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Urban green spaces activities: A preparatory groundwork for a safety management system

Lucia Bortolini, [a] Sirio R.S. Cividino, [b] Rino Gubiani, [b] Massimo Cecchini, [c] Lavinia M.P. Delfanti, [c] Andrea Colantoni [c,*]

[a] Department of Land, Environment, Agriculture and Forestry (TESAF), University of Padova, Viale dell'Università 16, 35020 Legnaro, Italy
[b] Department of Plant Sciences, University of Udine, Via delle Scienze, 208, 33100 Udine, Italy
[c] Department of Agriculture, Forest, Nature and Energy (DAFNE), University of Tuscia, Via S. Camillo de Lellis snc, 01100 Viterbo, Italy

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ABSTRACT

Introduction: Urban green spaces works and maintenance are high-risk activities and usually represent possible sources of injuries. The management issues are complex and strongly influenced by companies' policies in terms of safety management and human factor. A high number of tasks—including protecting public health and safety and safe working procedures—need to be faced by professional arborists or gardeners. *Method:* The present paper provides a preparatory groundwork for modeling and describing the real risk levels during the abovementioned activities. The methodology represents a useful tool for decision making both for group leaders and safety coordinators. This goal is reached by collecting data emerging from several workplaces located in North East Italy regarding the frequency and severity of injuries. *Results:* The preliminary results point out that the most frequent injuries in green maintenance activities are represented by cuts, contusions, and ocular lesions, but none of them have lead to particularly serious consequences for the operators; indeed, the high levels of severity are related to traumas, fractures, and acute lumbar herniated discs. The riskiest activities are related to pruning, especially using mobile elevating work platforms, and grass cutting, especially when operated in escarpments and banks. Workers' behavior and companies' safety policies are key elements for a correct safety management system.

1. Introduction

Green spaces in cities play a fundamental role for urban sustainability, especially considering that more than two thirds of Europeans live in urban contexts (Naess, 2001). On the one hand, they can contribute to improving environmental conditions through the reduction of air pollution (Nowak, Crane, & Stevens, 2006; Yang, McBride, Zhou, & Sun, 2004), regulating the micro-climates (Bernatzky, 1983; Dimoudi & Nikolopoulou, 2003), alleviating the heat island effect (Oliveira, Andrade, & Vaz, 2011; Zoulia, Santamouris, & Dimoudi, 2009), reducing the road traffic noise (Van Renterghem & Botteldooren, 2009), and preventing local floods caused by stormwater runoff from impervious surfaces (Dietz, 2007). Nevertheless, on the other hand, green spaces are high-required workforce activities (McPherson, 1992; McPherson, Simpson, Xiao, & Wu, 2011) so that a complex and professional approach is needed to protect workers and residents during all phases of these work sites (Rahardjo et al., 2009; Ricard & Bloniarz, 2006).

As it is commonly known, urban green spaces have an important role in citizens' health and well-being (Lee & Maheswaran, 2011; Nielsen & Hansen, 2007; Van Herzele & Wiedemann, 2003). As a consequence, the guidelines for planning and management are often "citizen-based" (Madureira, Andresen, & Monteiro, 2011), aimed at the creation of accessible and attractive places strictly connected with the populations' composition and their point of view (Jorgensen, Hitchmough, & Calvert, 2002; Young, 2010). However, it is important to clarify that the starting point of the present investigation is to ensure safe work places for workers; hence, the approach can be defined as "operator-oriented."

The current scientific literature about risk taking and accidents frequency among "green operators" is poor in terms of quantitative and qualitative analysis. In most of the cases, data on injuries emerge from agriculture and forestry studies (Bailer, Reed, & Stayner, 1997; Colantoni et al., 2012; Lilley, Feyer, & Kirk, 2002; Lindroos, Aspman, Lidestav, & Neely, 2008; Lindroos & Burström, 2010; Lundqvist & Gustafsson, 1992; Mann, Pouta, Gentin, & Jensen, 2010; Marucci, Pagniello, Monarca, Colantoni, & Biondi, 2012; Monarca et al., 2009; Montorselli et al., 2010; Neely & Wilhelmson, 2006; Potočnik, Pentek, & Poje, 2009; Solomon, Poole, Palmer, & Coggon, 2007; Suchomel & Belanová, 2009; Thelin, 2002). According to Solomon and his work on

* Corresponding author. Tel.: +39 0761357356.
E-mail address: colantoni@unitus.it (A. Colantoni).

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safety in agriculture in the UK (2002), the most common fatal accidents are those involving machinery, works at height, and electrocution whereas non-fatal injuries are due to manual handling. Due to the frequent use of chainsaws, human activity in green areas may be considered as most similar to forest works for which the mortality is higher than in other branches of agriculture (Tsioras, Rottensteiner, & Stampfer, 2014).

In this scenario, the present study leads to a definition of the indicators of accident frequency and severity of injuries starting from field data in order to create a specific model for urban green area maintenance related to companies, taking into account the current policies and companies' and operators' expertise and behavior. Thus, a survey was carried out to create a preparatory groundwork to properly develop a Safety Management System (SMS). According to Fernández-Muñiz, Montes-Peón, and Vázquez-Ordás (2007), the SMS comprises a set of policies and practices aimed at positively impacting on the employees' attitudes and behaviors with regard to risk. Thus, SMSs are meant to act on processes causing risks and accidents. Moreover, an SMS provides a systematic way to identify hazards and control risks (Hale, Heming, Carthey, & Kirwan, 1998) and can be defined as a business-like approach to safety. Since it is an explicit and comprehensive process for managing safety risks (Robson et al., 2007), a safety management system is extremely important in goal setting, planning, and measuring performance and is woven into the fabric of an organization (Transport Canada, 2001).

In more detail, an effective SMS should define how the organization itself is set up to manage risk, identify workplace risks, and implement suitable controls and effective communications across all levels of the organization.

In order to properly apply SMS specifications—such as safety policy, planning, implementation and performance evaluation—two main standards are available to Italian companies: OHSAS 18001 (British Standards Institution, 1999) and ILO/OHS-MS (International Labour Organization, 2001).

2. Material and methods

2.1. Background

Broadly speaking, a method is able to provide a clear answer on how to manage a workplace for green spaces maintenance if it starts from an efficient and effective approach. Several risk analysis models are currently available and are based on specific modeling paradigms (Beroggi & Aebi, 1996). However, the most frequently used methodologies in risk management can be summarized as (a) decision modeling (Doheny & Fraser, 1996); (b) data modeling (Crockett, Guynes, & Slinkman, 1991); and (c) dynamic modeling (Cowing, Elisabeth Pate Cornell, & Glynn, 2004).

The data/knowledge modeling was adopted in the initial phase of the study. This choice is relevant because the uncertainty inherent in risk issues can be reduced significantly by employing appropriate data and knowledge models. Data base systems can support risk management by analyzing historical data, using forecasting methods, estimating probability distributions, and analyzing causal relationships. Knowledge is represented in knowledge-based systems, which are implemented into decision support systems to help the analysis and decision making process of risk managers.

2.2. Data modeling

To perform an analysis on safety in green spaces management workplaces, a procedure was implemented to make the analysis repeatable and verifiable. A subdivision in subsequent phases was used. The procedure followed will allow us to implement a SMS model, called GreenSafety model, useful to prevent injuries in green spaces activities. The scheme of the GreenSafety process is illustrated in Fig. 1. The preparatory groundwork hereinafter described concerns the first two parts of the process: the problem structuring and the problem formalization to assign values to the indicators of the risk analysis.

2.2.1. Survey activities in green areas workplaces

First, to ensure a deeper analysis of the problem and to obtain more detailed research questions, a data collection was made to create a first database on accident frequency and severity of injuries in urban green areas maintenance. Field surveys were carried out in Veneto and Friuli-Venezia Giulia Regions (in the North-East of Italy) between May 2008 and May 2011 using a field questionnaire. Five companies operating in the Province of Padova, Vicenza, Udine, and Gorizia were involved for a total of 80 workplaces investigated. The contents of the questionnaire are presented in Table 1. The aim of the questionnaire was to assist the surveyors in monitoring and analyzing workplaces, including off- and in-site preparations: the behavior of workers (e.g. use of PPEs,

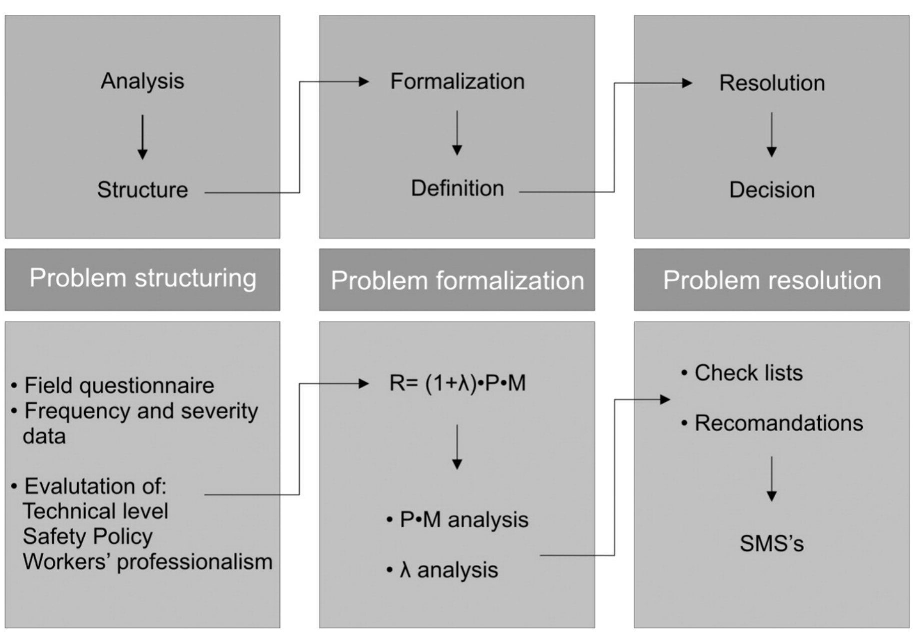

Fig. 1. GreenSafety SMS model: methodological approach (R = risk index; P = probability of accident; M = severity of accident; λ = critical index).

correct use of equipment, etc.), signals presence, the safety operational plan, the level of maintenance of machinery and equipment, the working plan adopted by the company in daily activities, etc.

Urban green spaces activities were classified into four groups (soil preparation and planting, pruning and abatements, lawn maintenance and grass cutting, pest and disease control), each subdivided into elementary tasks. The surveys carried out in the different workplaces allowed to point out the risk factors in green areas management activities and improve the list used by surveyors.

2.2.2. Accident frequency and severity of injuries

In order to give a clear perspective on the relationship between accident frequency and severity of injuries in the period 2000–2010, more than 12,000 workplaces were analyzed using data from the Accident Register of the investigated companies, considering all the reports of labor accidents over 11 years: the total number of non-fatal injuries was equal to 71. The accidents and injuries abovementioned have been codified according to INAIL (National Organization for the Labour Insurance), which adopts the resolutions of the International Labour Organization presented at the 10th International Conference of Labour Statisticians in 1962.

To evaluate safety performances, the frequency index (I_F) was calculated, pointing out the incidence of accidents for workers exposed to risk, as the ratio of number of injuries to one million worked hours (UNI 2742, 2007):

$$I_F = \frac{\text{Number of total injuries}}{\text{Number of worked hours}} \times 10^6$$

The index encompasses all injuries—illness is not included and requires a different report—thus involving all consequences in man, and results to be suitable to highlight possible correlations with the company size.

Frequency index can represent a proper tool for accidents assessing thanks to the regular calculation of the worked hours. Worked hours and workers' numbers were obtained from the official reports laid down by INAIL and were evaluated once a year (up to 31st of December). It is important to highlight that INAIL is the only insurance institution for workers in Italy and its owned data are complete and reliable because all companies are obliged to declare injuries and workers' numbers (Fabiano, Curro, & Pastorino, 2004).

Besides, a severity index (Is) was calculated as the ratio between the magnitude of the psychophysics lesions and the duration of risk exposure (equal to number of worked hours) by using (UNI 2742, 2007):

$$I_S = \frac{\sum d_T + \sum d_P + \sum d_D}{\text{Number of worked hours}} \times 10^3$$

where d_T, d_P, and d_D are days of actual absence from work, respectively, with temporary disability, permanent disability, and death. On a conventional basis, 75 working days for each point of detected disability are considered for the injuries with permanent disability and 7500 working days when death occurs (equal to 100% of detected disability). Therefore, the Is index is related to the days lost due to injury for 1000 worked hours.

2.2.3. Risk analysis

Another step in the model implementation was represented by the definition of the task-specific risk (R_{task}). The method is currently widespread in industrial practices (OHSAS 18001) and can be easily applied to case studies although several limits occur. More precisely, Grassi, Gamberini, Mora, and Rimini (2009) underlines that the classical risk index (R)—as a product of probability of an accident (P) and its severity (M)—does not take into account human factors and the characteristics of the working environment. Moreover, quantifying the severity of an injury to a human operator is difficult to assess and statistical data are not often available to estimate the occurrence probability of an accident, so P and M evaluation is usually made through the use of sets of whole numbers (1, 2, 3, etc.). Other significant problems of the $R = P{\cdot}M$ function are (Grassi et al., 2009):

- different combinations of judgments on the criteria can lead to the same risk class;
- risk index is extremely sensible to small variations of judgments, affecting the analysis;
- the quantitative scale of judgment is often limited up to four or six values, in order to limit potential incoherencies among the evaluations of all the hazardous activities.

Table 1
The contents of the field questionnaire.

Data collected on	Assess/measure	Details/options
Site details		
Location (general)	Assess	Classification of green area
Location (detail)	Measure	GPS location
Weather condition	Assess	List
Date		
Type of activity	Assess	List
Operators	Assess	Site safety coordinator, person in charge, team composition, etc.
Off-site preparations		
Visual tree assessment	Assess	Yes/No
Safe strategy to carry out an operation	Assess	List
In-site preparations		
Safety factors and other management issues	Assess	List
Condition of site/plant	Assess	New, good, moderate, non-functional or remnant
Safety of site	Assess	Low, moderate, high, very high
Presence of signs	Assess	Yes/No
Documents and authorizations (contingency plan)	Assess	Yes/No
Tasks (or sub-activities)		
Type of task	Assess	List
Equipments	Assess	List
Risk factors	Assess	List
Duration	Measure	Minutes

Table 2
Topics for the different coefficients used for the evaluation of criticality index λ.

Safety aspects	Topics
Expertise and professional standards λ_{Hu}	Gardener or arborist certification (recommended), utility specialist certification
	Flexibility of the plan to be varied if circumstances change
	Attitude of the operator underestimating the hazard involved in the execution of the activity
	Correct use of personal protective equipment
	Training in safety
	Workers' incentives
Technical level λ_{Te}	Type, use and maintenance of machinery and equipments
Occupational health and safety policy λ_{Po}	Improved internal engineering and management procedures
	Identification and reduction of human-related project risks
	Internal self-assessment
	Day-to-day operations and inspections
	Preparation and assessment of safety cases and risk assessments
	Project monitoring
	Presence of contingency plans in place for dealing with unexpected or emergency situations
	Incidents, accidents, and near-misses analysis

Table 3
Classes of probability of an accident (P) and its severity (M).

Class	Probability/frequency	Severity
1	Extremely rare	Minor
2	Rare/occasional	Moderate
3	Frequent	Significant/serious
4	Very frequent	Extremely serious

Several scientific works have been published to develop methodologies able to overcome the aforementioned problems, allowing consistent improvements in the maintenance management process (Bevilacqua & Braglia, 2002; Bevilacqua, Braglia, & Montanari, 2003; Bowles & Pelaez, 1995). We tried to integrate technical aspects, occupational health and safety policy, and expertise and professional standards in order to propose a methodology similar to that described by Jørgensen (2011). Thus, a criticality index □ has been introduced and the $R = P \cdot M$ function transformed into:

$$R_{\text{task}} = (1 + \lambda) \cdot P \cdot M$$

with

$$\lambda = \lambda_{\text{Hu}} + \lambda_{\text{Te}} + \lambda_{\text{Po}}.$$

and $0 \le \lambda \le 0.3$ and $0 \le \lambda_{\text{Hu}}, \lambda_{\text{Te}}, \lambda_{\text{Po}} \le 0.1$.

where

R_{task} is the task-specific risk index,
λ_{Hu} is a coefficient related to the human factor and the evaluation of workers' professionalism (expertise and professional standards),
λ_{Te} is a coefficient related to the evaluation of the technical level,
λ_{Po} is a coefficient related to the occupational health and safety policy.

In particular, we consider human factor as a risk parameter with its intrinsic characteristics: age of workers, experience in the activity, specific knowledge (Seppala, 1995), level of experience in the same company, satisfaction (Henning et al., 2009), training period (Burt, Chmiel, & Hayes, 2009), and heavy workload.

The values of the three coefficients can range from 0 to 0.1 going from excellent to poor situation. Table 2 shows the topics of the safety aspects used to define the λ values.

Table 4
List of the types of activities and elementary tasks in urban green spaces.

Soil preparation and planting	Pruning and abatements
Land grading and levelling	Ascending/descending in tree-climbing
Soil tillage	Pruning by platform
Hole digging	Pruning with tree-climbing techniques
Manual handling of trees	Manual abatement (chainsaw)
Mechanical handling of trees	Mechanical abatement (harvester)
Trees and shrubs planting	Clearing-up works
Anchors installation	Truck loading
Lawn seeding	Plant residue grinding
Lawn transplanting	

Lawn maintenance and grass cutting	Pest and disease control
Grass cutting in escarpments and banks	Pesticide preparation
Mowing	Pesticide application
Grass harvesting	Pesticide application equipment cleaning
Vertical mowing (dethatching)	Nests processionary removing
Verticutting	
Top dressing	

Table 5
List of the risk factors in green spaces management activities.

Id	Risk
Handling and loading	
H1	Manual handling of loads
H2	Mechanical handling of loads
H3	Dangerous substances
H4	Large-dimension objects
H5	Repetitive movements
Falls (of workers)	
F1	Falls from a height or different level
F2	Falls from the same level (slipping)
Collisions	
K1	Against stationary objects
K2	Against moving objects
K3	Moving machinery or traffic
K4	Electrical cables and wires
K5	In-pressure liquids
Noise	
N1	Below 80 dB
N2	Between 80 and 87 dB
N3	Higher than 87 dB
Micro-climate and operating environment	
M1	Cold (hypothermia)
M2	Warm
M3	High-humidity
M4	Wind
M5	Ponding water (including drowning)
M6	Snow/ice
Physical fatigue	
P1	Heavy work
P2	Dirty work
Workload	
W1	Stress-correlated
W2	Overstraining
Biological factors	
B1	Presence of dangerous animals/insects
B2	Presence of toxic/dangerous organic substances
Contact and entrapment	
C1	Contact with hot surfaces
C2	Contact with sharp edges
C3	Trampled by...
C4	Struck by...
C5	Trapped by... or between equipment parts
Extreme works	
E1	Work at height
E2	Deep excavation
E3	Use of hydraulic *pressure machines*
Vibrations	
V1	Hand-arm vibration
V2	Whole body vibration
Radiation and chemicals	
R1	Toxic and poisonous substances
R2	Radiation
Interference	
I1	External people interference
Human factor	
H1	Gender, age, nationality, etc...
H2	Correct use of PPEs
Support/rescue	
S1	Working alone
S2	Night works
Dust	
D1	Natural dust/particulates
D2	Polluted dust/particulates
Explosions and fire	
X1	Fire
X2	Explosion

Table 6
Indexes of frequency (I_F) and severity (I_S) for type of lesion.

Type of lesion	I_F	Type of lesion	I_S
Cut	1079.5	Trauma	7.84
Contusion	852.3	Fracture	5.46
Ocular lesion	795.5	Acute lumbar herniated disc	3.07
Contused and lacerated wound	681.8	Distortion	1.88
Blunt trauma	454.5	Blunt trauma	1.14
Lumbalgia	397.7	Vertebral column trauma	0.85
Distortion	340.9	Tendonitis	0.80
Fracture	340.9	Compound fracture	0.78
Vertebral column trauma	170.5	Oedema	0.77
Non-specified	113.6	Contusion	0.75
Dislocation	113.6	Lumbalgia	0.63
Oedema	56.8	Dislocation	0.57
Haematoma	56.8	Cut	0.55
Compound fracture	56.8	Contused and lacerated wound	0.54
Acute lumbar herniated disc	56.8	Non-specified	0.53
Dislocation -distortion	56.8	Vertebral column trauma + wound	0.45
Bite	56.8	Dislocation -distortion	0.40
Tendonitis	56.8	Haematoma	0.34
Trauma	56.8	Irritation	0.28
Vertebral column trauma + wound	56.8	Ocular lesion	0.23
Irritation	0.0	Bite	0.17

During the surveys in the 80 workplaces, a preliminary evaluation of λ coefficients was done and associated with each observed task. The development of a carefully and well-designed list, which can be revised appropriately as far as practices and procedures are added or changed, can be considered the first step to analyzing the relationship between risk and human, environment and policy-related aspects in terms of risk management.

In accordance with the guidelines of INAIL (ISPELS, 1994), four classes with increasing probability (frequency) and severity level ranging from 1 to 4 was chosen to assign a value to P and M (Table 3) of each single task. Depending on the values of the frequency (I_F) and severity (I_S) indexes, a width to any class should be assigned in a future step of the model implementation.

3. Results

3.1. Risk factors in green spaces management activities

As a result of the survey activities conducted in the workplaces investigated, a preliminary list of 27 elementary tasks or sub-activities

Table 7
Indexes of frequency (I_F) and severity (I_S) of source of injury.

Source of injury	I_F	Source of injury	I_S
"struck by…"	1022.7	"accident on board of…"	3.18
"injured by…"	795.5	"footing…"	2.33
"footing…"	738.6	"fall from a height…"	2.19
"uplift with effort"	738.6	"uplift with effort"	1.93
"fall from a height…"	397.7	"flatted by…"	1.26
"collided against…"	340.9	"uncoordinated movement…"	1.15
"uncoordinated movement…"	284.1	"caught…"	0.85
"flatted by…"	227.3	"hit by…"	0.85
"hit himself by…"	227.3	"collided against…"	0.65
"in contact with…"	56.8	"injured by…"	0.61
"fall into a depth…"	56.8	"struck by…"	0.57
"fall from the same level…"	56.8	"fall into a depth…"	0.57
"exposed to…"	56.8	"fall from the same level…"	0.57
"caught…"	56.8	"being struck by…"	0.55
"accident on board of…"	56.8	"in contact with…"	0.51
"hit by…"	56.8	"exposed to…"	0.11
"stung by…"	0.0	"stung by…"	0.11
"injured by…"	0.0	"injured by…"	0.11
"being struck by…"	0.0	"hit himself by…"	0.11

Table 8
Indexes of frequency and severity for material agent of injury.

Material agent	I_F	Material agent	I_S
Foreign bodies	1.9	Others	2.95
Machinery	1.5	Equipments	1.56
Undetermined	1.1	Machinery	0.84
Equipments	0.9	Undetermined	0.71
Others	0.7	Foreign bodies	0.55
Animals	0.2	Animals	0.17

(Table 4) as well as the risk factors were drawn up. The risk factors were classified by categories and codified (Table 5).

3.2. Frequency and severity of injuries

The analysis of the data from the Accident Register of the companies involved in the survey allowed to highlight the major risks in which workers can be involved. As regards accidents related to causative factors, more than 30% of the total accidents were related to foreign bodies. Machinery and other equipment together accounted for approximately 29.1% of the total accidents. An important part of accidents (21.8%) depend on others unspecified agents. The parts of the human body more involved in accidents are the hands (23%) and the backbone (15%) as a result of the high stress to which these parts are subjected during green maintenance works.

Analyzing the trend of accidents during the year, even distinguishing Veneto and Friuli Venezia-Giulia Regions (Fig. 2), seasonal variations in incidence rate for different types of accidents/injuries were observed, although with some differences between the two regions, with the highest incidence rate in July (13.45%), followed by March (11.76%) and October (10.92%), while the lowest monthly rates were found in January and November (5.88%). The peaks correspond to the highest workforce depending on the period of the year: pruning in March, grass cutting in July, high-intensity activities (especially works related to cleaning of green spaces) before the winter break in October/November. July is the warmest month in Italy and injuries could be related to dehydration and heat stroke.

By elaboration of the 11-year data from the Accident Register, complete frequency/severity lists subdivided on type of lesion, source of injury, and material agent were obtained. The most frequent injuries in green maintenance activities (Table 6) are represented by cuts ($I_F = 1079.5$), contusions ($I_F = 872.3$), ocular lesions ($I_F = 795.5$), contused and lacerated wounds ($I_F = 681.8$) but none of them lead to particularly serious consequences for the operators; indeed, the high levels of severity are related to traumas ($I_S = 7.84$), fractures, acute lumbar herniated disc ($I_S = 3.07$), distortion ($I_S = 1.88$) and blunt traumas ($I_S = 1.14$).

Table 7 shows analysis of frequency and severity for each source of injury, or the situation in which an accident has occurred: significantly high are the injuries as "struck by…" ($I_F = 1022.7$), "injured by…" ($I_F = 795.5$), "footing…" and "uplift with effort…" ($I_F = 738.6$). In this case, a direct correspondence between frequency and severity is evident: "footing…" ($I_S = 2.33$) and "uplift with effort…" ($I_S = 2.19$) accidents are not only frequents but also severe events. Furthermore, the study confirms that "accidents on board of…" ($I_S = 3.18$) are the most serious injuries, likely in agriculture and forestry sectors (Ciarapica & Giacchetta, 2009; Solomon et al., 2007).

Finally, regarding material agents of injury (Table 8), the higher risks are related to machinery and equipment utilization. Accidents caused by foreign bodies are frequent but they bring on injuries with low severity.

3.3. Risk analysis

During the field survey, the presence or absence of different risk factors was checked in each task analyzed.

Table 9
List of risk factors for some elementary tasks in green spaces.

Id Risk	Pruning by platform	Pruning in tree-climbing	Grass cutting in banks	Mowing	Manual abatement	Clearing-up works	Pesticide preparation	Pesticide application
H1	*	*			*	*		
H2								
H3							*	*
H4	*	*			*			
H5			*	*		*		*
F1	*	*						
F2	*	*	*	*	*	*	*	*
K1	*	*			*	*		*
K2	*							
K3	*		*	*				
K4	*	*			*			
K5								*
N1	*	*						*
N2	*	*						
N3	*	*	*	*	*	*		
M1	*	*			*			
M2	*	*	*	*	*	*		*
M3	*	*	*	*	*			*
M4	*	*	*	*	*			
M5						*		
M6	*	*			*			
P1		*			*			
P2			*			*		
W1	*	*	*	*				*
W2					*			
B1	*	*				*		*
B2							*	*
C1	*	*	*	*	*	*		
C2	*	*						
C3			*	*				
C4	*	*			*	*		
C5	*		*	*		*		
E1	*	*						
E2								
E3								
V1	*	*	*	*	*	*		
V2			*	*				*
R1							*	*
R2								
I1	*	*	*	*	*	*		*
H1	*	*	*	*	*	*	*	*
H2	*	*	*	*	*	*	*	*
S1			*	*		*	*	*
S2								
D1	*	*	*	*	*	*		
D2	*	*			*	*	*	*
X1								
X2							*	

For this study, a matrix 27 tasks/48 risk factors was examined; a quantitative inquiry, summing all values of risk in every task string and from a comparison through the strings, allowed us to define the riskiest tasks.

The preliminary results underline that tasks related to pruning using mobile elevating work platforms (MEWPs) show the highest number of risks for the operator ($\sum$ risk factors = 29), but even grass cutting, especially when operated in escarpments and banks, adds up a high number of risks (($\sum$ risk factors = 19). Height is the critical aspect in the first case to which other problems associated with work in the canopy adds up as, for example, low visibility, slippery climbing surfaces created by rain-, ice-, or snow-covered branches and mosses and lichens, contact with insect colonies, contact with overhead power lines that can cause fatal or severe electric shock and burn injuries, and many others. On the other hand, grass cutting, performed by a worker for many hours per day, is a stressful activity (consider, for example, noise, vibration, and gas exposition). In Table 9, the different risk factors for some elementary tasks are listed.

Table 10
Mean λ values for the urban green spaces activities estimated during the field survey.

Type of activity	Expertise and professional standards λ_{Hu}	Technical level λ_{Te}	Occupational health and safety policy λ_{Po}	λ
Soil preparation and planting	0.030	0.025	0.029	0.084
Pruning and abatements	0.035	0.027	0.032	0.093
Lawn maintenance and grass cutting	0.032	0.026	0.031	0.089
Pest and disease control	0.051	0.045	0.052	0.148

Table 10 depicts the highest partial and global average values of criticality index λ estimated for each type of activity observed during the field survey. It must be noticed that simple preparation and distribution of pesticides and fertilizers represent activities in which the levels of prevention in the workplaces analyzed are low (λ = 0148): no PPE specifics used, no specific training for operators, no sprayer maintenance ensured. So a low-risk can begin a problematic activity and the λ value can highlight the impact of factors connected with processing, environment, and work organization characteristics in the risk assessment. The

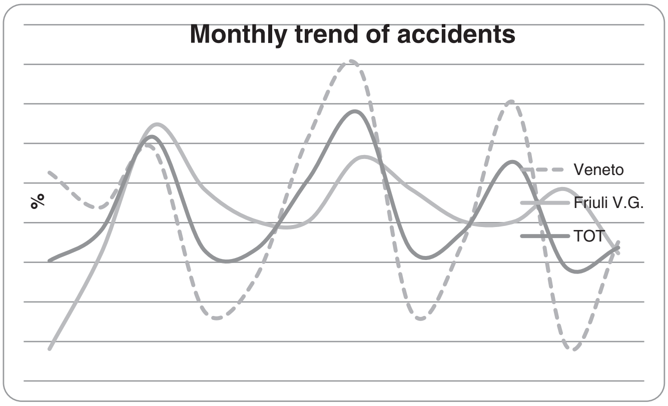

Fig. 2. Trend of % accidents during the year in Veneto Region and in Friuli Venezia Giulia Region (Italy).

study confirms the common opinion that pruning is not only hazardous (Solomon, 2002) but also an operation often realized in non-conformity with the basilar rules of prevention, as turf maintenance and tree planting. In particular, in trees planting activities surveyors have revealed many deficits in the handling of loads (manually or by mechanical equipment) and set up of job-sites.

4. Discussion

In order to understand if the current method is suitable for risk management, its use has been extended to 60 case studies. The present approach combines subjective and objective metrics of the same factor into a single aggregate measure. The results reflect multiple pieces of information emerging from different measurement methods. Future improvements will be addressed to improve the field questionnaire (e.g. λ values estimation with more specific questions), to validate the goodness-of-fit statistics for $R = (1 + \lambda) \cdot P \cdot M$ function in order to define real risk levels directly associated to empirical analyses (P and M variables) and specific work sites and company evaluation. Furthermore, the results pointed out that accidents involved workers who were going to complete their work quickly or to produce more and for other deliberate intentions. In order to confirm the partial good goals of this work, future operative directions can be identified as follows:

I. To analyze the existing safety documents/recommendations for the riskiest activities in order to consequently validate and propose more detailed guidelines.
II. Depending on the behavioral (λ_{Hu}) and internal safety policies (λ_{Po}), risk assessment needs to be linked to the attitude for that work. Thus, the creation of instruments to help workers and persons in charge to interact with each other is required.
III. To perform risk assessment benchmark exercises, and elaboration of harmonized definitions and procedures, even if they concern technical aspects.
IV. To develop a training program for surveyors.

Nevertheless, the present survey has its limitations since it investigates two regions of Italy and for a restricted number of cases and with a basic questionnaire. In the future, the validation of the model by a representative sample of companies, operating on all Italian territories, is desirable. In addition, comparison studies across urban and suburban areas are recommended in the validation phase.

5. Conclusion

This paper describes the first and preparatory steps to creating an appropriate and successful SMS for green areas maintenance activities and implements the so-called operator-oriented approach. Because of the poor scientific literature on this important topic, a preliminary phase was needed to properly structure the problem and define technical parameters, the human factor, and health and safety policies. The preliminary results of risk analysis underline that tasks related to pruning represents the highest level of risk for the operator, followed by grass cutting in the second rank. Seasonal variations in incidence rate for different types of accidents/injuries have been observed. Moreover, it emerged that limited attention to safety aspects is paid. The comparison among criticality indexes λ for all inquired tasks highlights that workers' behavior (λ_{Hu}) and company safety policies (λ_{Po}) are weak elements where safety coordinators' and researchers' attention should be focused.

The final object of our study is to create an SMS model to support, efficiently and effectively, the person(s) in charge and the company safety coordinators who work to improve the quality of urban green areas. The model should be able to generate:

- a field questionnaire to monitor the work site safety level;
- a rapid risk assessment for accidents/injuries of different tasks;
- guidelines for the most common activities/tasks in urban green spaces.

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Lucia Bortolini graduated in Agricultural Sciences at the Faculty of Agriculture, University of Padova, in 1986. PhD in Agricultural Mechanics and Mechanization in 1992. From 1990 to 2002 she was Graduate Technician at the Department TESAF (Land, Environment, Agriculture and Forestry) of the University of Padova, and since 2002 she has been Assistant Professor in the same University for the scientific sector Agricultural Mechanics. Her research activities include (a) the rational management of water resources through the application of innovative irrigation technologies with low environmental impact; (b) the green structures for the sustainable management of the outflows in urbanized environments (green roofs, rain gardens, bioretentions, etc.); (c) the application of hydrological models in agriculture; and (d) the risk analysis in the workplaces for the maintenance of the green spaces. At the University of Padova she teaches Irrigation and drainage in the First Cycle Degree Course in Land and landscape restoration and enhancement and Maintenance of green areas in the Second Cycle Degree Course in Forestry and Environment Sciences. She also organizes extra-curricular courses related to maintenance of green spaces, such as tree-climbing, use and maintenance of the chain saw in man-made environment, and arboriculture. Supervisor of more than 90 Theses and Dissertations and reviewer of some scientific journals. Erasmus Responsible Person for the Degree Course in Land and landscape restoration and enhancement, and Erasmus Departmental Coordinator for some European Universities.

Andrea Colantoni graduated with a Degree in Forestry from the University of Tuscia in 2000; Doctor of Philosophy in Agricultural Mechanization (29th cycle) with the thesis: "Study and development of innovative technologies for small and medium companies for the use of renewable energy sources" (30th December 2010). He is an Assistant Professor (code sector AGR09) at the Department of Agriculture, Forests, Nature and Energy of the University of Tuscia (Viterbo, Italy). He is also a member of the Italian Society of Ergonomics (division of Latium Region), of the Italian Association of Agricultural Engineers, which is part of the European Society of Agricultural Engineers (EurAgEng), of the International Commission of Agricultural Engineering (CIGR), of the Italian Association of Scientific Agricultural Societies (AISSA) for the 3rd edition on "Mechanization and technologies for agriculture" and for the 5th edition on "Ergonomics and work organization". He serves as a technical consultant (temporary contract) at the Experimental Research Centre in Agriculture (CRA), a branch of the Ministry of Agriculture and Forestry, and has the following tasks: research program coordinator for budgeting and reporting, projects, technical support, agreements, and filing. Cooperation with the research activities of the Institute of Prevention and Safety and Health at work (ISPESL)—Department of Hygiene—on "Assessment, measurement and control of microclimate risk in moderate, severe hot and cold environments". His scientific activity is mainly focused on (a) harvesting mechanization of tree crops (hazelnut), industrial crops (tomato) and fibre plants; (b) safety and quality in agro-food and agro-industrial chains; (c) ergonomics and analysis of working loads in agro-forestry; and (d) safety and risk assessment in agro-industrial workplaces and use of renewable energy sources in agriculture.

Massimo Cecchini is an associate professor for the field competition 07/C1 "Agricultural, Forestry and Biosystems Engineering" (SSD AGR/09 Agricultural Mechanics) at the University of Tuscia, which pertains to the DAFNE Department (formerly Institute of Rural Engineering, then GEMINI). Since 2012, he has been the coordinator of the doctoral course in "Engineering of Agricultural and Forestry Systems" (formerly "Agricultural Mechanics") at the University of Tuscia. His scientific activities since October 2000 regarded: (a) the ergonomics and analysis of major workloads from agro-forestry and agro-industrial work environments; (b) occupational safety and risk assessment in agro-industrial work environments; (c) the mechanization of some tree crops (chestnuts, hazelnuts, and walnuts), industrial (processing tomatoes), and harvesting of coloring plants; (d) assessment of the quality and shelf life of mechanically harvested products (chestnuts, fennel, nuts, etc.); and (e) the use of renewable energy in agriculture.

Sirio Cividino Achieved his five-year degree in Agricultural Science and Technology specializing in Economic Management (vote 98/110) with a thesis about job security in the wine sector at the Department of Sciences Agricultural and Environmental University of Udine (speaker Dr. Rino Gubiani). He has a research grant for the study and development of industrial agro-food in the mountains testing activities, design training and dissemination in the areas of local products, wild plants, biomass, and workplace safety.

Rino Gubiani Ricercatore since 1991 in Agricultural Mechanics (AGR 09) at the Faculty of Agriculture, University of Udine. Associate Professor from 2007, Socio AIIA, ASAE, and Ruralia. His scientific activity covered the following topics: complete mechanization of farming operations in vineyards; quality of work in pesticide treatment and calibration systems; analysis of the quality of the treatments sull'asparago; study of the safety and health in the workplace; and the development of guidelines for the design of safety systems and buildings in the wine sector. He has been responsible for several scientific projects, and is the author of about 180 publications in technical science. He teaches at the doctoral school of the University of Padua, Address of technologies, Mechanical Processes of Agricultural and Forestry, and at the University of Tuscia, Agricultural Mechanics.

Lavinia Maria Priscilla Delfanti PhD student in production ecosystems and systems, curriculum systems engineering agricultural and forestry of University of Tuscia, Department of Science and Technology for Agriculture, Forestry, Nature and Energy (Viterbo). Her experimental investigations include new technologies about energy recovery by biomasses and experimental territorial investigation about new agro-energetic districts in Tuscia Romana (central Italy).