Severity Analysis of Accidents in Forest Operations

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Abstract – Nacrtak

This paper deals with the severity of accidents in forest operations in Slovenian state forests in the period 1990–2005. A total of 846 accidents were analyzed. Most accidents happened in felling (68% and 20 lost days), and somewhat less during skidding (24% and 19 lost days). Most injuries were caused by direct contact of the tree parts (60% and 20 lost days) with stones, rocks and surface (24% and 21 days lost days). Power saw only caused 6% of injuries (17 lost days). Contusion was the most frequent type of injury in accidents due to stroke (56%), open sore (19%) and sprain with muscle strain (11%). Severity of injuries of extremities (20.5 lost days) seems to be different from face injuries (11.6 lost days). It can be concluded that the results are useful for implementation in everyday forest operations based on safety and accident prevention.

Key words: forest operations, accident, severity, injury

1. Introduction – *Uvod*

Forestry continues to be one of the most hazardous industrial sectors in most countries. Around the world, there are often discouraging trends of increasing accident rates and a high incidence of occupational diseases and early retirement among forestry workers. However, clear evidence shows that good safety and health performance in forestry is feasible (ILO 1998).

The employer is responsible for ensuring that any method chosen to control risk is working (Code of Practice 2002). Monitoring and review is a very important aspect of OHS (Occupational Health and Safety) management and should be included in regular performance reporting to management. In this way, OHS risk management is an ongoing process. In addition, to make sure that a workplace stays safe and keeps abreast of change, an employer must redo the risk assessment and review any control measures whenever:

⇒ There is evidence that the risk assessment is no longer applicable;

⇒ An injury or illness occurs because of a hazard that the risk assessment addressed, or failed to address;

⇒ A change is planned to the place of work, work practices, or work procedures that the risk assessment addressed.

Three steps should be performed: identification, assessment and elimination or control for every health and safety issue that requires attention. For forest harvesting operations, this method provides a systematic way of working out effective action to control risks.

According to recommendations (ILO 1996), occupational accidents, diseases and dangerous occurrences should be reported and analyzed accordingly at 3 levels: national level, level of enterprise and level of self-employed person. Also, minimum required information is defined for each level an accident/disease.

Forestry work managers should comply with the requirements of the key tasks (Management of Health and Safety at Work 1999):

⇒ Use the information from the landowner to prepare an outline risk assessment for on-site work and for timber extraction;

⇒ Select competent contractors who have made adequate health and safety provisions;

⇒ Specify health and safety measures for on-site contractors and others who may be affected by the work activity;

⇒ Liaise with the landowner;

⇒ Monitor on–site health and safety.

There are many factors that influence severity of accidents in mining, which is a physically intensive industry just like forestry; for example injured body parts, injured person's age, cause of accident, source of accident, injured person's activity, work duration prior to accident and workplace (Hull et al. 1996). Severity of accidents has a direct influence on employer's costs, due to worker's input loss and due to interruption of working process (Klen 1988). Application of safety equipment, such as safety trousers, decreases the number of accidents with chain saw (Sullman et al. 1999), but on the other hand it increases the number of injuries of other unprotected body parts. By using personal safety equipment, the comprehension of danger alters, and this can lead to increased risk-taking and consequently higher work tempo (Salminen et al. 1999, Klen 1997). Frequency and severity of accidents are also decreased by payment method. Thus, safety increased because of transition from piece rate to time based wages (Sundström and Frisk 1984). Mechanization of cutting and skidding has influenced the decrease of accident frequency, redistribution of accidents according to the injured body parts, and type of injuries, caused the occurrence of new risks (RSI), and changed the place of accident occurrence from productive working hours to the unproductive ones, i.e. maintenance of means of work (Axellson 1998, Väyrynen 1982, Salaminen et al. 1999, Laflamme and Cloutier 1998, Lefort 2003). The proposed measures for improvement of work safety are: additional education, lower work intensity and tempo, and shorter working hours (Nieuwenhuis and Lyons 2002).

Taking into account the above facts and experiences and available reports on accidents in Slovenian state forests, we decided to conduct the present study in order to point out the most crucial factors of severity of accidents in forest operations.

2. Research objectives – *Ciljevi istraživanja*

The study is limited to the assessment of activity when the accident happened, source and consequence of accidents related to severity of accidents. Therefore two general objectives were set:

⇒ To assess the influence of work activity, source of accident, type of injury and injured body part on severity of accidents;

⇒ To assess what combination of work activity, source and type of injury (injured part of body) contribute the most to lost days due to accidents as a whole.

Results of the set objectives bring practical meaning to work organization in forestry, mostly in modeling working technique, time schedule preparation, and right choice and development of forest worker personal safety equipment.

3. Working method and material *Metode rada i korišteni materijal*

The study is based on information of forest workers accidents, which are collected on an annual basis by the Department of Forestry and Renewable Forest Resources (University of Ljubljana, Biotechnical Faculty) in close cooperation with forest enterprises-concessionaires in Slovenian state forests. Each accident in forest operations is recorded using special questionnaires related to information on age and qualification of the person involved in the accident, time and location, activities, working phase, form and distribution of injuries, severity of accident, source and cause, and specific environmental data. The recorded accident is not limited by severity, meaning that the amount of lost days might also be 0. On the other hand, accidents with absence from work over the fiscal year result in lost days in the next year. Questionnaires are completed by professionals responsible for safety at work, specially trained for health and safety at work in forestry, but not necessarily foresters by education.

In the period discussed in this paper, the main harvesting technology was motor–manual work with chain saw in bucking conifers to length, whereas deciduous tree bucking was made according to quality. Apart from tree felling, trimming and bucking, some operations were also made in accordance with forest regulations so as to provide forest protection (piling of branches) and maintenance of roads and watercourses (removing of cutting remains). Skidding was mostly done by tractors (adjusted farm tractors and skidders), and tower yarders or manually at short distances. All forest workers had standard protection equipment (helmet with ear and eye protection, cut-proof trousers, shoes and gloves).

Analysis was made of accidents that occurred in the stand, skidding trail, forest road and auxiliary yard during the cutting, skidding and tending of juvenile stand. The analyzed accidents occurred to 13 concessionaires on a total area of 303,778 ha (data from 2005) of forest and 736,000 m^3 of annual cut, i.e. 84% of all wood (estimate for 1999–2003 period) that was part of concession works. Therefore, we managed to collect detailed information of 846 accidents (Table 1), where accidents severity (measured in lost

Table 1 Characteristics of accident severity distribution
Tablica 1. *Obilježja raspodjele težine nesreća*

Measure *Mjerna veličina*	Unit *Mjerna jedinica*	All accidents *Sve nesreće*	95 % of all accidents* 95 % svih nesreća*
Number of accidents - *Broj nesreća*		846	804
Mean - *Aritmetička sredina*	Lost days/accident - *Izgubljeni dani/nesreća*	29.27	19.10
Max. - *Najveće opažanje*	Lost days/accident - *Izgubljeni dani/nesreća*	722	111
Min. - *Najmanje opažanje*	Lost days/accident - *Izgubljeni dani/nesreća*	0	0
Median - *Medijana*	Lost days - *Izgubljeni dani*	14.00	14.00
Mode - *Mod*	Lost days - *Izgubljeni dani*	8	8
Sum - *Zbroj*	Lost days - *Izgubljeni dani*	24,762	15,375
1.Quartil - *Prvi kvartil*	Lost days - *Izgubljeni dani*	8.00	8.00
2.Quartil - *Drugi kvartil*	Lost days - *Izgubljeni dani*	14.00	14.00
3.Quartil - *Treći kvartil*	Lost days - *Izgubljeni dani*	27.00	23.00

* without 5 % of accidents with highest severity - *bez 5 % najtežih nesreća*

days/accident) showed typical J distribution and adequate distribution of mode, median and mean. The overall sum of lost days was 24,726. By additionally excluding 5% of accidents (n=42) with the highest severity (average severity of 223.5 of lost days/accident), the overall sum was reduced to 9,387 days. The purpose of excluding the most severe accidents was to estimate the variability of the calculated values of accident severity.

Referring to the study objectives, 4 factors were introduced that were supposedly related to accident severity: work activity, source of injury, type of injury and injured body part. Work activities were divided into 3 categories: tending (ground preparation and area clearance for forestation, nursing of young trees and grounds), cutting and skidding (manually, with tractors and tower yarders). Sources of injury (defined as objects that caused injury by direct contact) are hand tools (wire rope, chain, cutting wedge, axe), manual machines (power saw), mobile working machinery (tracked tractor, skidder, tower yarder, adjusted agricultural tractor), tree parts (trunk, branch, stump), insects and surface. Types of injuries were categorized into 6 categories: open sores (cuts, laceration, abrasion), contusions and suffusions, sprains (sprains, dislocations, muscle ruptures), fractures, insect bites, and eye injury/loss. Injured body parts were categorized according to adapted Injury Severity Score-ISS (Linn 1995) into 5 groups: head and neck, face, chest and back, stomach and hip, and limbs. Due to many recorded values of accidents with numerous injuries and injured body parts, only those assessed as the most severe were included into the study.

Apart from descriptive methods, Welch test for comparison of means was also applied as well as Tamhane test T2 for post hoc analysis, regression for curve estimation and binary multiple logistic regression for estimating factors within the complex influence on accident severity.

4. Results – *Rezultati*

Overall analysis of accidents (n=846) shows (Fig. 1) that accidents with the lowest severity are »missed« in theoretical J distribution; mostly accidents with up to 2 lost days/accident. According to theoretical J distribution (Figure 1) 734 accidents should be in this class, which means that 642 accidents are »missed«. The estimate of supposedly »missed« accident was achieved by applying the data on number of accidents in classes with accident severity from 5 to 100 days and class average means, to which the inversion function was adapted (frequency = 1887.7686/class average means –21.5954, R^2 = 0.97, p>0.000). According to the estimate, it is highly probable that the actual number of accidents is between 92 and 734 days for the class up to 5 lost days. The number of accidents with accident severity above 100 days equals 47, but the number contributes with considerable 40% to the total number of lost days. Accidents with such high severity score might distort the actual severity by particular factors so all further analyses are represented for all accidents, as well as for 95% of accidents – without accidents with severity higher than 111 lost days.

Within the discussed working phases, most accidents happened in cutting (68%), somewhat less during skidding (24%) and the least in tending operations (8%). Severity of accidents within working phases was significantly different when taking into account all accidents (Welch, p<0.000) or 95% of

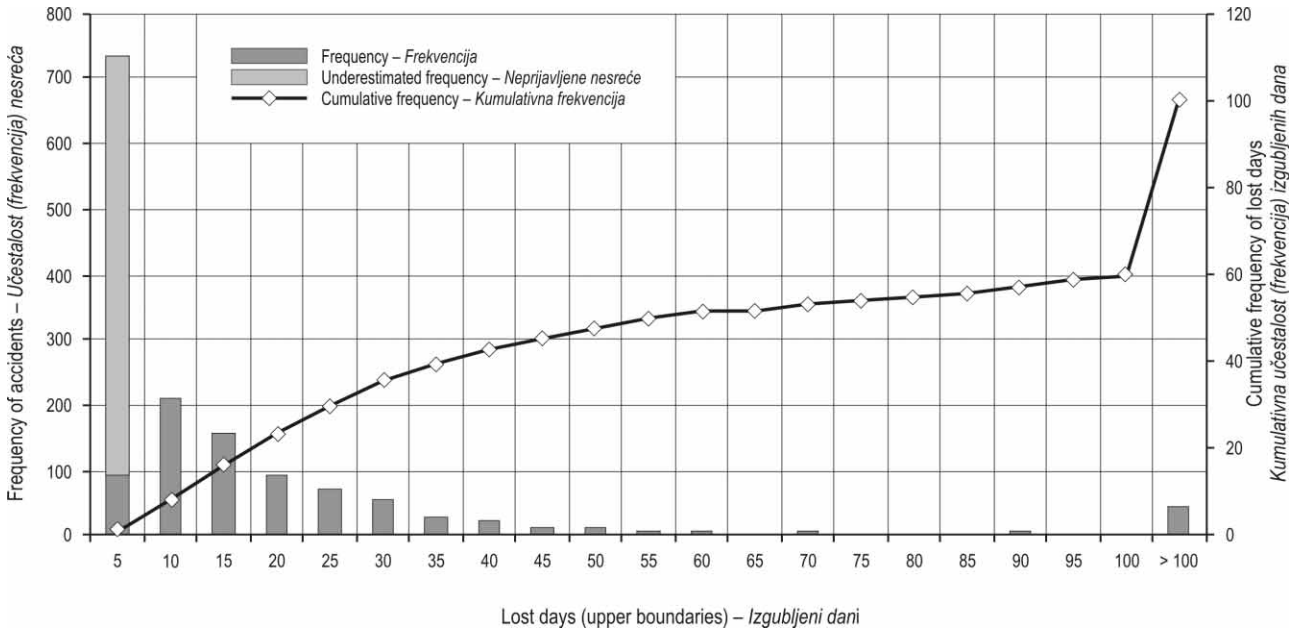

Fig. 1 Frequency and cumulative frequency distribution of accident by severity

Slika 1. *Raspodjela frekvencije i kumulativna frekvencija nesreća prema njihovoj težini*

them (Welch, $p_{95\%}$=0.002). In both cases accident severity was significantly different only between cutting and tending operations (Tamhane's T2, p=0.000; $p_{95\%}$=0.002), and skidding and tending operations (Tamhane's T2, p=0.001; p95%=0.024). Difference in accident severity within working phases between all accidents and 95% accidents shows (Fig. 2) that the most serious accidents mostly happened in cutting (Δ=10.1 lost days/accident) and skidding (Δ=13.5 lost days/ accident).

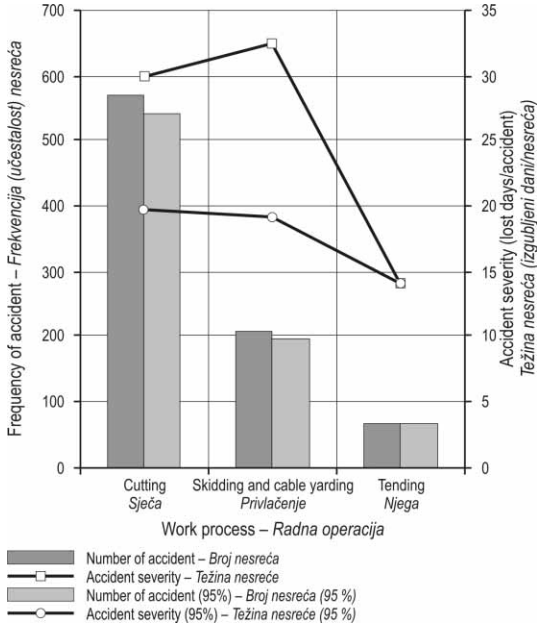

Fig. 2 Number and severity of accidents by forest operations

Slika 2. *Broj i težina nesreća prema šumskim operacijama*

When studying sources of injuries, 20 accidents with the unknown source were eliminated from the analyses. The range of the studied accidents was therefore decreased to 826 and 785 accidents, respectively, without taking account of the most severe accidents. Most accidents occurred by direct contact of the tree parts (60%) with stones, rocks and surface (24%). Contrary to common expectation, chain saw only caused 6% of injuries (Fig. 3).

Severity of accidents within a source of injury is statistically significant for both ranges of accidents (Welch, p<0,000, $p_{95\%}$<0,000). Despite the highest severity by contact with working machines, this source is not different from other sources (the only exception are injuries caused by insects in the case of 95% of accidents (Table 2). When comparing all accidents and 95% accidents, it can be concluded that accident severity due to tree parts (33.3 and 19.8 lost days/accident); stones, rocks and surface (26.7 and 21.0 lost days/accident) are significantly higher than the accident severity due to hand tools (13.6 and 11.4 lost days/accident) or insects (5 lost days/accident). With the total accident range, both sources with the highest accident severity are also higher than the chain saw accidents (15.3 lost days/accident), whereas within 95% of all accidents the injuries caused by insects are lower than all compared sources. Very sever accidents mostly occur in acci-

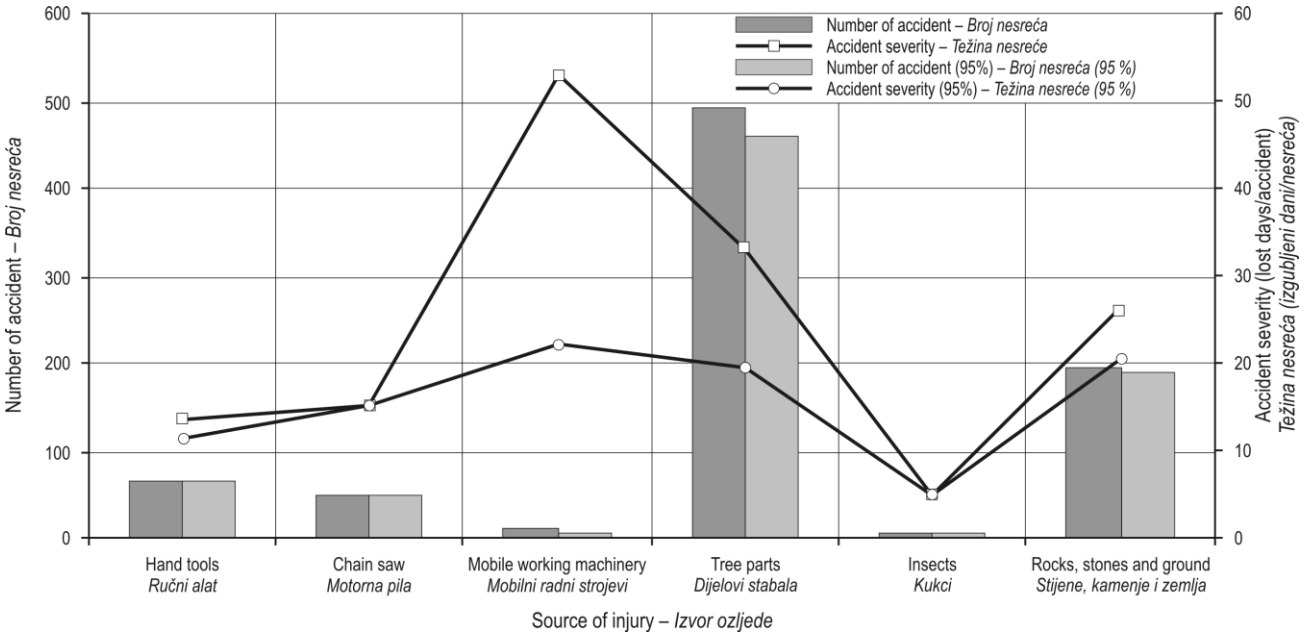

Fig. 3 Frequency and severity of accidents by sources of injuries

Slika 3. *Učestalost i težina nesreća prema izvoru ozljeđivanja*

dents with mobile working machinery, tree parts, and stones, rocks and surface.

Out of 846 accidents, this type of injury analysis considers only 819 accidents and 777 in the case of 95% of accidents without the most sever accidents, respectively. From all eliminated accidents, 26 were listed under the category Other, whereas 1 accident lacked the information on the type of injury. Contusion was the most frequent type of injury (Fig. 4) in accidents due to hit (56%), open sore (19%), and

Table 2 Significant differences ($p<0.05$) between sources of injuries (Tamhane's t2 post hoc test)

Tablica 2. *Statistički značajne razlike ($p<0,05$) između različitih izvora ozljeđivanja (Tamhanesov t2 post hoc test)*

	Hand tools *Ručni alat*	Chain saw *Motorna pila*	Mobile working machinery *Mobilni radni strojevi*	Tree parts *Dijelovi stabala*	Insects *Kukci*	Rocks, stones and ground *Stijene, kamenje i zemlja*
Hand tools *Ručni alat*						
Chain saw *Motorna pila*						
Mobile working machinery *Mobilni radni strojevi*						
Tree parts *Dijelovi stabala*						
Insects *Kukci*						
Rocks, stones and ground *Stijene, kamenje i zemlja*						

All accidents – *Ukupno nesreća*
95% of accidents – *95 % nesreća*
All and 95% accidents – *Ukupno i 95 % nesreća*

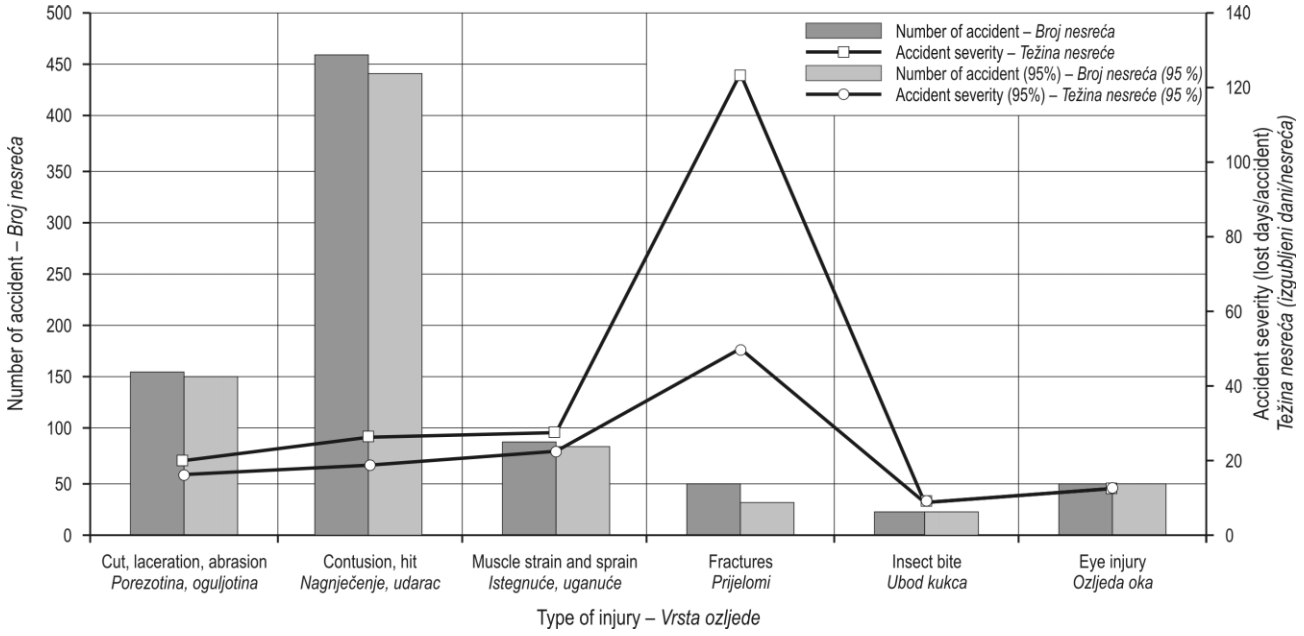

Fig. 4 Frequency and severity of accidents by type of injuries

Slika 4. *Učestalost i težina nesreće prema vrsti ozljede*

sprain with muscle strain (11%), where all differences were significant (Welch, $p<0.000$, $p_{95\%}<0.000$). In both cases severity was higher (except with eye injuries) in case of fractures (123.9 and 50.3 lost days/accident) and lower in case of insect bites (9.0 lost days/accident) comparing to all other injuries (Table 3). Rare and very sever accidents occur mostly due to bone fractures and contusions due to hit.

Out of all accidents, 13 accidents were eliminated from the analysis of injured body parts due to listing of body part injury under the category Other and 5 accidents due to missing data on the injured

Table 3 Significant differences ($p<0.05$) between type of injuries (tamhane's t2 post hoc test)

Tablica 3. *Statistički značajne razlike ($p<0,05$) između različitih vrsta ozljeda (Tamhanesov t2 post hoc test)*

	Cut, laceration, abrasion *Porezotina, oguljotina*	Contusion, hit *Nagnječenje, udarac*	Muscule, strain and sprain *Istegnuće, uganuće*	Fracture *Prijelomi*	Insects bite *Ubodi kukaca*	Eye injury *Povreda oka*
Cut, laceration, abrasion *Porezotina, oguljotina*						
Contusion, hit *Nagnječenje, udarac*						
Muscule, strain and sprain *Istegnuće, uganuće*						
Fracture *Prijelomi*						
Insects bite *Ubodi kukaca*						
Eye injury *Povreda oka*						

All accidents – *Ukupno nesreća*
95% of accidents – *95 % nesreća*
All and 95% accidents – *Ukupno i 95 % nesreća*

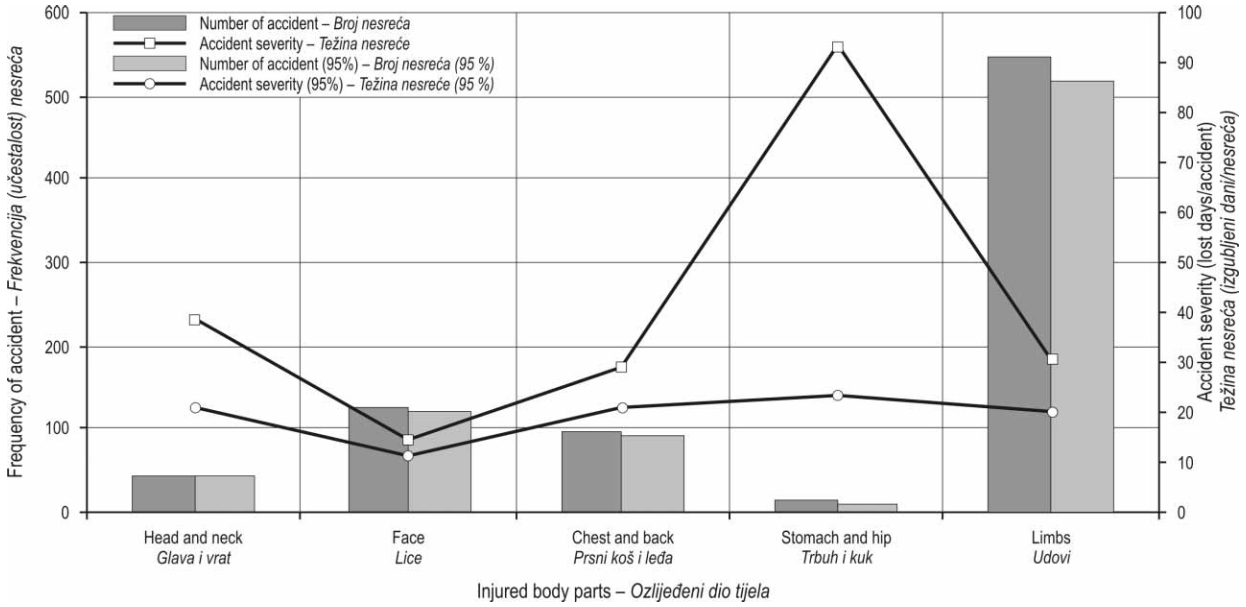

Fig. 5 Frequency and severity of accidents by injured body part

Slika 5. *Učestalost i težina nesreće prema ozlijeđenom dijelu tijela*

body part. Thus, the analysis of injured body parts includes 828 (95%, 786) accidents. 66% of accidents caused injuries of extremities, i.e. arms and legs (Fig. 5). Differences among injured body part are different in both extents of accidents (Welch, $p<0.000$, $p_{95\%}<0.000$). Severity of injuries of extremities (30.7 and 20.5 lost days/accident) is significantly higher than face injuries (14.2 and 11.6 lost days/accident). Regarding the data without the most severe accidents, injuries of thorax and back (20.7 lost days/accident) were significantly higher than those of face injuries (Tamhane's T2, $p_{95\%}=0.001$). The most severe accidents mostly prevailed in injuries of extremities, although their biggest influence is also noted in stomach and hip injuries.

The above analyses show that all studied factors affect the severity of accidents (Welch test, $p<0.05$), and that this influence is statistically significant only

Table 4 Impact factors on accidents severity by use of all accidents and binary logistics regression

Tablica 4. *Utjecajni čimbenici na težinu ozljede pri analizi svih nesreća binarnom logističkom regresijom*

Factors/category *Čimbenik/kategorija*	B *Procijenjeni parametar*	S.E. *Standardna pogreška*	Wald *Statistika*	df *Stupnjevi slobode*	Sig. *p*	Exp(B) *Exp(B)*
Injured body part - *Ozlijeđeni dio tijela*			37,919	4	0,000	
Head and neck - *Glava i vrat*	1.525	0.390	15.307	1	0.000	4.594
Chest and back - *Prsni koš i leđa*	1.219	0.310	15.475	1	0.000	3.384
Stomach and hip - *Trbuh i kuk*	2.285	0.633	13.020	1	0.000	9.822
Limbs - *Udovi*	1.425	0.245	33.758	1	0.000	4.156
Source of injury - *Uzrok nesreća*			19.681	5	0.001	
Chain saw - *Motorna pila*	0.848	0.406	4.361	1	0.037	2.335
Mobile working machinery - *Mobilni radni strojevi*	2.457	0.833	8.704	1	0.003	11.674
Tree parts - *Dijelovi stabala*	1.161	0.304	14.636	1	0.000	3.194
Insects - *Kukci*	-20.113	15987.291	0.000	1	0.999	0.000
Rocks stones and ground *Stijene, kamenje i zemlja*	1.239	0.323	14.695	1	0.000	3.451
Constant - *Konstanta*	-2.367	0.366	41.881	1	0.000	0.094

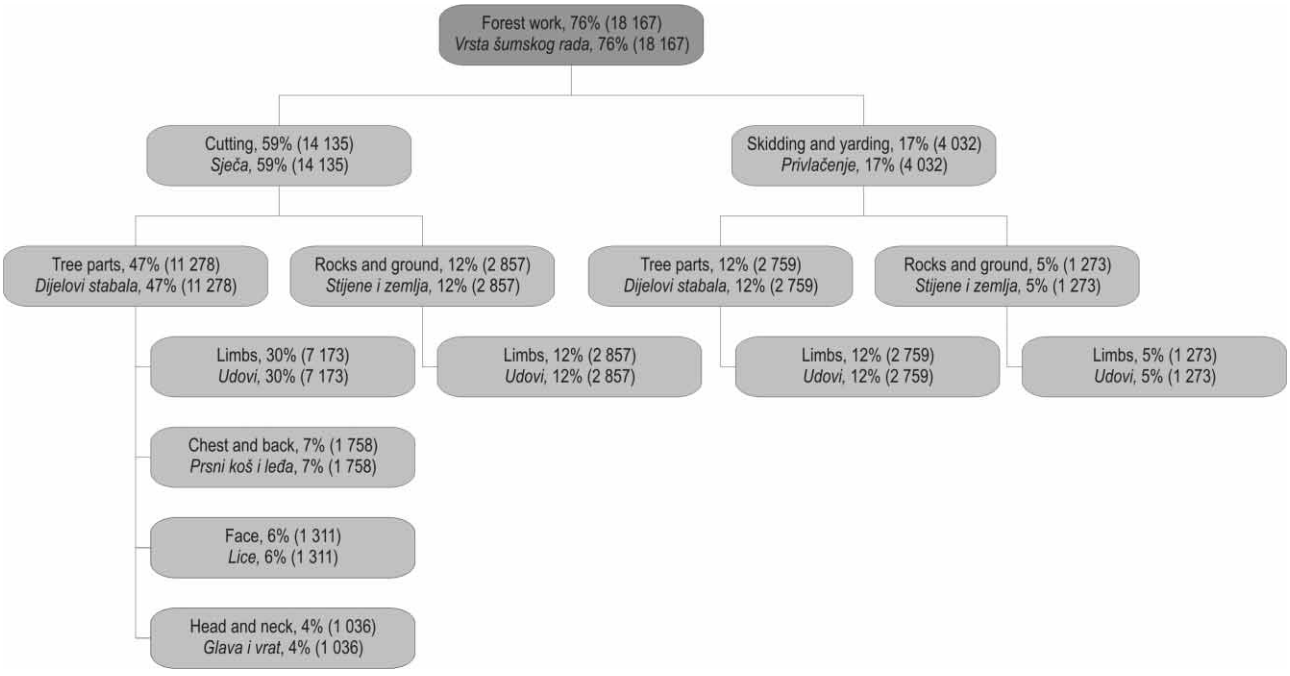

Fig. 6 Prevalent combination of injuries by injured body parts, source of injury and work activities

Slika 6. *Prevladavajuće kombinacije ozljeda prema ozlijeđenomu dijelu tijela, izvoru ozljeda i radnoj aktivnosti*

for some categories of specific factor (Tamhane's T2 test, $p<0.05$). The binary logistic regression was used for estimating simultaneous influence of factors on accident severity. We established that in the total accident range two factors significantly affected the accident severity, accident source and injured body part (Table 4). A more detailed analysis of accidents showed that the likelihood for accidents with severity higher than 14 days in chain saw accidents is 2.3 time higher, in mobile working machinery 11.7 time higher, in tree parts accidents 3.2 time higher, and in accidents caused by rocks, stone and ground 3.5 time higher than in accidents caused by hand tools. At the same time, the likelihood of head and neck injuries is

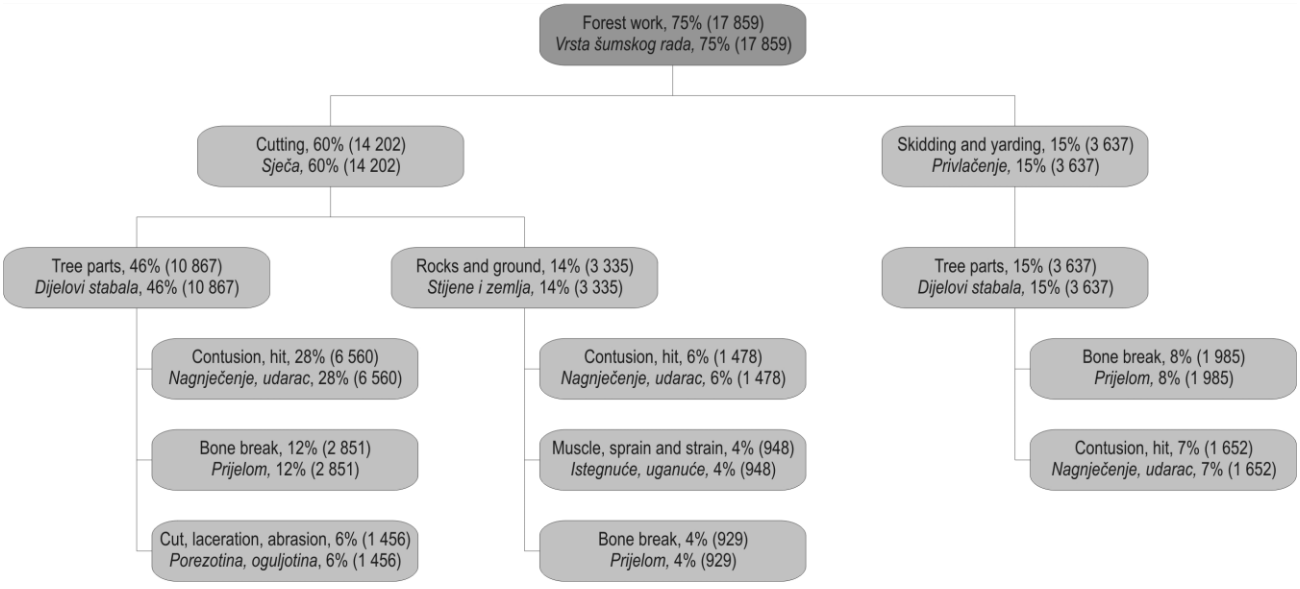

Fig. 7 Prevalent combination of injuries by sort and source of injury and work activities

Slika 7. *Prevladavajuće kombinacije ozljeda prema vrsti i izvoru te radnoj aktivnosti*

4.5 time higher, chest and back 3.9 times higher, stomach and hip 9.8 times higher and limbs 4.2 higher than face injuries.

According to the research aims, we analyzed the combination of the studied factors that represent the highest ratio of lost days. For the purpose of transparency, the combination of 3 factors is shown in two schemes (Fig. 6, Fig. 7), but only the combination that had the highest accident severity and whose contribution to the sum is more than 75% of all lost days.

Out of 90 possible combinations (3x6x5), seven combinations between injured body parts, injury source, and working phase contribute to 76% of lost days (Fig. 6). Regardless of the working phase, cutting and skidding, the sources of accidents comprise mostly tree parts and rocks, stone and ground, but as a consequence of these accidents, mostly injuries of arms and legs. Considerable share of cutting accidents with tree parts as accident sources is also noted on other body parts, chest and back, head and neck, and face.

With regard to the combination of type and source of accident, and working phase, the combination of 8 factors contributes to 75% of all lost days (Fig. 7). Contusions and suffusions and bone fractures are a consequence of injury sources, such as tree parts and rocks, stone and ground during cutting and tree parts during skidding operations. Regarding cutting operations, a considerable part of lost days is contributed by open sores due to tree parts as accident source, and also sprains and muscle strains as a consequence of rocks, stone and ground.

5. Discussion – *Rasprava*

There are only few comparable contemporary research works with the subject similar to our research, because countries with the most developed forestry conduct cutting and skidding mainly with machinery. In countries, where these operations are still mainly performed by chain saw, the social environment is probably less favorable for such research projects. With regard to transitional position in terms of forestry and technology, such research is necessary for Slovenia and similar countries (e.g. Croatia).

Research of accidents is primarily intended for planning measures for future accident prevention on the basis of past accident analyses. The validity of these analyses and their subsequent measures is thus directly connected to quality and quantity of data used in such analyses. Quality and quantity of the recorded data depends mostly on the required data (country regulations, comparisons of companies), evaluator and injured person (Johnson, Employment Outlook 1989).

The alleged underestimation of accident number (under reporting), which is also present in the majority of other accident research works due to various reasons, is particularly evident in our research in minor accidents with the severity up to 2 days. The main reason can be ascribed to the fact that the control of selected codes on accidents could be performed through questionnaires required by the Slovenian Labour Inspectorate, which gathers information on accidents for severity of more than 2 days. Other, but not insignificant reasons regard workers, who due to economic or other interests do not report such accidents, and also companies, which apart from regularity do not see advantages (but mainly disadvantages) of such accident analyses. The data confirmed the alleged underestimation of accident number with absence from work of less than 5 days. The share of similar forestry accidents in New Zealand was 42% (Gaskin and Parker 1993), whereas in our research the share of these accidents is 10.8%. To provide the best possible records of accidents at work, it would be necessary to raise awareness of companies and put them under obligation to carry out measures for improving safety at work on the basis of all accident analyses (not only those with fatal and most severe results). Inspection services should require such analyses and should not be satisfied only with informative data on the number of accidents. Workers should be encouraged to report dangerous events to their superiors, because such information is of key importance to future accident prevention.

Accident research showed that out of all accidents, 68% accidents occurred during cutting, 24% during skidding, and 8% during tending operations, and these results are slightly different from the results obtained in Sweden (60%, 20%, 20%, Engsás 1995). The difference can certainly be ascribed to ownership differences (state vs. private), working technology, and working conditions. Severity established during cutting (29.9 lost days/accident) and skidding (32.5 lost days/accident) greatly surpasses research results in New Zealand (13.6 and 11.1 lost days/accident; Bentley et. al 2005, Bentley et al. 2002). High accident severity during cutting rises from accident due to tree parts, whereas apart from tree parts, skidding accidents mainly occur due to mobile working machinery. Confirmed differences in severity between cutting and skidding compared to tending operations are a consequence of lower severity of accidents due to tree parts, hand tools, and rocks, stone and ground.

There are relatively few chain saw accidents (6%). Moreover their share is comparable to the data (8%)

stated by Sullman et al. (1999). The share of chain saw accidents in Slovenian state forests is decreasing (Jereb 2009) similarly to the findings of other research projects (Lefort et al. 2003), but in case of Slovenia the reason does not lie in work mechanization (introduction of cut-to-length technology only since 2005), but allegedly due to constant application of safety means and education (awareness) of workers. The established accident severity in chain saw injuries (15.3 lost days/accident) is somewhat higher than that stated by Bentley et al. (2002), but it was only recorded during skidding (11.2 lost days/accident). Accident share for all means of work (15%) is comparable with shares established in other research works (Lefort et al. 2003) and 14–20% (KWF).

Despite satisfactory decreasing of share of accidents with chain saw, the share of accidents due to tree parts (60%), and due to rocks, stone and ground (24%) is increasing. Considering these accidents, the accident severity is the highest (33.3 and 26.7 lost days/accident) and also higher compared to accident severity caused by means of work, and especially higher due to insect bites. The increased share of accidents due to tree parts and rocks, stone and grounds (Jereb 2009), and high severity values of these accidents are logical, if we consider that accidents due to tree parts are especially difficult to prevent with personal safety equipment, and that the cause of such accidents can lie in improper work tempo. Arduous work contributes to poor concentration and incaution, and as such increases accident risk.

The following types of injuries prevail: contusions (56%), injuries with open sore (19%), sprains and muscle strains (11%), and fracture bones (6%). The data for German state forests (KWF) show the same values for open sores, lower for contusions (41%), and higher for sprains (22%) and bone fractures (9%). The reason for these differences could be due to greater mechanization of cutting and skidding operations in German forests. During mechanized cutting, accidents mainly happen during maintenance works, whereas with regard to the types of injury the sprains (35%) and contusions (30%) prevail (Väyrynen 1982). The share of bone fractures is also increased (Lefort et al. 2003). Accident severity by types of injuries was higher in all cases compared to the research of Gaskin and Parker (1993), but the main reason is unknown. Neither mechanization nor working conditions have such an influence on differences in the number of lost days, e.g. due to bone fracture. Accident severity is significantly higher with bone fractures (123.9 lost days/accident), and lower with infections due to insect bites (9 lost days/accident) compared to other types of accidents. Our results show that according to further mechanization of forestry, the accident frequency in Slovenia will decrease, whereas the accident severity will increase. Similar results were also established in other research works (Lefort et al. 2003).

The majority of accidents by injured body parts occurred to arms and legs (66%) and is hence the same as in other research works (64%, KWF; 51%, Wang 2003; 50%, Lefort et al. 2003). Surprisingly, there were numerous face injuries (15%), especially during tending operations (33%), half of which pertain to eye injuries. This means, that all workers should use eye protection during all tending operations. Mechanization also influences the altered share of injured body parts (Väyrynen 1982). It was established that during cut-to-length operations there were numerous back injuries (20%), whereas our research shows a significantly lower share (6%). The highest severity occurred in stomach and back injuries (93.3 lost days/accident), and in head and neck accidents (38.5 lost days/accident), which is logical, if we consider possible consequences of such accidents.

This research shows that accident severity depends on all studied factors and mainly depends on injured body part and injury source when all factors are included. Practically it means that we have to protect or prevent accidents of specific body parts, especially stomach and back injuries, by applying mobile working means regardless of the working phase, if we are to decrease accident severity. Furthermore, the safety measures for the highest decrease of accident severity need to be directed to decrease of injuries due to tree parts, the consequences of which are contusions and bone fractures mostly in extremity injuries in both working phases, and other body parts during cutting, and decrease injuries of strokes, sprains and bone fractures due to ground, stones and rock.

6. References – *Literatura*

Anonym. 1999: Management of health and safety at work. Management of Health and Safety at Work Regulations 1999: Approved Code of Practice L21 HSE Books 2000.

Anonym. 2002: Code of Practice – Safety in Forest Harvesting Operations. New South Wales Government Gazette No. 178, pp. 8952–9017.

Axelsson, S. A., 1998: The mechanization of logging operations in Sweden and its effect on occupational safety and health. Journal of Forest Engineering 9(2): 25–31.

Bentley, T. A., Parker, R. J., Ashby, L., 2005: Understanding felling safety in the New Zealand forest industry. Applied Ergonomics 36(2): 165–175.

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.

Employment Outlook 1989. Occupational Accidents in OECD Countries. Organisation for Economic Co-operation and Development, Chapter 4: 133-159 <http://www.oecd. org/dataoecd/63/54/3888265.pdf >(Accessed 24 November 2009)

Engsás, J., 1995: Accidents in the private woodlot sector. Small Scale Forestry 23(1): 15–22.

Gaskin, J. E., Parker, R. J., 1993: Accidents in forestry and logging operations in New Zealand. Unasylva, 44, 172: 19–24 <http://www.fao.org/docrep/u8520e/u8520e05.htm> (Accessed 26 November 2009)

Hull, B. P., Leigh, J., Driscoll, T. R., Mandryk, J., 1996: Factors associated with occupational injury severity in the New South Wales underground coal mining industry. Safety Science 21(3): 191–204.

ILO (1996). Recording and notification of occupational accidents and disease. An ILO code of practice Geneva, International Labour Office, 94 pp.

ILO (1998). Safety and health in forestry work: An ILO code of practice. Geneva, International Labour Office, 132 pp.

Jereb, P., 2009: Nezgode pri delu gozdarskih podjetij pred in po letu 1993 (Work accidents in Slovenian forestry companies before and after year 1993. Bsc. Thesis, University of Ljubljana – Biotechenical Faculty, Department of Forestry and Forest Resources, 79 pp.

Wang, J., Bell, J. L., Grushecky, S. T., 2003: Logging injuries for a 10-year period in Jilin Province of the People's Republic of China. Journal of Safety Research 34(3): 273–279.

Johnson, C. W., 2003: Failure in Safety–Critical Systems: A Handbook of Accident and Incident Reporting. University of Glasgow Press, Glasgow, Scotland, 986 pp.

Klen, T., 1989: Factors affecting accident costs to employers, employees and public administration in forestry. Journal of Occupational Accidents 11(2): 131–147.

Klen, T., 1997: Personal protectors and working behaviour of loggers. Safety Science 25(1–3): 89–103.

KWF. Unfallstatistik für den Staatswald 1999–2007, <http://www.kwf-online.org/unfallstatistik.html>(Accessed 27 November 2009)

Laflamme, L., Cloutier, E., 1988: Mechanization and risk of occupational accidents in the logging industry. Journal of Occupational Accidents 10(3): 191–198.

Lefort, A. J. Jr., De Hoop, C. F., Pine, J. C., Marx, B. D., 2003: Characteristics of Injuries in the Logging Industry of Louisiana, USA: 1986 to 1998. Int. Journal of Forest Engineering 14(2): 75–89.

Nieuwenhuis, M., Lyons, M., 2002: Health and Safety Issues and Perceptions of Forest Harvesting Contractors in Ireland. Int. Journal of Forest Engineering 13(2): 69–76.

Salminen, S., Klen, T., Ojanen, K., 1999: Risk taking and accident frequency among Finnish forestry workers. Safety Science 33(3): 143–153.

Sullman, M. J. M., Kirk, P. M., Parker, R. J., Gaskin J. E., 1999: New Zealand Logging Industry Accident Reporting Scheme: Focus for a Human Factors Research Programme. Journal of Safety Research 30(2): 123–131.

Sundström-Frisk, C., 1984: Behavioural control through piece-rate wages. Journal of Occupational Accidents 6(1–3): 49–59.

Väyrynen, S., 1982: Occupational accidents in the maintenance of heavy forest machinery. Journal of Occupational Accidents 4(2–4): 175–175.

Sažetak

Analiza težine nesreća pri šumskim radovima

Šumarstvo je i dalje, u mnogim zemljama, jedna od najopasnijih gospodarskih grana. Stoga se nastoji smanjiti broj i težinu nesreća koje se događaju pri šumskim radovima, česte profesionalne bolesti i prijevremeno umirovljenje šumskih radnika. Pri tome je važno provođenje složenih mjera i postupaka u sigurnosti i zaštiti na radu (Occupational Health and Safety – OHS management). Praćenje i bilježenje vrlo su važne sastavnice cjelokupnoga procesa upravljanja sigurnosti i zaštite radnika u šumarstvu. Sukladno preporukama ILO-a (1996) nesreće, bolesti i opasne događaje treba evidentirati i analizirati na razini države, poduzeća i pojedinoga zaposlenika.

U rudarstvu (Hull i dr. 1996), koje je kao i šumarstvo za radnike fizički vrlo zahtjevna djelatnost, postoji mnogo čimbenika koji utječu na težinu nesreća pri radu. Neki od najvažnijih su: ozlijeđeni dio tijela, dob ozlijeđene osobe, način nastanka nesreće, izvor nesreće, tjelesna sprema radnika, trajanje rada prije same nesreće, radno mjesto. Težina nesreće ima izravan utjecaj na troškove poslodavca zbog gubitka prinosa ozlijeđenoga radnika te zbog zastoja radnoga procesa (Klen 1988). Mehaniziranje radova na sječi, izradbi i privlačenju drva utjecalo je na

smanjenje učestalosti nesreća, preraspodjelu nesreća prema ozlijeđenomu dijelu tijela i vrsti ozljede, pojavu novih opasnosti i pomicanje težišta vjerojatnosti pojavljivanja nesreća s proizvodnih na neproizvodne radne sate – održavanje i popravak sredstava za rad (Axellson 1998, Väyrynen 1982, Salaminen i dr. 1999, Laflamme i Cloutier 1998, Lefort 2003). Nieuwenhuis i Lyons (2002) preporučuju sljedeće mjere za unaprjeđivanje sigurnosti na radu: dodatno obrazovanje, manji radni intenzitet i ritam te kraći radni dan.

Uzevši u obzir sve do sada navedeno, a koristeći dostupna izvješća o nesrećama pri šumskim radovima u državnim šumama u Sloveniji, napisan je ovaj rad kojim se željelo osvijetliti najvažnije utjecajne čimbenike na težinu nesreća pri šumskim radovima. Istraživano je kako su okolnosti, izvor i posljedice same nesreće povezane s njezinom težinom. Definirana su dva temeljna cilja istraživanja:

- ⇒*pronalaženje utjecaja radnoga postupka, izvora nesreće, vrste ozljede i ozlijeđenoga dijela tijela na težinu nesreće,*
- ⇒*definiranje koja kombinacija radnoga postupka, izvora i vrste ozljede (ozlijeđenoga dijela tijela) uzrokuje najveći gubitak radnih dana zbog nesreće koja se dogodila.*

Rezultati istraživanja trebali bi pomoći pri organizaciji rada u šumarstvu (najviše pri modeliranju radnih tehnika), pripremi i planiranju posla te dobrom odabiru postojećih i daljnjem razvoju osobnih zaštitnih sredstava i opreme šumskih radnika.

Studija se temelji na postojećoj bazi podataka o nesrećama u šumarstvu koju je, na godišnjoj razini, skupio Odjel za šumarstvo i obnovljive šumske izvore Biotehničkoga fakulteta Sveučilišta u Ljubljani u suradnji sa zakupcima slovenskih državnih šuma. Svaka je nesreća pri šumskom radu evidentirana primjenom posebnoga upitnika koji je sadržavao ove informacije: dob i stručna sprema osobe uključene u nesreću, mjesto i vrijeme nesreće, vrsta posla, radna operacija, vrsta i intenzitet ozljeda, težina nesreće, izvor i uzrok nesreće te ostali specifični podaci. Sve su nesreće, bez obzira na njihovu težinu, evidentirale stručne osobe zadužene za provedbu zaštite na radu.

Tijekom istraživanja sječa i izrada obavljane su ručno–strojno uz primjenu motorne pile. Uz sječu i izradu obavljani su i ostali propisani poslovi (hrpanje grana te čišćenje prometnica i vodotoka od materijala koji je ostao nakon obavljenih navedenih radova). Pri privlačenju drva pretežno su korišteni prilagođeni poljoprivredni i zglobni traktori i stupne žičare, dok se na kraćim udaljenostima privlačilo manualno. Svi su se šumski radnici koristili propisanom zaštitnom opremom (šljem sa zaštitom očiju i ušiju, zaštitno radno odijelo, zaštitne rukavice i cipele).

Analizirane su sve nesreće koje su se dogodile u sastojini, na traktorskim putovima i vlakama, na šumskim cestama i pomoćnim stovarištima za vrijeme pridobivanja drva (sječa, izrada, privlačenje) i njege. Istraživanje je provedeno na ukupnoj površini od 303 778 ha i godišnjim etatom od 766 000 m^3. Skupljeni su podaci o 846 nesreća (tablica 1), a težina nesreća (iskazana u izgubljenim radnim danima po nesreći) pokazuje tipičnu J distribuciju i adekvatnu distribuciju moda, medijane i srednje vrijednosti. Ukupan je broj izgubljenih radnih dana za sve nesreće 24 726. Dodatnim eliminiranjem 5 % najtežih nesreća (42 nesreće) s prosječnim gubitkom od 223,5 radnih dana/nesreći ukupan je broj izgubljenih radnih dana smanjen na 9387.

Sukladno ciljevima istraživanja definirana su četiri čimbenika koja pretpostavljano imaju utjecaj na težinu nesreće: vrsta posla (radna operacija), izvor ozljede, vrsta ozljede i ozlijeđeni dio tijela. Radne operacije podijeljene su u 3 skupine: njega (priprema i čišćenje staništa za pošumljavanje, pošumljavanje i njega mladih biljaka), sječa i privlačenje (ručno, traktorom i stupnom žičarom). Izvor ozljede, definiran kao objekt koji je izazvao nesreću, može biti: ručni alat (žično uže ili uže vitla, ručna pila, klin, sjekira), ručni strojevi (motorna pila), mobilni strojevi (gusjeničar ili polugusjeničar, zglobni traktor, stupna žičara, prilagođeni poljoprivredni traktor), dijelovi stabla (deblo, grana, panj), kukci i površinski objekti. Vrste su ozljeda razdijeljene u 6 kategorija: otvorene rane (porezotina, razderotina, oguljotina), nagnječenja i udarci, istegnuća (istegnuća, uganuća, iščašenja, puknuće mišića), prijelomi, ubodi kukaca, ozljede/gubitak oka. Ozlijeđeni dio tijela može biti: vrat i glava, lice, prsni koš i leđa, trbuh i kuk, udovi.

Uz opisne metode pri statističkoj su analizi podataka korišteni Welchov test, Tamhanesov T2 post hoc test i binarna multipla logistička regresija.

Najveći se broj nesreća (slika 2) dogodio za vrijeme sječe (68 %), tijekom privlačenja zabilježeno je 24 % nesreća, dok je najmanji broj nesreća utvrđen tijekom njege (8 %). Težina je nesreća prema radnim operacijama značajno različita bez obzira radi li se o analizi svih nesreća ili analizi 95 % nesreća (izuzeto je 5 % najtežih nesreća). Raščlamba razlike u težini nesreća pri uzimanju u obzir svih ili samo 95 % nesreća, za pojedinu radnu operaciju, pokazuje da su se najteže nesreće događale pri sječi (Δ=10,1 izgubljeni dan/nesreća) i privlačenju drva (Δ=13,5 izgubljeni dan/nesreća).

Pri analizi izvora ozljede eliminirano je 20 nesreća s nepoznatim izvorom pa je ukupan broj svih nesreća bio 826, odnosno 785 nesreća bez onih najtežih 5 %. Najčešći uzrok ozljeda bili su različiti dijelovi stabla (60 %) te površinski objekti (stijene, kamenje i ostale površine) s udjelom od 24 %. Suprotno uobičajenomu očekivanju motorna je pila uzrokovala tek 6 % ozljeda (slika 3). Težina je nesreća, unutar pojedinoga izvora ozljeda, statistički značajna za obje analize, sve nesreće i 95 % nesreća (tablica 2). Usporedbom svih nesreća s 95 % nesreća možemo reći da je težina nesreća uzrokovanih različitim dijelovima stabla (33,3 i 19,8 izgubljeni dan/nesreća) i površinskim objektima (26,7 i 21,0 izgubljeni dan/nesreća) značajno viša od nesreća uzrokovanih ručnim alatima (13,6 i 11,4 izgubljeni dan/nesreća) ili kukcima (5,0 izgubljeni dan/nesreća). Unutar analize svih nesreća oba izvora ozljeda s najvećim udjelom veća su od nesreća uzrokovanih motornom pilom (15,3 izgubljeni dan/nesreća). Najteže su nesreće uzrokovane mobilnim strojevima, dijelovima stabla i površinskim objektima.

Od 846 nesreća, pri razmatranju vrste ozljeda, radilo se o 819, tj. 777 nesreća. Za sve eliminirane nesreće zabilježena je vrsta ozljeda u kategoriji »ostalo«, a za jednu je nesreću nedostajao podatak o vrsti ozljede. Kod većine je nesreća (slika 4) vrsta ozljede bila nagnječenje i udarac (56 %), otvorena rana (19 %), uganuće i iščašenje (11 %), a sve su razlike bile statistički značajne (za analizu svih i za analizi 95 % nesreća). Težina je ozljeda bila u objema analizama (ne uzevši u obzir ozljedu oka) najviša u slučaju lomova (129,9 i 50,3 izgubljeni dan/nesreća), a najniža u slučaju uboda kukca (9,0 izgubljeni dan/nesreća) u usporedbi sa svim ostalim vrstama ozljeda (tablica 3). Rijetke i vrlo teške nesreće rezultat su prijeloma kostiju i kontuzija zbog udaraca.

Iz svih je nesreća, pri analizi ozlijeđenoga dijela tijela, izuzeto 13 nesreća jer je kao ozlijeđeni dio tijela bila navedena kategorija »ostalo«, a za 5 je nesreća nedostajala informacija o ozlijeđenom dijelu tijela pa su i te nesreće izuzete iz predmetne analize. Dakle je raščlanjeno 828 nesreća (786 pri 95 % nesreća), a 66 % ozljeda odnosilo se na ruke i noge (slika 5). Težina nesreća s ozljedama ekstremiteta (30,7 i 20,5 izgubljeni dan/nesreća) statistički je značajno viša od težine nesreća s ozljedom lica (14,2 i 11,6 izgubljeni dan/nesreća). Najteže su nesreće povezane s ozljedama udova, iako je uočen i velik udio teških nesreća uzrokovanih ozljedama trbuha i kuka.

Binarnom multiplom logističkom regresijom obavljena je procjena istodobnoga utjecaja različitih čimbenika na težinu nesreće. Utvrđeno je da za sve nesreće dva čimbenika imaju statistički značajan utjecaj na težinu nesreće. To su izvor ozljede i ozlijeđeni dio tijela (tablica 4). Radi preglednosti dobivenih rezultata na slici 6 i na slici 7 prikazane su kombinacije po 3 utjecajna čimbenika čija kombinacija daje najveću težinu nesreće i koji u zbroju izgubljenih radnih dana sudjeluju s više od 75 %. Od 90 mogućih kombinacija (3 x 6 x 5) između ozlijeđenoga dijela tijela, izvora ozljede i radne operacije, njih 7 utječe na 76 % izgubljenih radnih dana (slika 6). Pri kombinaciji vrste ozljede, izvora ozljede i radnoj aktivnosti 8 kombinacija utječe na 7 % izgubljenih radnih dana (slika 7).

Rezultati su analize pokazali da se 68 % nesreća dogodi pri sječi i izradi stabala, 24 % tijekom privlačenja drva, a samo 6 % za vrijeme njege; to je ponešto drugačije nego u istraživanjima provedenima u Švedskoj (60 %, 20 %, 20 %; Engsás 1995). Razlike su uvjetovane drugačijom vlasničkom strukturom šuma u kojima su istraživanja provedena (državne šume/privatne šume), prije spomenutom tehnologijom rada i radnim uvjetima. Utvrđeni gubitak radnih dana po nesreći pri sječi i izradi stabala (29,9) i privlačenju drva (32,5) bitno odstupa od rezultata istraživanja u Novom Zelandu (13,6 i 11,1 izgubljeni dan/nesreća; Bentley i dr. 2002, 2005).

Zabilježeno je relativno malo ozljeda uzrokovanih motornom pilom (6 %), što je usporedivo s istraživanjima Sullmana i dr. (1999) na Novom Zelandu. Udio je ozljeda uzrokovanih motornom pilom u slovenskim državnim šumama u padu (Jereb 2009). Slično pokazuju i rezultati ostalih usporedivih projekata (Lefort i dr. 2003). Međutim, u Sloveniji razlog ne leži u mehaniziranju sječe i izradbe drva, već u stalnoj primjeni zaštitnih sredstava i obrazovanju radnika. Udio nesreća uzrokovanih svim radnim sredstvima (15 %) usporediv je s rezultatima KWF-a u njemačkim državnim šumama (14 – 20 %). Unatoč zadovoljavajućemu padu udjela nesreća u šumarstvu uzrokovanih motormom pilom, udio nesreća čiji su uzrok različiti dijelovi stabla i različiti površinski objekti u porastu je. Prema Jerebu (2009) takav je trend, uz visoku težinu tih ozljeda, logičan ako su nam poznate činjenice da se ozljede od dijelova stabala mogu vrlo teško spriječiti primjenom zaštitne opreme i da razlog njihova nastajanja najčešće leži u današnjem prebrzom tempu rada.

Prema vrsti ozljede zamijećeno je 56 % kontuzija, 19 % otvorenih rana, 11 % uganuća i iščašenja te 6 % prijeloma kostiju. Podaci KWF-a (u njemačkim državnim šumama) imaju istu vrijednost za otvorene rane, manju vrijednost za kontuzije (41 %), a veće vrijednosti za uganuća i iščašenja (22 %) i za lomove (9 %). Razlog tomu mogao bi biti veći stupanj mehaniziranosti sječe, izrade i privlačenja u njemačkom šumarstvu. Tijekom mehanizirane sječe i izradbe (Väyrynen 1982) glavnina se ozljeda događa pri popravku i održavanju stroja, a onda su to najčešće uganuća i iščašenja (35 %) te nagnječenja i udarci (30 %). Prema ozlijeđenomu dijelu tijela najčešće su ozljede ruku i nogu (66 %), a slično je i u istraživanjima KWF-a (64 %), Wanga (2003) – 51 % i Leforta (2003) – 50 %. Iznenađujuće je visok bio postotak ozljeda lica (15 %) posebno pri njezi (33 %), od čega je polovica ozljeda oka. Zaključujemo da pri njezi svi radnici trebaju nositi zaštitne naočale.

Istraživanje je pokazalo da težina nesreće ovisi o svim odabranim čimbenicima, a najviše o ozlijeđenom dijelu tijela i izvoru ozljede kada su u analizu uključeni svi čimbenici. U praksi to znači da se nesreće pojedinoga dijela tijela, poglavito trbuha i leđa, mogu izbjeći ili spriječiti primjenom mobilnih sredstava za rad u pojedinoj radnoj operaciji. Nadalje, mjere sigurnosti i zaštite usmjerene smanjenju težine nesreća u šumarstvu trebale bi voditi smanjenju ozljeda uzrokovanih različitim dijelovima stabla posljedice čega su kontuzije i lomovi ekstremiteta (te drugih dijelova tijela tijekom sječe) te površinskim objektima posljedice čega su uganuća, iščašenja i lomovi.

Rezultate ovoga istraživanja moguće je usporediti s vrlo malim brojem sličnih, novijih istraživanja jer, s jedne strane, razvijenije šumarske zemlje (što se tiče tehnoloških dostignuća) u kojima se slična istraživanja provode obavljaju sječu, izradbu i koranje stabala mehanizirano pa usporedba rezultata nije moguća, dok se, s druge strane, u zemljama koje primjenjuju podudarne načine pridobivanja drva i s kojima bi usporedba rezultata bila moguća, slična istraživanja nisu prioritetna. Ovakva istraživanja služe, ponajprije, da na temelju analiza nesreća u prošlosti planiramo mjere i postupke usmjerene prevenciji budućih nesreća pri šumskim radovima. Vrijednost rezultata istraživanja i temeljem toga preporučenih aktivnosti u izravnoj je vezi s kakvoćom i količinom ulaznih podataka.

Ključne riječi: šumski radovi, nesreća, težina, ozljeda

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