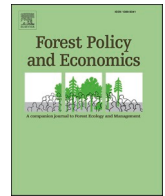




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Workload in wood harvesting and among transportation professionals — A study based on survey research in Finland[☆]

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ABSTRACT

This study focused on workload in forest harvesting and among transportation professionals and included all professional groups of the occupational sector: timber truck drivers, plant drivers, loggers and timber workers, officers, and other workers. A postal and Internet survey ($N = 1282$, response rate 32 %) comprised five variables indicating workload: stress, sense of control, mental load, working hours per week, and harmful factors at work. A random sampling ($N = 4000$), adjusted to professional groups, was carried out based on different databases and a register including information about forestry professionals. One-way analysis of variance (ANOVA) indicated the associated variables of stress. Over half of the sample respondents (59 %) reported stress and nearly half (47 %) assessed their work as mentally straining. Poor recovery from work was especially associated with stress. The average number of working hours per week (44.9 h) was large, and several respondent groups worked over 50 h per week. The most common harmful factors at work were sitting for a long time, similar, repetitive work movements, working alone, vibration, and coldness or draft. Vulnerable groups to workload were those with higher education levels, officers, women, and employers. Cooperation between stakeholders is needed to alleviate the heavy workload in this work sector, which includes a lot of small enterprises and self-employed persons working in a changing operational environment.

1. Introduction

Most of the Finnish land area (almost 75 %) is covered by forests. During the past centuries, forests have provided shelter, food, and wood material for various purposes in rural areas. In addition to being a source of wood material and bioenergy, forests are currently also considered recreational areas, carbon sinks, and areas that maintain natural biodiversity (Berg-Andersson et al., 2022). Utilizing forest resources has had a remarkable effect on national economy, as forests have provided work opportunities and sources of livelihood for citizens, and foreign trade income and tax revenue for the national economy (Heinikäinen and Saarinen, 2021). In a long run, forests have been an important element in the welfare state construction (Kauppi and Kettunen, 2022). Among European countries, Finland had the third largest contribution of the forest sector to gross domestic product (over 4 %) (Kovalčík, 2020).

Today, forests are estimated to provide jobs and entrepreneurship to a total of 74,000 employed persons in Finland (Hujo et al., 2022).

Wood trade-based income is divided among over 600,000 private forest owners (Karppinen et al., 2020). The most important forest landowners are private citizens and families (share 43 %), state (35 %) and companies (8 %) (Finnish Forest Centre, 2023). Private owners sell the main part (80 %) of the wood material needed by forest industry due to the better growth capacity of their land (Hänninen et al., 2021).

Wood harvesting operations have changed during the past two decades (Jylhä et al., 2020). The Finnish forest harvesting and transportation sector includes a large number of small enterprises and self-employed entrepreneurs, which can be described as having an overcapacity of technology, competition between the enterprises, low profitability, and also greater productivity than previously (Owuor et al., 2021). Forest industry enterprises have increased their contract sizes

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(harvested wood volumes) with harvesting enterprises, and harvesting logistics previously operated by the forest industry's own organizations have been outsourced to local entrepreneurs (Jylhä et al., 2020). Smaller machine entrepreneurs work as subcontractors for larger enterprises, but they may experience difficulties coping with changing work opportunities, potentially high machine or loan costs, and/or lower capacity to compete for skilled workers (Jylhä et al., 2020). Forest machine enterprises and entrepreneurs have bought technological equipment, but only some of them obtain agreements or enough work orders with forest industry companies. On the other hand, the lack of forest work force has been a problem during past years. The main reasons are the seasonality of work due to the economic cycle, the amount of wood trade and the season (Kankaanhuhta et al., 2018).

The operational environment of forest machine enterprises is constantly changing in Finland, but their competitiveness and productivity depend on employee well-being (Pere et al., 2015). The observed main threats to well-being at work were working conditions like difficult weather circumstances and working alone. Responsibilities, feeling rushed, and work pressure were sources of mental load. Proper leadership skills were needed to handle the every-day situations (Pere et al., 2015). Tiilikainen (2018) also reported tightened requirements related to harvest quality, productivity, and quality requirements. Living in a rural community was mentioned as a positive element of the work sector (Tiilikainen, 2018). Similarly, forestry experts and workers in Greece did not want to change their work because they valued the lifestyle in rural communities despite experiencing low job satisfaction and professional problems such as feelings of isolation, high accident rates, seasonal employment, and low income (Tsioras, 2012).

2. Literature review

Forest harvesting and transportation methods, technologies and overall circumstances may vary significantly in different locations of the globe. Consequently, workload has been studied in diverse situations, e.g. in using an auxiliary winch in Italian steep terrain (Magagnotti et al., 2016), in an operating chainsaw in Iranian pine plantation (Arman et al., 2022), in using modern multi-functional harvester machine in steep terrain (Szewczyk et al., 2020), in pine debarking in Turkey (Çağlar, 2021), as well as among Canadian brushcutters (Toupin et al., 2007), Tanzanian loggers (Silayo et al., 2021), Slovenian petrol-powered and battery-powered chainsaw operators (Poje et al., 2024), feller-buncher, skidder and loader operators in the United States (Mapatunage, 2024), and manual forest workers in Brazilian mountain regions (Minette et al., 2015). In addition, a harvester simulator in virtual circumstances has been utilized in workload studies (Dvořák et al., 2016; Spinelli et al., 2020).

In these studies, workload was measured with different methods, divided into two main categories: subjective and objective methods. Questionnaires or surveys are usually utilized as subjective methods, as workers self-report their workload (Mapatunage et al., 2025). A tool used in several studies is the National Aeronautics and Space Administration Task Load Index (NASA-TLX) (e.g. Spinelli et al., 2020; Arman et al., 2022; Mapatunage, 2024). This method was originally established for aviation needs, and it rates six dimensions of workload including mental demand, physical demand, temporal demand, effort, performance and frustration (Hart, 2006). In a study about mental workload, occupational fatigue and musculoskeletal disorders among forest professionals, Arman et al. (2022) used the NASA-TLX tool in addition to the Nordic Musculoskeletal Questionnaire (NMQ) and the Swedish Occupational Fatigue Inventory (SOFI). Measurements of heartbeat rates among forest workers represent a common objective method (e.g. Minette et al., 2015; Magagnotti et al., 2016; Spinelli et al., 2020; Silayo et al., 2021; Poje et al., 2024; Eroglu et al., 2025).

Despite the differences in the work methods, forest work has been repeatedly assessed as a demanding profession, as it elevated excessive physical and mental load (Mapatunage, 2024), owned very demanding

work conditions (Arman et al., 2022), was considered as tough and difficult occupation (Lotfalian et al., 2012), or advanced technology was assessed to increase the cognitive demands for the operator (Mapatunage et al., 2025). Modern technological tools and methods often decrease physical workload, but the effect on mental load may be opposite. For example, Mapatunage et al. (2025) observed that long-lasting operating with complex, heavy forest machinery increased workload of logging operations in the USA, as new complexities strengthened cognitive demands among the drivers. Similarly, mental demand, effort and frustration increased in two virtual stands when the harvester work environment changed from the "pure conifer" stand to the "mixwood" stand (Spinelli et al., 2020). In addition, increasing slope gradient created also increasing mental load for steep slope harvester operators (Szewczyk et al., 2020).

3. Theoretical background

Based on a literature review, the dimensions of workload can be grouped into three main aspects; first, the amount of work and various issues to be accomplished, second, time and the particular aspect of time an individual is concerned with, and finally, the subjective psychological responses and experiences of the human operator (Cain, 2007; Lysaght et al., 1989). No widely accepted theory or definition related to workload is available, but workload may be described as a *mental construct that reflects the mental strain*, which is a result from working in a certain environment and under certain operational conditions in combination with *the capacity of the operator to respond* to the demands. In other words, Gawron (2019) suggested the definition of workload as a combination of task demands (e.g. goals, efforts, the time required, and the performance level) and activities of the worker. The *emotional response* to the situation is also considered. Lindström et al. (2002) reported workload measurements to include working time and emotional reactions. Emotional stress is mentioned as a cost of task requirements (Hart and Wickens, 1990).

Stress is described as a situation where the demands of work exceed a worker's capacity to cope or manage the straining situation (Gray, 1998; Milczarek et al., 2009). Based on a literature review, Cox et al. (2000) presented a psychological approach to the definition of work-related stress by describing a *dynamic interaction* between humans and the work environment, which can be assessed as *problematic*, elevating negative psychological states, which in turn may lead to cognitive and/or emotional ill-health symptoms. In other words, stress is described as a negative interaction or misfit of environmental opportunities and demands, personal needs, and abilities or expectations (Sutherland and Cooper, 2000). The assessments related to the situation and reactions are personal, therefore workers' experiences concerning the same potentially stressful situation may vary considerably due to different skills, past experiences, education levels, and personal qualifications. In addition, an appropriate level of stress may be a positive element, as it enables utilizing available resources, achieving goals, and adapting to new circumstances (Rout and Rout, 2002). Distinguishing between negative and positive stress is essential. Selye (1956) has referred to positive stress as *eustress* (good stress).

The job demand-control model of stress (Theorell and Karasek, 1996) identifies two dimensions, *decision latitude* and *psychological demands*, which may vary from low to high. Circumstances are described as *passive* if both decision latitude and psychological demands are low, and consequently, work motivation may decrease and development and learning at work may become difficult (Kinnunen and Feldt, 2008). In a situation of *low strain*, decision latitude is high but psychological demands are low: the worker has many opportunities to handle the work situations, but psychological demands are low and therefore straining elements remain low. If decision latitude is high and psychological demands are also high, the work may be assessed as stimulating and *active*, as it provides new skills, knowledge, and learning, and work motivation may increase. In this case, the job situation may be described as positive

for the worker. Stress-elevating and high-strain circumstances include a combination of low decision latitude (no ability to control or handle the situation) and high psychological demands, which may increase the risk of mental strain and physical illness, especially in the long run. Symptoms of exhaustion may gradually increase. The crucial element of high strain and a stressful situation is the loss of control when the worker is unable to handle or fix the stressful situation. Social support was included later in the model. Low support from other workers and/or from a supervisor may increase the mental load and decrease employee well-being (Kinnunen and Feldt, 2008).

4. The research questions and aims

The research covered the professionals who harvest and transport various wood materials to processing plants or who enable this work for example through wood trade or advisory work. This knowledge and inclusion of all professional groups of forestry has been lacking in earlier studies. The data are based on a survey sample ($N = 1282$) of an experimental statistic project gathered in autumn 2019. The aim was also to compare the survey results with working population in general by utilizing other wider samples to find out the status of workload among this professional group. The comparison samples were “Work and Health 2012” data (Perkiö-Mäkelä and Hirvonen, 2013) provided by The Finnish Institute of Occupational Health (FIOH) and the European Working Conditions Survey 2015 by Eurofound (2017).

The research questions are:

1. What is the workload in wood harvesting and among transportation professionals from the perspective of stress, sense of control, mental load, working hours per week, and harmful factors at work?
2. What is the prevalence of stress and associated variables related to stress among these professionals?
3. How does the workload appear compared with general Finnish and European working population?

The output of these professionals is essential to the whole forest sector, but this was the first time that well-being at work was studied with a representative sample among all different professional groups of wood harvesting and transportation: timber truck drivers, plant drivers, loggers and timber workers, officers, and other workers.

5. Materials and methods

5.1. Ethics approval

Participating in the survey was voluntary. Informed consent was obtained from each respondent before they responded to the survey. The data were anonymized before the analysis process. A project-specific privacy notice, risk assessment procedure, and impact assessment of the survey were prepared in cooperation with a lawyer representing Natural Resources Institute Finland (Luke). The responsible person for ethical principles and good scientific practices at Natural Resources Institute Finland (Luke) was contacted, and the survey plan was assessed before the postal deliveries. Ethical approval or written informed consent for participation were not required for this kind of study involving humans, in accordance with national legislation and institutional requirements (TENK, 2019; University of Turku, 2023).

5.2. The survey sample

Sampling was carried out by Statistics Finland, which utilized the databases of the labour force and entrepreneurs to identify persons working in wood harvesting, transportation, and in professions enabling such work. The sampling process was formulated between statistical authorities of Statistics Finland and Natural Resources Institute Finland (Luke). This procedural was needed to reach the sample according to

Finnish legislation. However, Statistics Finland was unable to distinguish wood transportation professionals from a wider statistical group of transportation. A magazine for forestry professionals (called *Metsätrens*) identified Finnish vehicle register information regarding truck owners with equipment suitable for timber loading. This register information was included in the frame population. The contact information of potential respondents was also obtained from the Finnish Digital and Population Data Services Agency. Finally, the frame population included 14,189 professionals. The sampling fraction was determined based on the total number of the frame population; when equal respondent share (28 %) was calculated for each professional groups, the target number of potential respondents ($N = 4000$) was reached.

In total, 4000 persons were contacted three times in autumn 2019 by postal delivery, and responding to the survey was possible from October 4th, 2019 to January 6th, 2020. The cover letter, paper questionnaire, and postage paid return envelope were sent to all respondents twice and a reminder letter once. All postal deliveries included the personal code for the on-line questionnaire, as responding was possible using a paper questionnaire, computer, or smart phone. The materials were provided in Finnish or Swedish. Two press releases from Luke were published (in May and August 2019) informing readers about the survey. In addition, a professional paper (*Maaseudun Tulevaisuus*) published two articles related to the ongoing survey. As an incentive to respond, ten gift cards were drawn among those who returned the questionnaire. In total 1282 filled out questionnaires were received, giving a final response rate of 32 %. Over half (67 %) filled out a paper questionnaire and a third answered online. The attained survey sample was named as Timber2019. An overview of the main elements and content of the manuscript is presented in Fig. 1.

5.3. Measures and variables concerning workload

The Finnish Institute of Occupational Health (FIOH) has established a stress measure based on symptom checklists and clinical experience of the research organization (Elo et al., 2003). Stress was first defined to the respondent in the following manner: *Stress is a situation in which a person feels tense, restless, nervous, or anxious or is unable to sleep at night because their mind is constantly troubled. Do you feel this kind of stress these days? The response options are not at all, only slightly, some, quite a lot, a great deal, and I am unsure.* The options *some, quite a lot, and a great deal* are summed up to indicate the prevalence of stress. The validity of this measure has been assessed with four independent datasets, and the measure was observed to associate with scales of mental well-being. The content, criteria, and construct validity of this measure were assessed as satisfactory (Elo et al., 2003). The measure distinguishes positive and negative elements of stress, as the question first describes the negative symptoms of stress and the positive effects are circumscribed beyond the question.

The question regarding sense of control was: *How often do you feel like difficulties are piling up so that you are unable to cope with them? The response options were hardly ever, sometimes, often, nearly always, and constantly.* This question embodies features of the stress model (Theorell and Karasek, 1996) when job demands are high and possibilities to control the situation are weak, unavailable, or unattainable.

The question concerning mental load was: *Is your work mentally...? The response options were: unexacting, somewhat unexacting, somewhat straining, quite straining, very straining, and I am unsure.* The questions regarding stress, mental load, and recovery from work were similar as those used in a wide survey of the Finnish working population (Perkiö-Mäkelä and Hirvonen, 2013). The question concerning working hours was the same as that used in the European Working Conditions Survey (EWCS) (Eurofound, 2017): *How many hours do you usually work per week in your main paid job?*

Harmful factors were assessed with a table including 19 potential harmful elements: *noise; working alone; heat; cold or draught; moisture; dustiness; dirtiness; vibration; chemicals or substances that are harmful or*

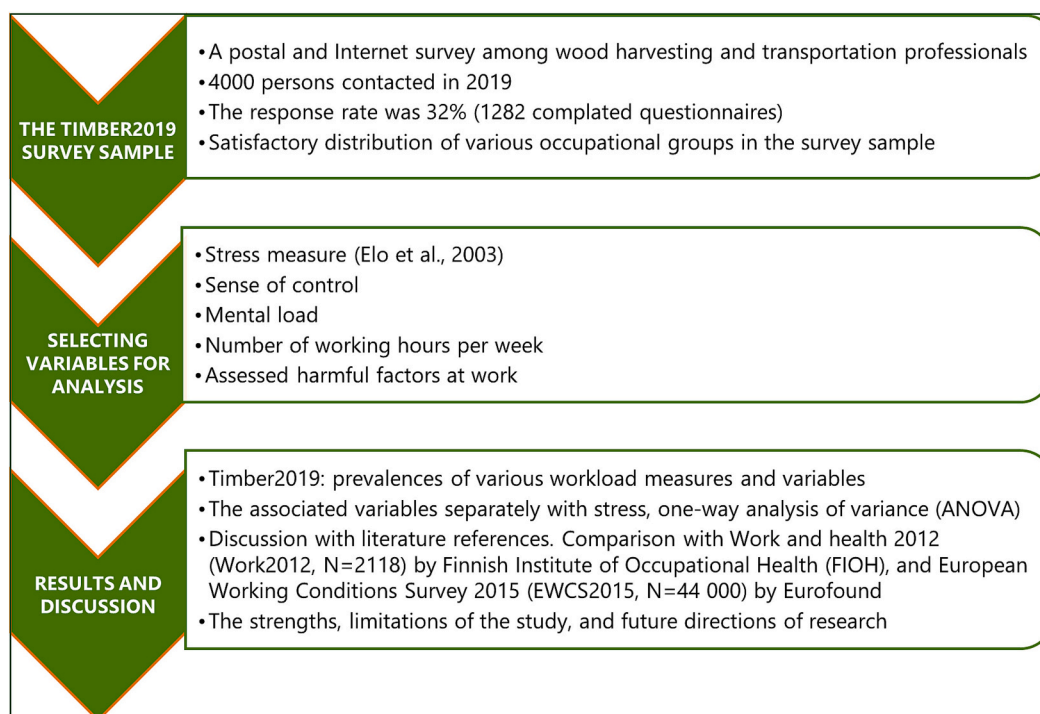


Fig. 1. Overview of the article's main content.

dangerous to health; heavy physical labour; repetitive work movements; standing still; sitting for a long time; lifting, carrying or supporting by hand without any aids; awkward working positions; deficiencies in the workplace or working conditions; deficiencies in work tools; problems with order and cleanliness in the workplace and insufficient lighting or glare. The question was *Do the following harmful factors occur in your own work environment or in your work to a harmful degree?* The respondents were asked to assess each factor by responding either *no*, *yes*, or *I am unsure*. The number of yes responses was calculated and used as an overall hazard exposure score.

5.4. Statistical methods

The stress level was used as a continuous dependent variable, although it was measured on a 5-point ordinal scale. Ordinal variables with five or more categories are often considered an ordinal approximation of continuous variables without compromising the analysis (Norman, 2010). Each predictor of stress level was represented by a single question or item. If a predictor had at least five categories and exhibited a linear relationship with stress level, the predictor was treated as a continuous variable in the regression model. A continuous predictor was categorized if the relationship between a predictor and stress level was not linear. For instance, the number of sick days required categorization. The statistical significance of each categorical predictor for stress level was assessed using one-way analysis of variance (ANOVA).

The predictors for the regression model were selected based on existing literature and their significance to the stress level in the preliminary ANOVA analysis. The correlation matrix of the predictors and stress level was utilized in the selection process, and irrelevant predictors were excluded. All included variables are presented in [Supplementary file, Table S1](#). Multicollinearity among the predictors was assessed using variance inflation factor (VIF) values, and it was determined to be negligible. The values exceeding 10, 5 or even 2.5, from liberal to conservative thresholds, are generally considered indicative of considerable collinearity (Johnston et al., 2018). However, the highest VIF value in the analysis was only 2.02. Predictors with substantial

missing values were also omitted from the model. All selected categorical and continuous predictors were initially included in the model, and non-significant predictors were systematically removed to enhance the model parsimony. In addition, the stepwise model selection method was employed to confirm the results and to detect potential missing predictors. Predictors were included and kept in the model based on significance levels of 0.25 and 0.10, respectively. These thresholds are commonly used in exploratory analysis and are the default options in SAS, reflecting both statistical reasoning and practical considerations. A significance level of 0.05 was used for all pairwise comparisons between the predictor categories. Residual analysis was used to assess the fit of the regression model and ANOVAs. All statistical analyses were conducted using SAS Enterprise Guide 7.15. (SAS Institute Inc., Cary, NC, USA).

6. Results

6.1. Sample characteristics

Survey sample characteristics ($N = 1282$) (gender, age group, professional group, professional status, work experience in the forest sector, and education) are reported in [Table 1](#). The respondents were mainly men (94 %), and the average age was 47 years (range 20–86 years). The average age among women (44 years, range 23–63 years) was lower than among men (47 years, range 20–86 years). The respondents were mainly (69 %) salary earners, nearly every fifth (18 %) was an employer, and 13 % were self-employed ([Table 1](#)). Women respondents were mainly (85 %) salary earners ([Fig. 2](#)). The share of self-employed individuals was large among loggers and timber workers (27 %), the share of employers was large among timber lorry drivers (39 %), and most officer respondents were salary earners (95 %).

Most (61 %) respondents had worked in the forestry sector for over ten years. Work experience averaged 23 years for loggers and timber workers, 22 years for timber lorry drivers, 16 years for plant drivers, and 13 years for officers. All respondents had worked an average 17 years in their current positions. Over half (58 %) had professional education, at least from vocational school. Almost a quarter (24 %) did not have any

Table 1
Survey respondent characteristics ($N = 1282$), stress^a prevalence, assessments regarding sense of control^b and mental load.^c

Variable	n (%)	Workload, measure, variables (%)		
		Stress ^a	Control ^b	Mental load ^c
All respondents	1282	59	8	47
Gender				
Man	1222 (94)	58	7	47
Woman	53 (4)	74	17	62
Age				
30 years or younger	141 (11)	61	7	49
31–44	381 (30)	62	8	52
45–54	319 (25)	58	6	50
55–60	273 (21)	55	7	39
61 years or older	160 (13)	54	7	45
Professional group				
Loggers and timber workers	186 (15)	47	6	26
Plant drivers	454 (37)	57	6	43
Timber lorry drivers	266 (21)	56	7	49
Officers	266 (21)	76	9	66
Professional status				
Salary earner	867 (69)	58		47
Employer	232 (18)	67	9	54
Self-employed	165 (13)	57	8	35
Work experience in the forest sector				
0–5 years	82 (19)	59	2	44
6–10 years	168 (20)	67	12	51
Over 10 years	1024 (61)	57	6	47
Education				
No professional education	296 (24)	54	5	43
Professional courses	219 (18)	48	9	70
Vocational school	365 (29)	55	6	43
Vocational college	152 (12)	67	6	56
University of Applied Sciences	168 (13)	78	13	63
University	50 (4)	70	6	68

^a Question *Stress is a situation in which a person feels tense, restless, nervous, or anxious or is unable to sleep at night because their mind is constantly troubled. Do you feel this kind of stress these days?* The response options: *not at all, only slightly, some, quite a lot, a great deal, or I am unsure*. The share is calculated as the sum of responses *some, quite a lot, and a great deal* (Elo et al., 2003; Perkiö-Mäkelä and Hirvonen, 2013).

^b Question *How often do you feel like difficulties are piling up so that you are unable to cope with them?* The response options: *hardly ever, sometimes, often, nearly always, and constantly*. The share is calculated as the sum of responses *often, nearly always, and constantly*.

^c Question *Is your work mentally...?* The response options: *unexacting, somewhat unexacting, somewhat straining, quite straining, very straining, and I am unsure*. The share is calculated as the sum of responses *quite straining and very straining*.

professional education.

The frame population was compared with the attained survey sample. The share of timber truck drivers was the same (21 % in both the frame population and the sample) and the share of official workers was also fairly even (20 % vs. 21 %). The proportion of loggers and timber workers was a bit higher, as the share was 23 % in the frame population and only 15 % in the sample. In turn, the share of plant drivers was 33 % in the frame population and 37 % in the sample. The proportion of entrepreneurs (self-employed and employers) was 31 % in the sample. According to Statistics Finland, the proportion of entrepreneurs is approximately half of all forestry workers, but these statistics do not include timber truck drivers. Compared with the frame population, the distribution of different professional groups may be assessed as

satisfactory. The sample is considered relatively large and representative of the occupational groups in forest harvesting and transportation. The respondents represented 9 % of the frame population.

6.2. Stress and associated variables

On average, over half (59 %) of respondents in timber harvesting and transportation reported having some, quite a lot, or a great deal of stress (Table 1). Respondent groups reporting high stress levels were respondents with university of applied sciences education (78 %), officers (76 %), women (74 %), respondents who had a university education (70 %), employers (67 %), respondents with 6 to 10 years of work experience in the forest sector (67 %), and respondents with vocational college education (67 %). Respondent groups with lower stress levels were loggers and timber workers (47 %) and respondents who had passed professional courses as their education (48 %). Experiencing stress decreased with age, as 54 % of 61-year-olds or older respondents experienced stress, while younger respondent groups (aged 30 years or younger, aged 31–44 years) showed larger shares (61 % and 62 %, respectively) of stress.

The regression model partially explained stress variability, identifying poor recovery and low control as key factors. The variables expressing the strongest relationship with stress were *recovery from work, professional group, professional status, opportunity to affect personal matters at work, and financial situation*. In addition, the following variables had an association with stress although this association was weaker: *having enough vacation time, absences from work due to illness or health issues (number of days), opportunity to receive support or help from co-workers if needed, exercising, and the number of days worked while sick* (Table 2, Fig. 3). These ten variables explained 39 % of the variability of stress.

A variable related to recovery from work had the strongest association with stress (Fig. 3), which is based on a question asking *How well do you recover from the load caused by work after a working day or a work shift?* The response options were *poorly, considerably, well, or I am unsure*. On average, 26 % of respondents assessed that they recover well, over half (57 %) recovered considerably, and 17 % of respondents recovered poorly from the load caused by work. Among the professional groups and professional statuses, the respondent groups that particularly associated with stress were the officers and employers, respectively (Fig. 3).

6.3. Sense of control

Concerning the sense of control, 8 % of all respondents assessed that difficulties were often or nearly always piling up so that respondents were unable to cope. The response options *often* or *nearly always* were chosen most commonly by the respondent group *women* (17 %), by respondents with *university of applied sciences education* (13 %), and by respondents who had worked 6 to 10 years in the forest sector (12 %) (Table 1).

6.4. Mental load

Related to mental load, nearly half (47 %) assessed their work as either very straining (13 %) or quite straining (34 %). Work was assessed as quite or very straining by respondents who had a *university education* (68 %), *officers* (66 %), respondents who had *university of applied sciences education* (63 %), and *women* (62 %) (Table 1).

6.5. Working hours per week

The respondents worked an average 44.9 h per week (SD 11.1) (Fig. 4). Timber truck drivers with different professional statuses (salary

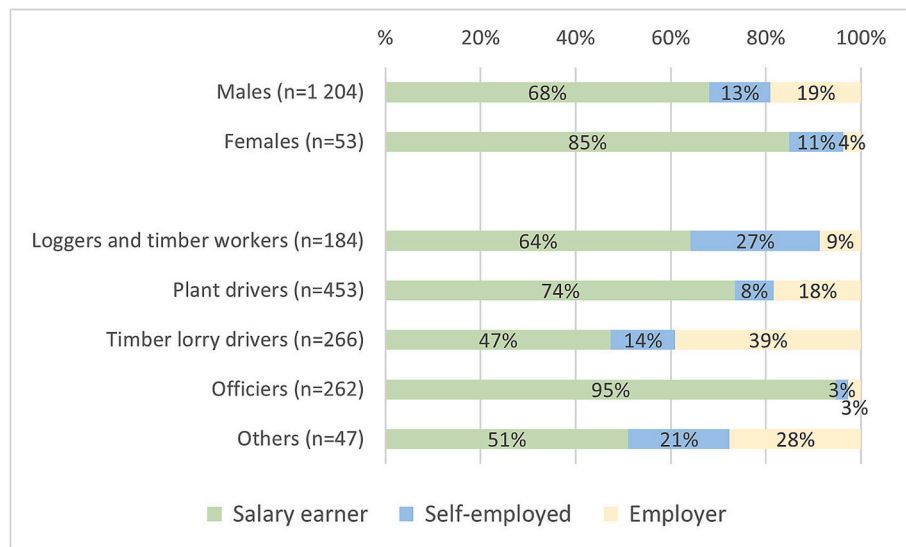


Fig. 2. Shares of professional positions (salary earners, self-employed, and employers) among men and women respondents and in different professional groups of the Timber2019 survey sample. The total numbers of persons in each respondent group are given in brackets.

Table 2

Statistically significant variables associated with stress analyzed by linear regression analysis. The last three variables were continuous, and the others had 3–5 categories. $N = 1124$.

Effect	DFs	F value	P value
Professional status	2, 1103	21.4	0.000
Professional group	4, 1103	27.3	0.000
Absences from work due to illness or health issues, n days	3, 1103	5.4	0.001
Number of days worked while sick	2, 1103	4.1	0.016
Recovery from work	2, 1103	89.3	0.000
Living habits; exercising	2, 1103	4.2	0.016
Living habits; having enough vacation time	2, 1103	6.1	0.002
Opportunity to affect personal matters at work	1, 1103	20.3	0.000
Financial situation	1, 1103	17.9	0.000
Opportunity to receive support or help from coworkers if needed	1, 1103	4.7	0.030

earners, employers, and self-employed workers) all averaged more than 50 h of work per week. Plant drivers who were employers and officers who were self-employed also worked over 50 h per week (Fig. 4).

6.6. Harmful factors of work

The most common harmful factor of work among all respondents was *sitting for a long time* (72 % of respondents assessed this as a work disadvantage). Other common harmful factors were *similar, repetitive work movements* (66 %), *working alone* (58 %), *vibration* (53 %), and *coldness or draft* (51 %). The situation was different especially among loggers and timber workers, as 90 % of them assessed *moisture* as the most harmful factor of work, followed by *coldness or draft* (86 %), *heavy physical work* (84 %), *similar, repetitive work movements* (84 %), and *heat* (78 %). Officers reported fewer work disadvantages, and *sitting for a long time* was the most mentioned factor (68 %) for this group.

7. Discussion

In general, the forest harvesting and transportation professional group reported heavy workload (stress, mental load and working hours). The variables expressing the strongest relationship with stress were *recovery from work*, *professional group*, *professional status*, *opportunity to affect personal matters at work*, and *financial situation*. The most common harmful factors at work related to both physical and mental aspects: *sitting for a long time*, *similar, repetitive work movements*, *working alone*, *vibration*, and *coldness or draft*.

The questionnaire was formulated to enable comparisons with wider samples of the working population. The first reference, the *Work and health 2012* study, later named *Work2012*, is a part of a series of wide surveys that have been carried out by FIOH since 1997. In 2012, the sample ($N = 2118$) was assessed as representative of the Finnish working population (Perkiö-Mäkelä and Hirvonen, 2013). The same questions concerning stress (Elo et al., 2003), mental load, and recovery from work were asked in both studies. Over half (59 %) of the Timber2019 respondents experienced a *great deal*, *very much*, or *some* stress, while the corresponding share in the *Work2012* sample was approximately a third (34 %). The situation concerning mental load was congruent, as mentally *quite straining* or *very straining* work were reported by nearly half (47 %) of Timber2019 respondents and by 27 % of the *Work2012* sample. Timber2019 respondents also recovered less effectively from work, as over half (54 %) recovered well in the *Work2012* sample while the corresponding share was 26 % in the Timber2019 sample. The number of respondents that recovered *poorly* was greater in Timber2019 than in *Work2012* (17 % vs. 5 %) (Perkiö-Mäkelä and Hirvonen, 2013).

Working hours per week were compared with the European Working Conditions Survey 2015 ($N = 44,000$), which was named *EWCS2015* (Eurofound, 2017) (Fig. 4). Timber harvesting and transportation respondents reported an average of 44.9 working hours per week, and Timber2019 respondents worked more hours per week than those in the *EWCS2015* sample in all the compared groups (an average of all respondents, salary earners, and entrepreneurs). Several respondent groups in Timber2019 worked more than 50 h per week (Fig. 4).

The *Lancet* (2021) assessed increasing working hours as one of the

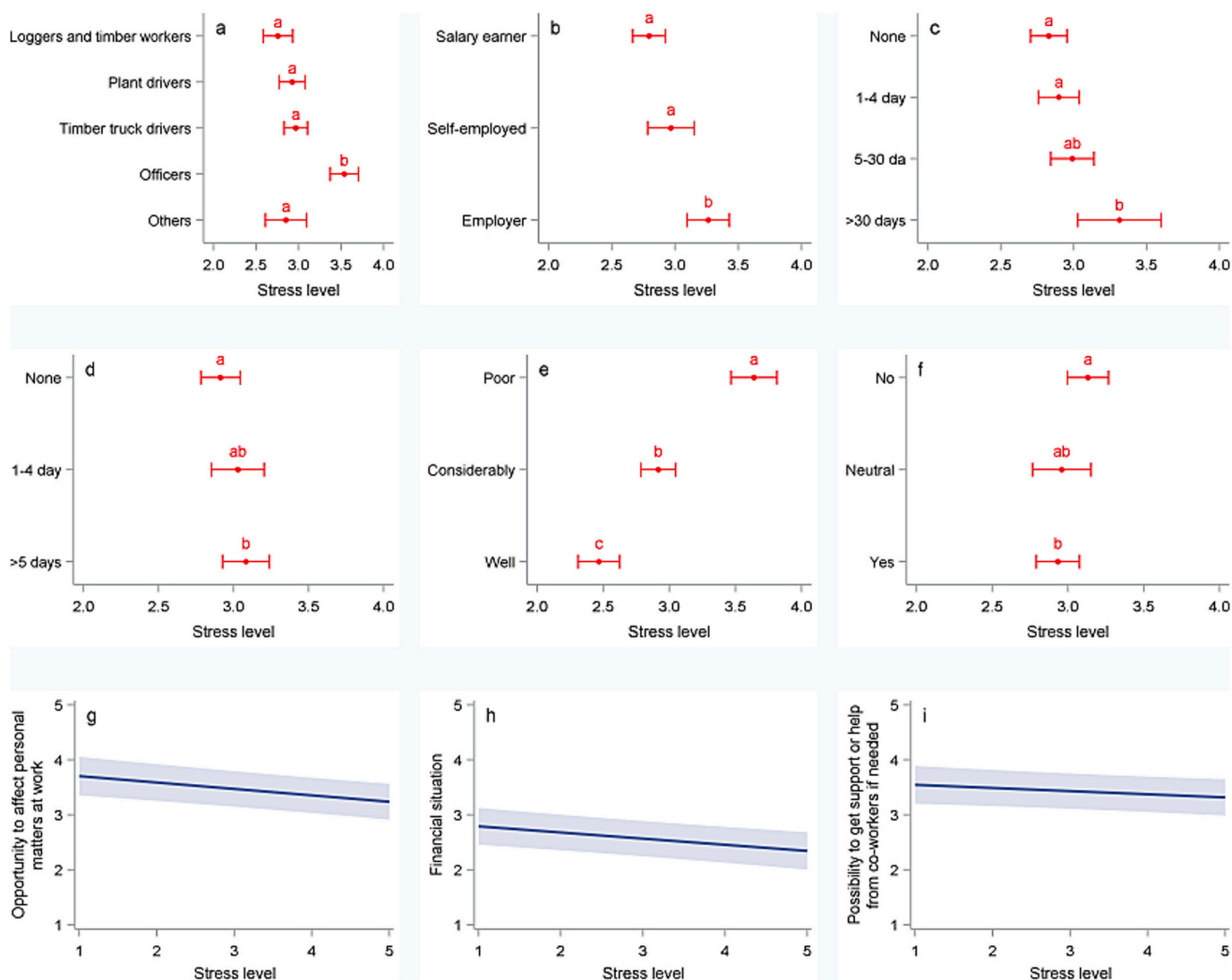


Fig. 3. Stress measure results (see Table 2) associated with the following variables: (a) professional group, (b) professional status, (c) absences from work due to illness or health issues, days (d) the number of days worked while sick, (e) recovery from work, (f) living habits; having enough vacation time, g) opportunity to affect personal matters at work, h) financial situation, and i) opportunity to receive support or help from coworkers if needed. Mean estimates and 95 % confidence interval of stress levels are shown. Letters on the lines indicate statistically significant differences ($p < 0.05$). $N = 1124$.

most important current occupational health threats. Overworking has the potential to increase the risks of cardiovascular diseases, stroke, and mental health problems. In addition, it may elevate stress, sleeping problems, and unhealthy lifestyle changes. Wide cooperation is needed to improve this health and social problem (Lancet, 2021). In the case of forest harvesting workers, long working days may be rooted in the challenging operational environment, which is described by Kastenholz et al. (2011) (Fig. 5). The work tasks in forests vary considerably according to the economic cycle, the situation in international markets, and according to season (Kankaanhuhta et al., 2018). The international situation also has an effect, as the war in Ukraine ended the import of Russian pulpwood and chips (Leppänen, 2022), thereby increasing wood demand from Finnish forests (Routa and Niinistö, 2022). In general, long working hours are connected to economic growth in society, the demand for profits, and the uncertainty of work opportunities (Lancet, 2021).

The survey variables indicating workload were associated with higher education level (university of applied sciences or university education), and vulnerable respondent groups were officers, women, those who had worked 6 to 10 years in the forest sector, and employers. Some general changes concerning work environment and rural circumstances

have possibly affected to officers' work in the forestry sector. During the past years, working life has changed to more independent, digitalization has progressed, and remote work has increased (Ranki, 2023). Poorer digital infrastructure and difficulties in reaching high-speed telecommunication networks are practical elements potentially hampering work in rural circumstances. As Lehtonen et al. (2023) concluded, based on countrywide data, the digital divide is verifiable in the urban-rural dimension. A survey in Turkey observed considerable stress among forest administration chief officers mainly due to a large operating area (Akyüz, 2023). In Iran, increased levels of mental stress were found also among forest and skidder operators (Lotfalian et al., 2012).

The Timber2019 sample only included 53 women, representing 4 % of the whole sample. They reported symptoms of stress, weakened sense of control, mentally straining work, and poor recovery from work. Literature references support the characterization that the forest sector is a highly gender-segregated sector (Ville et al., 2023), where the position of women in working life is weaker and work tasks are divided according to gender. Among professionals with a university degree, men reportedly received a job corresponding to their education more commonly than women did, and unemployment was at a higher level among women graduates (Kilpeläinen and Lautanen, 2022). After

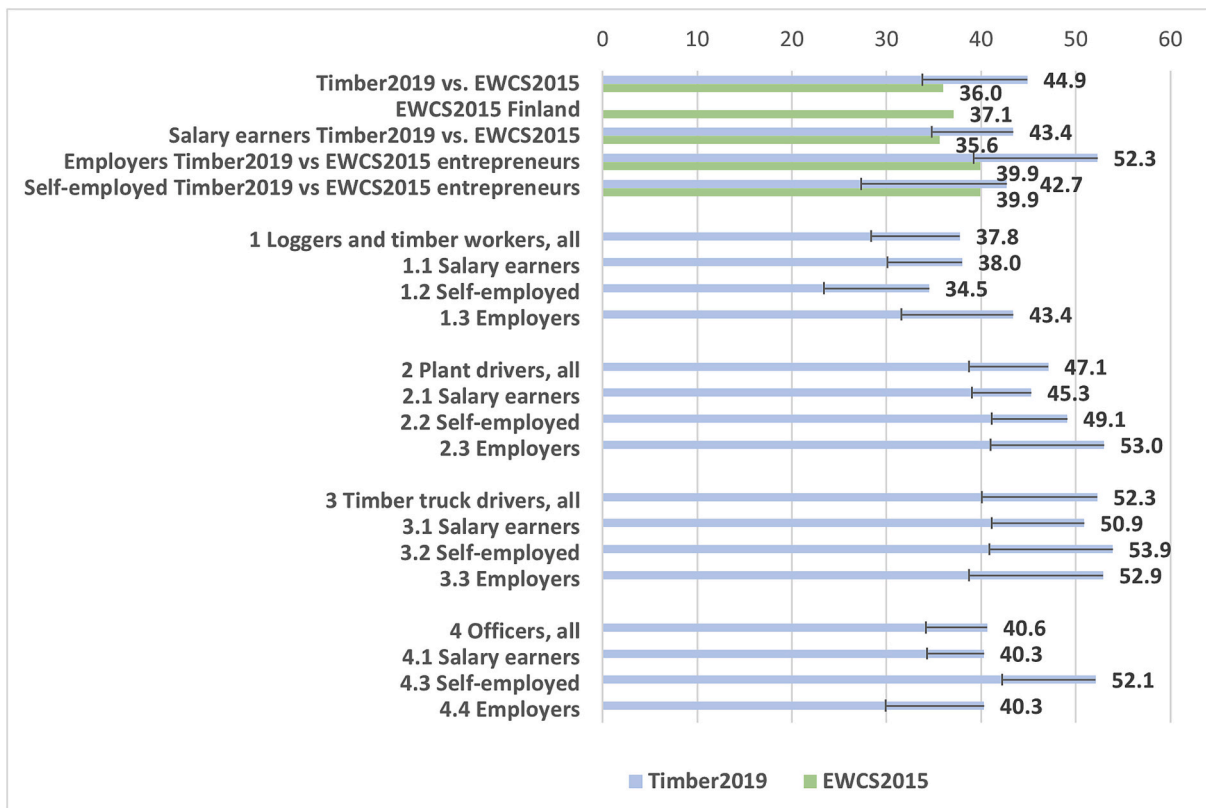


Fig. 4. Working hours per week in a full-time position among respondents in wood harvesting and transportation (Timber2019, N = 1256) sample (including standard deviations, SD) and among respondent groups in the European Working Conditions Survey 2015 (EWCS2015, N = 44,000). Reference: Eurofound, 2017. Working time patterns for sustainable work. Statistical annex. Publications Office of the European Union, Luxembourg.

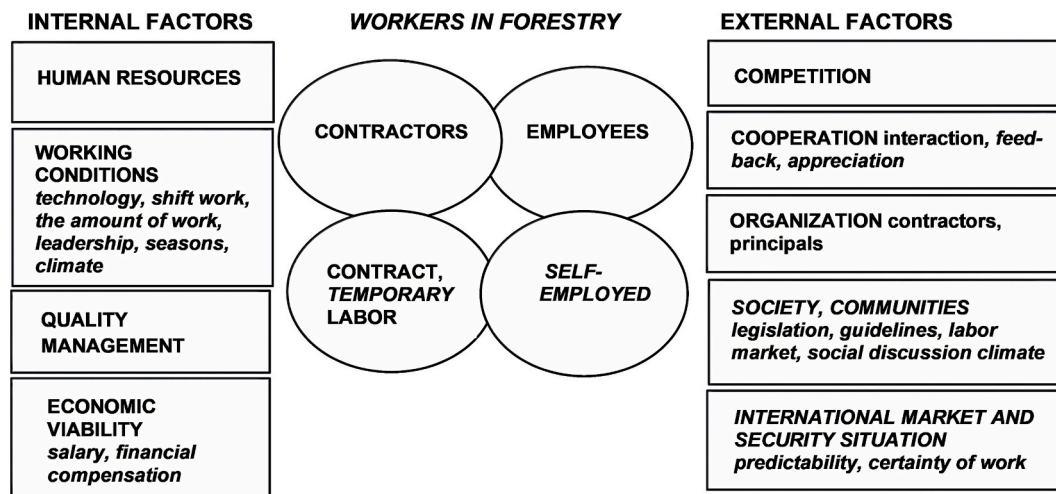


Fig. 5. The different positions of forestry workers (in the middle), and the internal and external factors related to their operational environment. Source of the original picture Kastenholz et al. (2011), page 11. The text in italics was added based on Timber2019 survey results. Permission to utilize the picture was obtained from Dr. Edgar Kastenholz on August 6th, 2024. Reference: Kastenholz, E., Dyduch, C., Fitzgerald, R., Hudson, B., Jaakkola, S., Lidén, E., Monoyios, K., Morat, J., Pasek, F., Sachse, M., Street, W. and Lorbach, J. 2011. Guide to good practice in contract labour in forestry. Report UNECE/FAO. Food and Agriculture Organization, Rome.

obtaining a forestry degree, men earned more than women graduates (Kilpeläinen et al., 2014). Gender is usually assessed as an insignificant element in Finnish working life, but when compared with the situation in Europe, the segregation of work sectors and the choice of education according to gender are noticeably differentiated in Finland (Korvajärvi, 2010). Women represent 19 % of all workers in the Finnish forest sector while their share of the whole working population was almost half (48

%) (Statistics Finland, 2024). According to da Silva and Schweinle (2022) every fifth (21 %) employed in the European forest sector was woman.

The *recovery from work* variable had the strongest association with stress. Poor recovery from work has also been observed in another Finnish study (Siukola et al., 2018) focusing on forest harvesting entrepreneurs and workers. Half of the respondents did not recover from

work sufficiently, and the mental load was the most significant problem. According to the study, mental recovery was assessed as especially important for maintaining good performance and well-being at work. Based on these results, Siukola et al. (2018) recommended improving cooperation with occupational health services.

Weak opportunities to affect personal matters at work or limited opportunities for receiving support or help from coworkers if needed were associated with stress. Earlier research (Ylimäki et al., 2012) also indicated that individuals need and request more feedback concerning their own work in forest harvesting. Social interaction has the potential to mitigate the negative effects of a stressful work situation (Sonntag and Frese, 2003). Small-scale enterprises and the professional statuses of the self-employed may be factors elevating the difficulties and/or lack of social interaction in forest sector work, as both these factors limit work communities and social interaction. The competition among forest sector actors is mentioned by Owuor et al. (2021), see also Fig. 5 (Kastenholz et al., 2011).

Working alone was mentioned as a harmful factor at work (also Tsioras, 2012; Pere et al., 2015). A remarkable share of forestry work force in Finland are entrepreneurs, who take care of and answer for the occupational safety by themselves. In general, working alone is allowed, but the employer must assess the risks and hazards, and the means to reduce these risks. In addition, the employer must provide the employee a possibility to communicate and suitable equipment to call for help if needed (Työsuojelu, 2025). According to a special legislative decree guiding occupational safety in wood harvesting, it is forbidden to work alone when harvesting wood due to storm damage (Finlex, 2001).

Respondents' financial situation was associated with experienced stress, which is supported by several other studies. A lower salary level has been found to be a reason for switching from forest work to another profession (Lautanen et al., 2020; Vihottula, 2010), and the income level of forest sector professionals was associated with well-being at work among Australian forest sector workers (Mylek and Schirmer, 2015). Work-related rewards, like salary or financial compensation, are one the main elements in the Effort–Reward Imbalance stress model (Siegrist et al., 2004). Furthermore, adequate earnings are included in the Decent Work Indicators of the International Labour Organization (ILO, 2013). Kastenholz (2019) described forestry as a business type with low profit margins and forestry contractors as the weakest link in the line running from forest owners to forest industry plants. In addition, the situation among various operators may range from a flourishing business to poor financial circumstances, and price fluctuations may be a problem (Kastenholz et al., 2011). Tough competition among enterprises, when the work tasks are not divided evenly and observed overcapacity concerning available forest harvesting machinery may lead to a situation where clients try to benefit from the situation with lowered harvesting costs (Siukola et al., 2018). This situation obviously lowers the profit opportunities among entrepreneurs.

Absences from work due to illness or health issues and the number of days worked while sick were also associated with stress. Tasks in forestry are interconnected, so absences may render the work of colleagues more difficult or impossible. Obtaining a replacement in the form of qualified workforce may be difficult, as it takes an average 15.6 months for an inexperienced harvesting operator to learn the necessary skills, and job performance is only 40 % at the beginning of the learning process (Ylimäki et al., 2012). An earlier survey study also showed that nearly half of forest harvesting entrepreneurs and machine drivers assessed that they had worked while sick at least twice during the past year (Siukola et al., 2018). Two variables concerning living habits, namely not having adequate vacation time and exercising, had an association with stress. Too little vacation time may be connected to poor recovery from work, which was also connected to stress. In turn, exercising may be related to long working days in the sample, which leaves less time to keep fit, or exercising may limit available free time and thus elevate stress.

7.1. Strengths and limitations

The strengths of this study include a large number of survey respondents, and with communication efforts, a response rate of 32 % was reached. The attained sample was assessed as representative of different forestry occupational groups. The advantage of the survey method is getting research material about personal respondent experiences. The questionnaire included questions and measures used in wider national and European surveys to enable comparisons with working population in general. However, in many cases the survey method yields as a low response rate. The study provides important information, yet it has several limitations. The research is cross-sectional, which limits observing causality (Van der Stede, 2014; Spector, 2019). Cross-sectional studies may provide knowledge regarding the prevalence of outcomes, risk factors, and relationships among variables (Spector, 2019). The share of survey respondents represented only 9 % of the formulated sampling frame. The survey, provided in Finnish and Swedish languages, was not able to reach temporary, often foreign seasonal workers in forestry. Comparisons with the reference studies also include limitations. The posed questions were similar, but the survey methods differed: Work2012 was based on telephone interviews, EWCS2015 on personal interviews, and Timber2019 on postal and Internet surveys. The reference surveys were carried out four and seven years earlier than Timber2019. Working life conditions or social situations may have changed during those years.

8. Conclusions

The workload in wood harvesting and among transportation professionals was examined from the perspective of stress, sense of control, mental load, working hours per week, and harmful factors at work. Secondly, the prevalence of stress and associated factors related to stress were examined. Thirdly, the workload of these professionals was compared with that of general Finnish and European working population. The random survey sample ($N = 1282$) was gathered in autumn 2019 and included for the first time all forestry professional groups; timber truck drivers, plant drivers, loggers and timber workers, officers, and other workers.

In general, the professional group reported heavy workload, as over half of the respondents reported stress and nearly half assessed their work as mentally straining. The average number of hours worked per week was large, and several respondent groups worked more than 50 h of work per week. The most common harmful factors at work were *sitting for a long time, similar, repetitive work movements, working alone, vibration, and coldness or draft*.

The variables expressing the strongest relationship with stress were *recovery from work, professional group, professional status, opportunity to affect personal matters at work, and financial situation*. In addition, the following variables had a significant association with stress although weaker: *having enough vacation time, absences from work due to illness or health issues (number of days), opportunity to receive support or help from co-workers if needed, exercising, and the number of days worked while sick*. These ten variables explained 39 % of the variability of stress.

This study adds important knowledge both for academics and practitioners, since the results provide information for other studies and research projects focusing on well-being at work among forestry personnel. Intervention studies that account for the different professional statuses of this sector (employers, self-employed, and salary earners) and the abundance of small businesses are suggested. For example, useful and feasible methods for increasing interaction and communication would be an important step forward. We suggest also finding out if artificial intelligence could be utilized for helping the administrative reporting load of small entrepreneurs. Practical and management implications include influencing on the development of digital infrastructure on rural and remote areas, more equal division of tasks and responsibilities, enhancing an atmosphere approving

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