a3b0

Lilley, R., Feyer, A.M., Kirk, P., Gander, P., 2002: A survey of forest workers in New Zealand. Do hours of work, rest, and recovery play a role in accidents and injury? Journal of Safety Research 33: 53–71. http://dx.doi.org/10.1016/S0022-4375(02)00003-8

Lindroos, O., Burström, L., 2010: Accident rates and types among self-employed private forest owners. Accident Analysis and Prevention 42(6): 1729–1735. http://dx.doi.org/10.1016/j.aap.2010.04.013

Makin, A.M., Winder, C., 2008: A new conceptual framework to improve the application of health and safety management systems. Safety Science 46: 935–948. http://dx.doi.org/10.1016/j.ssci.2007.11.011

Marchi, E., Chung, W., Visser, R., Abbas, D., Nordfjell, T., Mederski, P.S., McEwan, A., Brink, M., Laschi, A., 2018: Sustainable Forest Operations (SFO): A new paradigm in a changing world and climate. Science of The Total Environment 634(1): 1385–1397. http://dx.doi.org/10.1016/j.scitotenv.2018.04.084

Ministry of Environment and Forestry of Republic of Indonesia (MoEF), 2017: Statistik Lingkungan Hidup dan Kehutanan Tahun 2016 (Statistical Yearbook of Indonesian Environment and Forestry 2016). Jakarta: MoEF.

Ministry of Forestry of Republic of Indonesia (MoF), 2012: Forestry Statistic of Indonesia 2011. Jakarta: MoF.

National Institute for Occupational Safety and Health (NIOSH), 2018: Hierarchy of control [Online]. Available at: https://www.cdc.gov/niosh/topics/hierarchy/ (Accessed: 28 April 2018).

Neu, D., Kajosch, H., Peigneux, P., Verbanck, P., Linkowski, P., Le Bon, O., 2011: Cognitive impairment in fatigue and sleepiness associated conditions. Psychiatry Research 189(1): 128–134. http://dx.doi.org/10.1016/j.psychres.2010.12.005.

Newson, R., 2001: Parameters behind »non-parametric« statistics: Kendall's τa, Somers' D and median differences. The Stata Journal 1(1): 1–20.

Ohlendorf, D., Troebs, P., Lenk, A., Wanke, E., Natrup, J., Groneberg, D., 2017: Postural sway, working years and BMI in healthy truck drivers: an observational study. BMJ Open 7(7): e013281. http://dx.doi.org/10.1136/bmjopen-2016-013281

Orton, L., Lloyd-Williams, F., Taylor-Robinson, D., O'Flaherty, M., Capewell, S., 2011: The use of research evidence in public health decision making processes: Systematic review. PLoS ONE 6(7): e21704. http://dx.doi.org/10.1371/journal.pone.0021704

Piedrahita, H., 2006: Costs of work-related musculoskeletal disorders (MSDs) in developing countries: Colombia case. International Journal of Occupational Safety and Ergonomics 12(4): 379–386. http://dx.doi.org/10.1080/10803548.2006.11076696

Potočnik, I., Pentek, T., Poje, A., 2009: Severity analysis of accidents in forest operations. Croatian Journal of Forest Engineering 30(2): 171–184.

Potočnik, I., Poje, A., 2017: Forestry ergonomics and occupational safety in high ranking scientific journals from 2005–2016. Croatian Journal of Forest Engineering 38(2): 291–310.

Probst, T., Brubaker, T., 2001: The effects of job insecurity on employee safety outcomes: Cross-sectional and longitudinal explorations. Journal of Occupational Health Psychology 6: 39–159.

Reason, J., 1990: Human Error. New York: Cambridge University Press.

Reynolds, K.J., Vernon, S.D., Bouchery, E., Reeves, W.C., 2004: The economic impact of chronic fatigue syndrome. Cost Effectiveness and Resource Allocation 2(1): 4. http://dx.doi.org/10.1186/1478-7547-2-4

Shalini, R.T., 2009 Economic cost of occupational accidents: Evidence from a small island economy. Safety Science 47: 973–979. http://dx.doi.org/10.1016/j.ssci.2008.10.021

Shappell, S.A., Wiegmann, D.A., 2000: The Human Factors Analysis and Classification System–HFACS. Final Report No. DOT/FAA/AM-00/7. Springfield: National Technical Information Service, US Department of Transportation.

Thelin, A., 2002: Fatal accidents in Swedish farming and forestry, 1988–1997. Safety Science 40: 501–517. http://dx.doi.org/10.1016/S0925-7535(01)00017-0

Tsioras, P.A., Rottensteiner, C., Stampfer, K., 2014: Wood harvesting accidents in the Austrian State Forest Enterprise 2000–2009. Safety Science 62: 400–408. http://dx.doi.org/10.1016/j.ssci.2013.09.016

Wilhelmson, E., StaalWästerlund, D., Burström, L., Bylund, P.O., 2005: Public health effects of accidents in self-employed forestry work. Small-Scale Forestry 4(4): 427–436.

Yoshimura, T., Acar, H.H., 2004: Occupational safety and health conditions of forestry workers in Turkey. Journal of Forest Research 9: 225–232. http://dx.doi.org/10.1007/s10310-004-0078-y

Yovi, E.Y., Nurrochmat, D.R., 2018: An occupational ergonomics in the Indonesian state mandatory sustainable forest management instrument: A review. Forest Policy and Economics 91: 27–35. http://dx.doi.org/10.1016/j.forpol.2017.11.007

Yovi, E.Y., Pradjawati, W., 2015: High risk posture on motor-manual short wood logging system in *Acacia mangium* planta-

tion. Jurnal Manajemen Hutan Tropika XXI(1): 11–18. http://dx.doi.org/10.7226/jtfm.21.1.11

Yovi, E.Y., Takimoto, Y., Ichihara, K., Matsubara, C., 2005: A study of workload and work efficiency in timber harvesting by using chainsaw in pine plantation forest in Java Island: Clear cutting operation. Applied Forest Science 14(1): 17–26.

Yovi, E.Y., Takimoto, Y., Ichihara, K., Matsubara, C., 2006: A study of workload and work efficiency in timber harvesting by using chainsaw in pine plantation forest in Java Island (2): Thinning operation. Applied Forest Science 15(1): 23–31.

Yovi, E.Y., Yamada, Y., 2015: Strategy to disseminate occupational safety and health information to forestry workers: The felling safety game. Journal of Tropical Forest Science 27(2): 213–221.

Yovi, E.Y., Yamada, Y., Zaini, M.F., Kusumadewi, C.A.Y., Marisiana, L., 2016: Improving the OSH knowledge of Indonesian forestry workers by using safety game application: Tree felling supervisors and operators. Jurnal Manajemen Hutan Tropika 22(1):75–85. http://dx.doi.org/10.7226/jtfm.22.1.75.

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