Identifying causes, dynamics and consequences of work accidents in forest operations in an alpine context

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ABSTRACT

In a sustainable perspective, where wood harvesting and use perfectly respond to environmental needs, social sustainability and related health and safety of forest workers cannot be disregarded. The aim of this study was the analysis of the accidents records in public companies in the Province of Trento, in Northern Italy, regarding forest operations in the period 1995–2013. Several information were available thanks to the up-to-date accident books compiled by each company. With an average Frequency index in the examined period of 88 injuries per million hours worked, forest operations were confirmed as one of the most dangerous works along all productive sectors. Monday had a significant higher frequency of accidents comparing to the other weekdays. The age of the workers seemed influencing the recovery period after injuries, which exponentially increase at rising age. Felling and processing definitely resulted as the most dangerous activity in forest operations covering the 31% of total accidents happened. 'He puts a foot wrong…', 'He was hit by…' were the most common phrases used in describing the studied accidents; these were the action cause of the accident and contribute explaining why body extremities, first of all the hands, were the body parts most injured. Finally, a new concept in accident analysis was proposed introducing the analysis of 'recidivism', which analysed the eventual recurrence of accidents to the same worker in a given period. Results have underlined that some workers had more than one injury during the analysed period, up to seven accidents for one of them.

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1. Introduction

Forests supply several environmental, social and economics goods and services for people and society worldwide. Among the other, wood production is one of the most important functions of forests in many areas, and in order to guarantee a sustainable production of woody products a sustainable forest management is required. A sustainable forest management should guarantee the best safety and health conditions for people who directly work in forests. Forest operations are considered the most dangerous job in all fields of production (Albizu-Urionabarrenetxea et al., 2013; Bentley et al., 2005; Klun and Medved, 2007; Köhl et al., 2010; Lindroos and Burström, 2010; Rhee et al., 2013; Tsioras et al., 2011). Risks related to forest operations are firstly due to worksite environment, which implies uncommon factors of risks in comparison with the most part of other jobs (Bolognesi et al., 2013; Hippoliti and Piegai, 2000). The main risks related to worksite environment are: i) terrain conditions; ii) weather conditions, and in particular high and low temperatures, wind, ice, snow and rain; iii) biological agents. Other risks related to forest operation are due to: use of machines and tools; exposure to heavy loads; exposure to physical agents (noise, vibration); exposure to wood dust and exhaust gasses (Bolognesi et al., 2013; Hippoliti and Piegai, 2000; Hippoliti, 1997). Heinimann highlighted the fundamental importance of social aspects in forest operations, in particular on health and safety of forest workers (Heinimann, 2000).

Several studies already produced interesting analysis based on statistical data on risk and injuries collected in different situations and countries. These studies evaluated the work conditions (Ahola et al., 2013; Bush et al., 2014; Canto et al., 2007; Wilmsen et al., 2015), the accidents occurred during forest activities (Bentley et al., 2005; Lilley et al., 2002; Lindroos and Burström, 2010) or during specific logging systems in forest operations (Bentley et al., 2005; Montorselli et al., 2010; Poschen, 1993; Shaffer and Milburn, 1999; Tsioras et al., 2011; Wang et al., 2003). Considering accident analysis, there is a lack of information regarding southern European countries in comparison with the better-studied events in central and northern countries (Albizu-Urionabarrenetxea et al., 2013; Tsioras et al., 2014). Interesting case studies were also

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developed in New Zealand (Bentley et al., 2005; Gaskin and Parker, 1993), United States (Shaffer and Milburn, 1999; Wilmsen et al., 2015) and China (Wang et al., 2003). A fundamental difference between occasional wood cutters in comparison with professional ones has been underlined by Fischer (Fischer et al., 2005).

The increase of mechanization level in forest operations contributes in reducing both the risks and the frequency of accidents and/or occupational diseases (Bell, 2002). In fact, today the modern machines permits to work in better conditions in terms of ergonomic and safety than in the past. However not always high mechanization may be applied, both for management and/or technical reasons. In particular, there are technical and environmental limitations often attributable to the terrain slope. Even if a high mechanized ground-based machines for extraction already exist, also for steep terrain (Visser and Stampfer, 2015), sometimes there are some restrictions to their use, mainly related to environmental risks. Especially in high populated countries as Italy, where forests are mainly located on mountainous areas (Alps and Apennines), and several restriction related to environmental protection are applied, high mechanization is relatively uncommon (Picchio et al., 2010). On the Alps cable-based technologies have been the backbone of steep-slope harvesting (Bont and Heinimann, 2012). For these reasons motor-manual felling (Montorselli et al., 2010) and extraction by tractor with winch and cable yarder are the most common work systems adopted by forest companies (Picchio et al., 2010).

In this study the interest was focused on professional workers, in an area were a mix of high and medium mechanization level is applied. In Italy forests cover more than 36% of total surface (INFC, 2005) and forest sector has a fundamental role in terms of economics and environment (VV.AA., 2015). In Italy, the 'National Institute for Insurance against Accidents at Work (INAIL)' provides data in relation to forest activities and related injuries, but often the information are aggregated with agriculture (INAIL, 2015a). Moreover, despite the good structure of archives, available specific information regarding forest operations are mainly incomplete. For this reason, a lack of information regarding accidents during forest operations exists. Considering the high risks related to this job, a deep analysis regarding injuries occurred during works in forest could have a key-role in order to develop new solutions for accident reduction in this field. The aim of this study was to analyse in deep the registered work accidents occurred in a representative Italian forest area, in order to identify the different causes, dynamics and consequences of accidents, which commonly affect forest workers during forest operations and related activities. Moreover, in this study not only strictly defined operations with specific machines and techniques (i.e. extraction by cable yarder) were examined, but all the operation that a forest worker could make during his career in the analysed area. In particular, different parameters of the accidents were analysed, identifying the most important factors of risk.

2. Materials and methods

2.1. Study area

In this study, work accidents occurred within different public companies located in northern Italy – distributed in the Autonomous Province of Trento (Italy), on the Alps – were investigated. These companies are all included in one of the most known Italian forest areas characterised by a well developed forest sector. Each company directly manage different public forests. For these reasons each company directly hire forest workers, who all work generally in the same forest conditions and with the same mechanization level. Considering terrain steepness and the forest

management practices which characterise these areas, motor-manual felling and cable logging are the most common and convenient logging systems applied (Spinelli et al., 2015). Beyond steep terrain, also weather conditions increase risk level during work. The forest workers of all the companies had been offered the proper Personal Protective Equipment (PPE) for each operation. Moreover, forest operators followed training periods focused on the specifics tasks to be performed by each one.

2.2. Data collection

As in Austrian case (Tsioras et al., 2011), also in Italy both public and private companies must have and compile an accident book, where all injuries occurred to company's worker have to be registered (Italian Republic, 2008). This prescription must be attended only when the accident implies three or more days of prognosis, however the companies included in this study registered also the injuries with minor severity.

In this study, data registered from 1995 to 2013 were considered. Sensitive data have been managed following law prescriptions and the information from the four analysed companies were aggregated in order to agree with the request of companies to avoid comparison between them.

Accident books were generally compiled collecting information on the event date, accident dynamics and consequences. Starting from the textual description of each event in the accident book, the following information were extracted:

(a) **Date** of the accident. These informations were used for a temporal analysis regarding the day of the week of the accidents.

(b) **Worker's age –** age of the worker at the time of the accident. The distribution of accidents in relation with worker's age were analysed taking into account classes of 10 years extent. In particular, 6 classes of age were identified: (i)<20 years old; (ii) 21–30 years old; (iii) 31–40 years old; (iv) 41–50 years old; (v) 51–60 years old; (vi) >60 years old.

(c) **Work operation –** specific task of the work that the worker was carrying out at the time of the accident. The task were included in one of the following operation used in the data analysis: 'Felling and processing', 'Bunching and extraction', 'Forest road construction/maintenance', 'Wood handling', 'Moving in forest', 'In itinere' and 'Other'. 'Other' includes all the activities, still related to forest operations, which could not be assimilated to the other ones. It is normal that each forest worker is more confident working in a phase than in another, but all of them were able to work on all the described phases

(d) **Injuries severity**. For the data analysis, five classes were established on the basis of the number of workdays lost due to the injury: 'Minor injury', less than 8 days lost; 'Moderate injury', from 8 to 25 days of prognosis; 'Serious injury', between 26 and 60 days lost; 'Severe injury', from 61 to 100 workdays lost and 'Highly severe injury', for accidents which implied more than 100 days without working.

(e) **Material agent cause of the event**, identified in order to understand which were the most dangerous elements, materials and tools. Ten categories were resumed identifying accidents caused by: (i) 'Gr' = forest ground; (ii) 'BS' = boulder, stone; (iii) 'LST' = log, stump, tree; (iv) 'BT' = branches, top; (v) 'SFt' = splinter, fragment of tree; (vi) 'C' = chainsaw; (vii) 'OE' = other equipment (sickle, pruning hook, hatchet); (viii) 'Bio' = biological agents (tick, wasp, snake, etc.); (ix) 'MV' = machines and vehicles; (x) 'Ot' = other, including all that is not included in previous categories.