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ORIGINAL PAPER

Is cable yarding a dangerous occupation? A Survey from the public and private sector

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Abstract
Cable yarding is a physically demanding and dangerous occupation in forest harvesting. Currently, the technology is gaining interest due to its low environmental impacts compared to the ground based technologies. This paper was focused on comparing the subjective opinions regarding occupational safety and work environment with objective findings found in the literature. We used a questionnaire with 33 questions, divided into three main parts: (i) personal traits of the participants; (ii) occupation description; and (iii) the occupational risks identified the participants. The sample consisted of 92 workers who operated cable yarders from both the public and the private sector. Our survey showed that 90% of public and 75% of private sector employees view their work as physically very demanding. Regarding risky behaviour, 50% of public, and 54% of private employees stated they risked only when the circumstances forced them to. However, more than 41% of public and 50% of private employees stated they suffered an occupational accident in the last ten years of working with this technology. Considering the workers worked in unstable climatic conditions, on unstable terrain, and the work environment presents other hazards, such as the loads, sharp tools and equipment, this result was not surprising.

Key words: occupational accident; occupational risks; cable yarding; public and private sector; questionnaire

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1. Introduction

Forest harvesting is, from multiple views, a dangerous occupation (Bentley et al. 2005; Lindroos & Burström 2010) It is considered on of the most dangerous occupations in the world (Lilley et al. 2002; Klun & Medved 2007). In all countries, where comparable statistics are available, forestry has one of the highest frequency of occupational accidents per employee compared to other sectors of the economy (Ozden et al. 2011). Forest harvesting is especially dangerous on steep slopes (Tsioras et al. 2014). Slovakia, with 41% of forest area, is one of the most forested countries in Europe. Production-wise, forest harvesting is complicated in Slovakia (Bugoš & Stanovský 2009). Aside from other factors, such as tree species composition, soil bearing capacity, there is the fact that about 40% of Slovak forests are located in areas with slope steeper than 40% (Ministry of Agriculture and Rural Development of the Slovak Republic, National Forest Centre 2015).

Steep slopes and rugged terrain are conditions, which favour using cable yarding. Difficult conditions reflect in demanding work environment, which negatively affects workers when operating the yarders and requires skilled workers and their effective teamwork (Mologni et al. 2016). Effective teamwork requires good coordination of the team members, good communication, and good relationships within the team. According to West (2012) an effective team should meet the following criteria: task effectiveness (the extent to which the team is successful in achieving its task-related objectives), team member well-being (refers to factors such as the well-being or mental health, growth and development of team members), team viability (the likelihood that a team will continue to work together and function effectively), team innovation (the extent to which the team develops and implements new and improved processes, products and procedures), and inter-team cooperation (the effectiveness of the team in working with other teams in the organization with which it has to work in order to deliver products or services).

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Besides the need of cooperation, cable yarding is demanding physically and requires both static and dynamic muscle power, since it imposes hard labor of intense loads on the musculoskeletal system of forestry workers (Bovenzi et al. 2004; Yovi et al. 2015). Given that cable yarding operations need appropriate planning and dimensioning to respect safe working conditions (Mologni et al. 2016). It is a very difficult work, which can lead to serious accidents, especially on steep slopes (Tsioras et al. 2011). There is a lack of information on the complex analysis of cable yarding from the view of the workers who actually work with the technology.

This paper is focused on the overview of the physical demands, risks, and negative factors affecting workers employed in cable yarding. The research is conceived as a questionnaire survey aimed at the employees of both the large Slovak state forest enterprise (further in text: employees of the public sector; PU), as well as the employees of private contractors who carry out cable yarding (further in text: employees of the private sector; PR). We hypothesize that the number of occupational accidents per employee and the connected standard of occupational safety is higher in case of the PU employees. Public employees work in a large company, with elaborated safety standard and ergonomic risk management system. Smaller private companies that provide services in cable yarding usually do not emphasize occupational safety and health as much as larger companies.

2. Material and methods

Forests of the Slovak Republic, (FSR) works with the most cable yarders in Slovakia. During the year 2015, FSR owned 20 cable yarders on total and employed 80 people in cable yarding. The annual output of the cable yarders owned by the FSR was 100 000 m^3. The total amount of timber yarded in the FSR was higher though, about 400 000 – 500 000 m^3 per year (about 10% of the total annual fellings), the remaining volume of felled timber was yarded by private contractors. Public employees used the following cable yarders: Larix Kombi H, Larix 550, Larix Lamako, Larix 3T, Steyr KSK 16, and Mounty 4000, whereas PR employees used: Mounty 4100, Syncrofalke, KMS 12, Lanor 3, and Vlu 5 cable yarders. On total, 68 PU employees and 24 PR emplyees participated in our study. The personal characteristics of the participants are available in Table 1.

To evaluate the subjective views of the workers on working with cable yarders, we used a questionnaire containing 33 questions on the workers themselves and their work. The questionnaire was divided into three segments: (i) Personal traits: age, weight, experience, occupation; (ii) Work itself: physical demands, performance, work shift duration, communication within the team, usage of personal protective devices; (iii) Risks: individual factors of the work environment, operations, occupational accidents occurrence, injured bodyparts. The questions were multiple choice, the participants were able to select one of the choices. For better clarity, we selected fourteen most important questions for further inspection.

Table 1. Relative distribution of the workers who participated in the survey based on their age, practical experience, and weight.

Category	Class	Public employees [%]	Private employees [%]
Age [years]	≤30	22.4	20.8
	31–40	29.9	50
	41–50	31.3	12.5
	>50	16.4	16.7
Experience* [years]	<1	5.9	0
	1–5	41.2	16.7
	6–10	35.3	37.5
	>10	17.6	45.8
Weight [kg]	≤70	10.6	8.3
	71–90	50	58.4
	>90	39.4	33.3

*Number of years of practice by cable yarders.

We assessed the results of the questionnaire survey through a series of χ^2 tests (Scheer & Sedmák 2007). The tests served for detecting the effects of various variables on the number of occupational accidents occurring during cable yarding. The tests were elaborated independently for PU and PR employees. In the first χ^2 test, we focused on the relationship between the occupation (V_{1PU} or V_{1PR}) and the number of occupational accidents (Y_{PU} or Y_{PR}), in the second test, we tested the duration of the shift (V_{2PU} or V_{2PR}) on number of occupational accidents (Y_{PU} or Y_{PR}), then we tested effect of the quality of communication in the teams (V_{3PU} or V_{3PR}) on Y_{PU} or Y_{PR}. The fourth χ^2 test served to analyse the effect of using personal protective equipment (PPE) (V_{4PU} or V_{4PR}) on Y_{PU} or Y_{PR}. Further analysis was a multiple regression and correlation analysis, through which we observed the relationship between the duration of practical experience of the employees (V_{5PU} or V_{5PR}), the monthly volume of yarded timber (V_{6PU} or V_{6PR}), and the duration of the work shift (V_{7PU} or V_{7PR}) on either Y_{PU} or Y_{PR}. We used MS Excel, and STATISTICA 12.0 software to analyze the data.

3. Results

The overview of employees in particular occupations is depicted in Table 2. From the data, it is visible that in both PU and PR group, most employees had multiple occupations. In case of PU employees, it was 63% and in case of PR employees it was 50% of employees. Rotation of occupations was important mainly to reduce monotony, thus preventing occupational accidents.

We tested the relationship between occupation and occupation accidents. The results of the statistical analysis (χ^2) test showed, both for PU and PR employees, no statistically significant relationship between the occupation (V_{1PU} or V_{1PR}) and the occupational accidents (Y_{PU} or Y_{PR}) (χ^2_{PU} – 4.70; df – 4; p – 0.32 > 0.05; χ^2_{PR} – 2.48; df – 4; p – 0.65 > 0.05).

Table 2. Relative distribution of the workers, who participated in the survey based on their occupation, the operation they perceive as the most dangerous, and the season they perceive as the most dangerous.

Category	Conditions	Public employees [%]	Private employees [%]
Occupation	Yarder operator	19.1	4.2
	Choker setter	4.4	4.2
	Feller	1.5	29.2
	Skidder operator	11.8	12.4
	Combination	63.2	50
Hazards operations	Field preparation	25	20.8
	Mounting/Dismounting	3.6	8.3
	Yarding	37.5	29.2
	Combination	28.5	16.7
	Other	5.4	25
Hazards season	Spring	1.5	0.0
	Summer	4.4	12.5
	Fall	5.9	0.0
	Winter	88.2	87.5

Another important factor, affecting the occurrence of occupational accidents, is the duration of the shift. Our results show that 44% of the PU employees and 42% PR employees worked more than five hours per day, 56% of the PU employees and 50% of the PR employees stated they worked more than eight hours per day. In case of the PR employees, 8% stated that they worked more than 12 per day. The χ^2 test did not show a statistically significant relationship between V_{2PU} and Y_{PU}, or V_{2PR} and Y_{PR} (χ^2_{PU} – 0.45; df – 1; 0.51 > 0.05; χ^2_{PR} – 1.29; df – 2; 0.52 > 0.05). We can therefore state that there is no significant relationship between the length of the shift and the occurrence of an occupational accident.

From the view of the physical demands of working with a cable yarder, 90% of the PU employees and 75% of the PR employees identified the work as physically very demanding. About 10% of PU and 21% of PR employees identified the work as moderately physically demanding, and 4% of the PR employees identified the work as physically non-demanding.

The experience of the employees who suffered an occupational accident, is shown in Fig. 1.

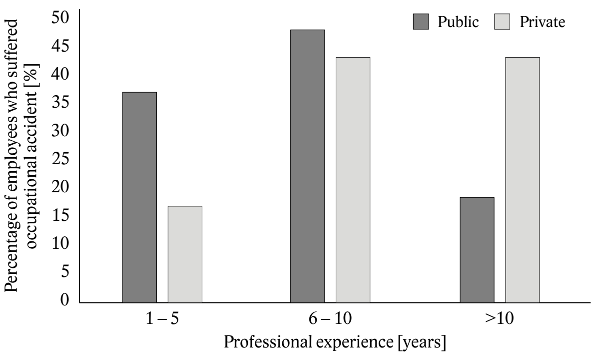

Fig. 1. Relative distribution of the public and private employees who suffered an occupational accident during the last ten years, based on practical experience.

The graph shows that there were some differences between the PU and PR employees regarding the practical experience of workers who suffered occupational accidents. Within the PU employee group, the most accidents occurred to employees with 6 – 10 years experience (46%). As for the PR employees, 42% of accidents occurred to both the class with 6 – 10 years experience and the class with more than 10 years experience (84% on total). The age structure of the employees who stated they suffered an occupational accidents is shown in Fig. 2.

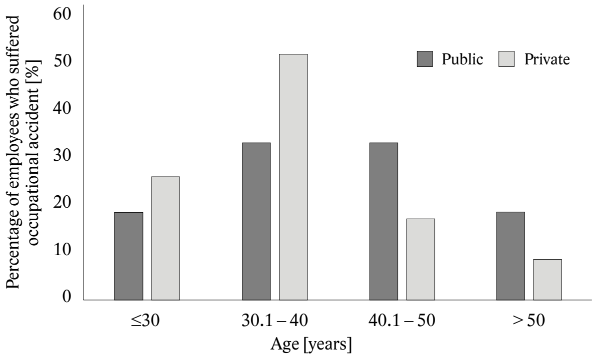

Fig. 2. The age structure of the public and private employees who sufferd an occupational accident in the last ten years.

It shows that for the PU employees, the most accidents happened to employees aged 30.1 – 40 and 40.1 – 50 years (32% each). In case of the PR employees, the most accidents (50%) occurred to employees aged between 30.1 to 40 years.

Suffcient, and appropriate communication within the team decreases the risk of an occupational accident occurring. From Table 3, we can see that the largest share of employees from both groups stated that the communication within the team was good (57% PU and 38% PR employees).

In case of the PU employees, another 25% stated the communication within the team was very good, and another 18% stated it was good with occasional conflicts. Private sector employees saw the state of communication within the team differently – 29% of the PR employees stated that the communication was good with occasional conflicts, 21% stated it was very good, and 13% stated that communication within the team was bad. We statistical analyzed communication within the team and occupational accidents. We tested the relationship between V_{3PU} and Y_{PU}, or V_{3PR} and Y_{PR} through the χ^2 test. In both the PU and the PR employee groups, the relationship did not prove to be statistically signiffcant (χ^2_{PU} – 0.45; df – 1; p – 0.50 > 0.05; χ^2_{PR} – 1.08; df – 2; p – 0.58 > 0.05).

The tendency of the employees towards risky behaviour can be seen in Table 3. In both the PU and PR employee group, the largest share stated they risk only when forced to by the circumstances (50% PU and 54% PR employees). The second most frequent answer was "I risk all the time" (27% PU and 33% PR employees). This fact might be the explanation of some occupational accidents in cable yarding. Only 24% of the PU employees and 13% of the PR employees stated that they do not risk at all during their work.

Using PPE is very important to ensure safe work. More than 94% of the PU employees stated they use prescribed PPE, and about 6% stated, they only use them when necessary. A similar structure was found within the PR employee group. Seventy-eight percent of employees stated that they use the prescribed PPE, and 22% stated they use them only when necessary. We statisticaly tested using of prescribed PPE and number of occupational accidents. To assess the relationship between the V_{4PU} and Y_{PU}, or V_{4PR} and Y_{PR}, we used a χ^2 test. We found no statistically significant relationship between the variables (χ^2_{PU} – 1.39; df – 2;p – 0,50 > 0.05; χ^2_{PR} – 3.31; df – 3; p – 0.35 > 0.05).

Almost every second PU employee (41%) suffered an occupational accident in the last ten years. Similar outcome was found in case of the PR employees, 50% suffered an occupational accidents (Table 4).

The most frequently injured bodypart were lower extremities (50%), upper extremities (27%), head and neck (10%), and spine (10%). The least injured bodypart was torso (3%). Private sector employees reported similar results: 36% were injuries of the lower extremities, 27% were injuries of both upper extremities, and head and neck each. The remaining 9% were injuries of the spine. These injuries are characteristic for working with a cable yarder (Table 4).

Table 5 shows the distribution of occupational accidents according to the operations during which they occurred. The answers of the PU employees show that 57% of accidents occured during felling and delimbing, and 27% occurred during yarding. Operations such as bucking, maintenance, or mounting and dismounting the yarder constituted about 17% of all occupational accidents. Similar structure was found for the PR employees, where 46% of all occupational accidents occurred during felling and delimbing, 36% during yarding, and 18% during bucking, maintenance, or mounting and dismounting the yarder. However, the employees considered yarding to be the most dangerous operation (38% PU and 29% PR employees). Yarding was followed by a groupt that considered multiple operations to be similarly dangerous (29% PU and 17% PR employees).

One quarter of the PU employees, and 21% of the PR employees thought that preparation of the forest stand for yarding was the most dangerous (Table 2). In case of the PR employees, 25% stated that "other" operations were the most dangerous. Regarding the season of yarding, both the PU and the PR employees thought winter was

Table 3. Relative distribution of the workers, who perticipated in the survey, based on their attitude towards risky behaviour, and the perceived quality of communication within the squads.

Category	Status	Public employees [%]	Private employees [%]
Communication within the group	Very good	25	20.8
	Good	57.4	37.5
	Occasional arguments	17.6	29.2
	Bad	0.0	12.5
Risky behaviour	I risk when I am forced to	50	54.2
	I risk all time at work	26.5	33.3
	I do not risk at work	23.5	12.5

Table 4. Number of accidents in the last ten years and the bodyparts the workers injured when the occupational accidents occured.

Category	Status	Public employees [%]	Private employees [%]
Accidents in the last ten years	Yes	41.2	50.0
	No	58.8	50.0
Bodypart injured	Upper extremity	26.7	27.3
	Lower extremity	50.0	36.3
	Head and neck	10.0	27.3
	Spine	10.0	9.1
	Torso	3.3	0.0

Table 5. Relative distribution of the operations during which the occupational accidents occured, the perceived significance of a particular factor of the work environment on the total risk from the work environment.

Category	Status	Public employees [%]	Private employees [%]
Share of particular operation	Felling/Delimbing	56.6	45.5
	Yarding	26.7	36.3
	Bucking	3.3	0.0
	Mounting/Dismounting	6.7	9.1
	Maintenance	6.7	9.1
Factors of the work environment	High and low temperatures	11.8	12.5
	Terrain	44.1	45.9
	Physical exertion	2.9	8.3
	Moving stems	5.9	8.3
	Combination	35.3	25.0

the most dangerous (Table 2). The reason for increased danger of working in winter was the instability of the terrain due to snow, ice, etc. Public sector employees considered fall, summer, and spring (in order). Private sector employees considered only summer to be dangerous besides winter, due to high temperatures.

The most dangerous factor of the work environment was, according to almost half (44%) of the PU employees, the terrain (Table 5), followed by a combination of multiple factors (35% of the PU employees), and microclimatic conditions at the work-place (12% of the PU employees). Employees from the private sector stated, similarly as the PU employees, that the terrain is the most dangerous factor of the work environment (46%), 25% considered a combination of multiple factors as the most dangerous, and 13% stated that microclimatic conditions were the most dangerous. We used a regression and correlation analysis to study the relationship between V_{5PU}, V_{6PU}, V_{7PU}, and Y_{PU}, or V_{5PR}, V_{6PR}, V_{7PR}, and Y_{PR}. Both analysises were inconclusive, no statistically significant relationship was found (R_{PU} – 0.22; p – 0.38; R_{PR} – 0.35; p – 0.49).

4. Discussion

Synwoldt & Gellerstedt (2003) state that the health of workers is at risk and the probability of an occupational accident increases when workload is high in the long term. Gallis (2006) during his study of forestry workers in Greece found that the mean age is about 45 ± 14 years and the mean workshift duration is nine ± two hours, and the workweek lasted six ±one day per week. Lilley et al. (2002) state that workers in forest harvesting work more than nine hours per day on average. These results correspond with our results, the majority of participants stated they work longer than the standard eight hour shift. Gandaseca & Yoshimura (2001) state that 73% of the workers in forest harvesting in Turkey does not wear the prescribed PPE, and the remaining 27% uses protective gloves, boots, glasses, and hearing protectors. On the other hand, Enez et al. (2014) found in his study that 54% of workers in forest harvesting in Turkey uses gloves, 9% uses boots, and 2% uses helmet. To compare, the participants in our study stated they use all prescribed PPE.

Tsioras et al. (2014) states that in Austria 19% of the total amount of occupational accidents occurr during timber extraction from the forest stand to the roadside on average. In timber yarding, 15% of all occupational accidents occurr during yarding itself. Compared to other countries, this share is low, e.g. in Slovinia, Enez et al. (2014) state that 24% of occupational accidents occurr during yarding, in New Zealand it is 22% (Gaskin & Parker 1993), in Sweden it is 20% (Engsås 1995). Most of the injuries that the employees suffered were located on the extremities in our case, though in case of the PR employees, head and neck was a frequent injury location. Our results correspond with what other authors found: Tsioras et al. (2011) – 64% of injuries were located on the extremities, Potočnik et al. (2009) – 66% of injuries were located on the extremities and (KWF 2011) in Germany – 64% of injuries were located on the extremities . In China, Wang et al. (2003) state that the share of injuries located on extremities was 51%, and in Louisiana, Lefort et al. (2003) state a similar 50% share of injuries located on extremities. Enez et al. (20014) in their study state that the most injured bodyparts during forest harvesting were feet and toes (41%), spine (30%), legs (20%), torso (14%), and hands and fingers (11%). Acar & Sentürk (1999) state that the most injured bodyparts were feet and arms (17%) and head and neck (9%).

When considering the operations during which the occupational accident occurred, more than half of the PU employees stated that they were injured during felling and delimbing, followed by yarding, maintenance and repairs of the yarder, and mounting and dismounting the yarder. The answers of the PR employees had similar distribution. During an objective analysis of occupational accidents, Tsioras et al. (2011) state that occupational accidents occurr mainly during yarding (43%), and mounting and dismounting the yarder (33%), followed by repairs and maintenance of the yarder. Tsioras et al. (2011) also state that broken supports, oscilating cables, anchoring trees, falling objects, and tree stems cause more than two thirds of all occupational accidents. Machine failures are a frequent source of occupational accidents in forest harvesting, as well as not using safe practices during work (Bentley et al. 2005).

Assessing the seasonal effects on the occurrence of occupational accidents showed that the most employees consider winter the most dangerous season. However, when compared to objective data by Tsioras et al. (2011) on seasonal occurrence of occupational accidents, we see that the most occupational accidents occurr in October, followed by March, June, and November.

Enez et al. (2014) states that 39% of the workers described terrain at the time when the occupational accident happened as steep, out of which 82% stated that the soil surface was moist and slippery. This corresponds to our results, as both PU and PR employees stated they consider terrain to be the dominant factor of the work environment.

5. Conclusion

High rate of occupational accidents during forest harvesting is well known. From the results we reached it can be seen that worker consider cable yarding to be physically demanding occupation with high risk of an occupational accident occurring. In this study, 41% of the PU employees and 50% of the PR employees stated that they suffered an occupational accident during the last ten years. This result is not surprising, considering the workers work in unstable climatic conditions, on unstable terrain, and the work environment presents other hazards, such as the loads, sharp tools and equipment, etc. For this reason, it is vital to ensure the workers are well informed about the individual factors of the work environment, and the potential hazards they present during work, and the proper working procedures in cable yarding. Only by ensuring that the workers know what is the toll for using improper (dangerous) tools or working techniques and enforcing the workers to adhere to safety protocols we can limit the number of occupational accidents in cable yarding, or forest harvesting as a whole.

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