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FACTORS AFFECTING ACCIDENTS ON SKI HILLS (Slovenian Case)

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ABSTRACT

Safety on the licensed ski slopes in Slovenia, like in many other winter countries, is a complex notion involving, in addition to ski slope owners and operators, several governmental agencies and functionaries, such as inspectors, supervisors, police, medical staff, and others. We cannot assign blame for accidents to them. Our research, in agreement with the Inspectorate of the Republic of Slovenia responsible for Internal Affairs and the Police Academy, focuses on the causes for skiing accidents. We found out that a skier plays an important role in safe-guarding his/her own safety as well as that of fellow skiers on the ski slopes. Obligations of the skier using a licensed ski slope are described in 10 internationally endorsed FIS Rules of Skiing. We obtained data on ski accidents for three consecutive ski seasons between December 2012 and April 2015. We studied whether or not the skiers followed FIS regulations and whether or not they adequately safeguarded their own safety. We also studied who is most often responsible for ski accidents.

Key words: *safety on ski slopes, causes of accidents, skier, skier's fault.*

VPLIVNI DEJAVNIKI NESREČ NA SMUČIŠČU

IZVLEČEK

Varnost na smučiščih je zelo kompleksen pojem. Zanj so pristojni številni organi- nadzorniki, upravljavci, policija in drugi. Vendar pa krivde za nastanek nesreč ne smemo pripisati njim. Izsledki dosedanjih raziskav in našega raziskovanja, ki smo ga opravili s soglasjem Inšpektorata RS, pristojnim za notranje zadeve in Policijsko akademijo kažejo, da nesrečo v večini primerov povzroči smučar s svojim ravnanjem. Največjo odgovornost za lastno varnost in varnost ostalih smučarjev na smučišču nosi smučar sam, njegove dolžnosti pa so opisane v 10 mednarodno sprejetih smučarskih FIS pravilih. Podatke o nesrečah smo zbrali in obdelali za obdobje smučarskih sezon v letih 2012/2013, 2013/2014 in 2014/2015. Zanimalo nas je, če smučarji upoštevajo predpise in dovolj dobro poskrbijo za svojo varnost. Preverili smo tudi, kdo je najpogosteje odgovoren za nastanek nesreč na smučišču.

Ključne besede: *varnost na smučišču, vzroki za nesrečo, smučar, krivda smučarja*

INTRODUCTION

Safety on ski slopes is a complex and difficult-to-define term. It does not depend only on the ski slope's operations, safety supervisors, and technical conditions that a ski slope is required by law to satisfy; it is also strongly affected by the behaviour of the ski slope's clients, i.e., the skiers themselves. All these factors represent risks for potential skiing accidents to occur (Burton, Brown & Fischer, 1984; Haegeli, Gunn, & Haider, 2012).

Scott and Steiger (2013) studied in detail the external factors that influence the development of skiing destinations in Europe as well as North America, and concluded that the environment depends on climate change. Artificial snow is one of the possible solutions to ever-decreasing snow fall; however, a low client base, i.e., low attendance on ski slopes or difficulties in obtaining funding for the purchase and installation of artificial snow equipment often preclude this solution. Furthermore, Simpson, Gössling, Scott, and Hall in Gladin (2008) state that the production of artificial snow is relatively costly, since it requires a significant amount of energy, the production of which causes an increase in global warming and accelerates the melting of glaciers. Jahn (2005) mentions an interesting technological advance introduced to several glaciers in Austria where these were covered with special white-coloured plastic covers that keep the snow at a constant temperature thereby slowing down the melting of glaciers.

Kipp (2012) describes skiing as a unique activity that requires a certain level of body equilibrium and skill for a proper execution. Joubert (1978), the pioneer of Alpine

skiing in France, explains that a skier is the central element in the execution of a ski turn. According to him, skiers executing a ski turn must remain in steady equilibrium while seeking support from the surface material on which they ski.

According to ZVSmuč (2016, page 2), "a ski run/piste is a section of a ski slope that is dedicated to skiing and is adequately equipped with signage, secured, as well as maintained with regard to its purpose and separated from other areas". A ski run/piste must be equipped with cautionary and informative notices as well signs on prohibitions and obligations.

Ski runs/pistes are classified with various colours for a designation of the level of difficulty. The green colour represents ski runs/pistes for beginners with lateral and downhill slopes not exceeding 25% and the red colour represents intermediate ski runs/pistes with lateral and downhill slopes not exceeding 40%. The steepest and the most demanding ski runs/pistes for which the largest lateral and directional slopes exceed 40% are identified in black (Deutscher Skiverband, 2016). "It is the responsibility of all skiers themselves to evaluate their own skiing ability and choose ski runs/pistes that are appropriate for their skills" (Guček et al., 2011). Kipp (2012) is of the opinion that it is the responsibility of individual skiers to evaluate the available information on the ski runs/pistes of a given ski area before they actually embark on them.

Similarly, Köhne, Kusche, Schaller, and Gutsfeld (2007) concluded that the majority of injured skiers during a six-year period at the German ski resort Garmisch-Partenkirchen used the new model of skis with accentuated side curve (carving skis) and that the type of injury has changed significantly since the introduction of the new ski model. They compared two groups of skiers: a group that used carving skis and a group that skied with traditional ski models. Of specific interest were the differences in the number of injuries to individual body parts between the two groups and they found that the carving skis group suffered a significantly higher number of injuries on the trunk as well as upper and lower extremities than the group that skied on traditional skis.

Mechelen, Hlobil, and Kemper (2012) stress that the classification of sports' injuries depends on the definition of a given sport injury as well as the participation in a given sport. In their opinion the statistical data on sport injuries should be normalized to one hour of a given sport activity. The authors also introduced a model that allows the determination of the causes of sport's injuries and proposed that the level of a given injury should be categorized on the basis of the following seven categories: (i) type of injury; (ii) length of medical care; (iii) type of medical care; (iv) amount of time prevented from practising a given sport activity because of the injury; (v) loss of time from work; (vi) long-term bodily injury; and (vii) financial cost related to medical care. In addition, one needs to define all the causes and mechanisms that influence and act as source of injuries. The last part of the model deals with solutions that may in the future diminish the risk of injuries.

Hu, Baker, and Baker (2009) confirm that the causes of minor and serious injuries are difficult to determine, because they are influenced by various factors, such as the number of skiers on the ski slope, level of difficulty of the ski run/piste, the number of skiing days, and other factors. They note that their investigation of conditions on North

American ski slopes showed that the number of accidents increased during the period from the years 2000 to 2005, despite a decrease in the number of skiers during the same period. Moreover, they also note that hospitals providing data on the number of injuries in various sports' categories do not give a sufficiently large emphasis on skiing.

Caine and Maffulli (2005) and Onik, Szopa, Domagalska-Szopa, Knapik, and Sieroń-Stołtny (2014) have divided accident risks into two categories: non-material and material. Non-material risks of ski accidents include the skier's age, gender, and level of skill, while material risks are influenced by the quality of the skiing equipment, the use or non-use of helmets, and the special characteristics of the ski run/piste. The authors postulate that these two risk categories can lead to ski injuries. The seriousness of the ski injury is evaluated according to the model introduced above. Onik et al. (2014) arrived at the conclusion that the largest number of injured skiers with regard to their age fell within the group of children and youngsters below the age of 16, while the majority of accidents, according to these authors as well as to Caine and Maffulli (2005), can be attributed to falls of skiers that are the fault of the skiers themselves.

McBeth, Ball, Mulloy, and Kirkpatrick (2009) carried out an interesting study of ski injuries that occurred on Canadian ski areas during ten successive ski seasons from 1996 to 2006. They note that a significantly higher number of accidents occurred to skiers who used newer ski equipment. They also surmised that environmental factors play a large role in the number of accidents and proclaim that the afternoon skiing period is the most critical daily period on ski slopes because during that period of the day the quality of snow is the lowest and, on top of this, the skiers, after several hours of skiing, are physically and mentally tired and do not react to danger with the habitual alertness and speed with which they would react in the morning.

Goulet et al. (1999) studied children whose age was below 12 who were skiing at the Canadian ski resort Quebec City during the 1995/96 ski season. They noted that at that time, despite its popularity among the population and the use of traditional ski models, skiing in terms of bodily injuries ranked immediately after hockey. Furthermore, they found that the main causes of ski accidents resulting in bodily injuries were: inappropriate equipment; inadequate knowledge of skiing; low skiing skill level; and use of rented equipment. They also identified the high risks that skiers who rent ski equipment were faced with because of lack of experience with the rented equipment. They established that continuing instruction as well as skill improvement are the key components in the quest to decrease the risk of accidents in skiing and they recommended that beginners in skiing be thoroughly informed on how to deal with ski equipment and on the general rules of, and appropriate behaviour on, ski slopes.

We gave special consideration to serious ski accidents resulting in death. According to an article The Protective Effects of Helmets in Skiers and Snowboarders, these types of accidents are relatively rare in the ski world (Ruedl, Kopp & Burtscher, 2011) and neither recreational nor professional skiers are generally aware of the risks for this type of accident to happen (Williams, 2016). Unfortunately, the awareness of skiing etiquette as well as the appropriate behaviour on ski slopes are on a disappointingly low level among skiers.

Based on a study carried out on the Austrian ski slopes during the ski season 2009/10 and presented in the article Impact of Ski Helmet Mandatory on Helmet Use on Austrian Ski Slopes by Ruedl, Brunner, Kopp & Burtscher (2011) a conclusion can be reached that fatal ski accidents are rare and that the main cause of these accidents is head trauma, self-inflicted by the skier's irresponsible behaviour, such as not wearing a ski helmet while skiing.

As mentioned above, the causes of ski accidents can be attributed to a variety of factors. Williams et al. (2007) and Hildebrandt et al. (2011) place great emphasis on the behaviour of skiers as well as on honouring international ski regulations. Several organizations have been active in this area. Among them, it is worth mentioning the American organization called the Pennsylvania SafeKids Coalition that makes children aware of the importance of ski equipment. In this regard, the biggest impression on children was made by comparing a human head with a coconut that was smashed to pieces in a heavy blow representing a ski accident when no safety equipment such as a ski helmet was used.

After seeing the coconut experiment, all the children committed to wear a ski helmet while skiing. Alexander and Raub (2003) praised this programme pointing out that the knowledge and the understanding which the children acquire during theoretical and practical ski instruction are of great importance. Based on this finding, Hildebrandt et al. (2011) opined that schools as well as other educational institutions based in countries promoting skiing should put more emphasis on discussing safety issues on the ski slopes. We wholeheartedly agree with these authors, since children as well as beginners in skiing, similarly to skilled adult skiers, are all at risk of injury on ski slopes. We believe that an introduction of better schooling in skiing techniques as well as the obligations of all participants on ski slopes would diminish the number of ski accidents and serve to curtail situations that increase the risk of accidents. Of course, the prevention of skiing accidents does not end with teaching the skiers the rules and the etiquette of good behaviour on ski slopes. For example, Tuli et al. (2010) have shown that facial injuries resulted primarily in adult skiers who fell accidentally or collided with another skier on the ski run/piste. They strongly recommended a sensible solution that would prevent or at least alleviate facial injuries, namely the use of a ski helmet during skiing.

Williams et al. (2007) have reported on the importance of using a ski helmet in relationship to brain trauma. A helmet can to a certain degree alleviate the consequences of a ski accident; however, they do not see a ski helmet as the ultimate solution. Rather, they suggest that the best approach to accident prevention is an unconditional honouring of the FIS rules in conjunction with a controlled speed limit on ski slopes. To prevent the most serious bodily injuries Onik et al. (2014) recommend to all skiers the wearing of ski helmets irrespective of their skill level. Caine and Maffulli (2005) also suggest the use of ski helmets for reducing the number of ski injuries and, in addition, recommend the use of wrist shields, appropriate behaviour, and a skiing speed adjusted to the skill level of individual skiers.

All the authors quoted the good reasons presented above for strengthening and improving safety conditions on ski slopes. We believe that the learning process of children

at a young age is very important, because the knowledge that they gain at that time will serve them well throughout their lifetime. Therefore, we strongly support the activities of organizations and projects in Slovenia, such as "Schoolchildren on Skis" that are focused on educating youngsters regarding the rules and codes of behaviour on the ski slopes.

It should be noted, however, that the knowledge of rules and regulations is a necessary but not sufficient safety guarantee for an individual skier on ski slopes. In our opinion, adequate ski equipment as well as a tuned and well-conditioned body that is ready for vigorous sport activity are also of significant importance. This point was of interest to Whelan, Gass, and Moran (1999) who studied the influence of warming-up before skiing on decreasing the risk of skiing accidents. They concluded that a series of stretching exercises has a very beneficial effect, not only on the skiing ability itself but also on the reaction time in situations in which a body that is not properly warmed up would respond sluggishly and this could potentially lead to an accident.

Skiers using Slovenian ski slopes must: (i) follow the so-called ZVSmuč Law (Zakon o varnosti na smučiščih, 2016 – Ski Safety Act, 2016); (ii) honour the international FIS regulations; and (iii) behave following the principle of mutual respect and understanding between themselves and other skiers. They may use the ski slopes in a manner that does not threaten or injure themselves and other skiers, or damage the equipment on the ski slope. In addition, they must adjust their speed as well as the direction of skiing to the ski slope conditions, and they must overtake other skiers allowing sufficient separation between themselves and the skier they are passing. It should also be noted that the amount of alcohol in a skiers' blood is by law limited to 0.24 milligram per litre of exhaled air and that the use of ski helmets is mandatory for all skiers below the age of 14 years.

A skiing accident is defined as an incident that occurs as a result of skiing or some other sport activity on the ski slope and involves at least one skier who either dies, is injured, or causes material damage to the ski slope equipment (ZVSmuč, 2016, page 2). Skiing accidents are divided into the following four categories: (i) accidents without bodily injuries that may involve damage to the ski slopes' equipment, and will not be discussed in this paper; (ii) accidents with minor bodily injuries; (iii) accidents with serious bodily injuries; and (iv) fatal accidents. A wide variety of skiing accidents are possible. For example, the responsibility for the accident may lie with the operator of the ski slope and equipment or with the skier who did not follow the international FIS regulations; the accident may have been caused by a malfunction of the ski lift; or the cause for the accident may be something else, for example the weather conditions. The operator of the ski slope must keep records of skiing accidents, enforce safety standards, maintain the ski slope equipment, and organize the manpower as well as the operation of the ski slope.

RESEARCH QUESTION

The safety considerations for ski slopes have several components. Some authors conclude that the new style "carving skis" has had an effect on the number of ski accidents (Burtscher et al., 2008; Dingerkus & Mang, 2002; Hörterer, 2004; Köhne et al., 2007; Sabeti, 2013). Others (Caine & Maffulli, 2005; Goulet, Régnier, Grimard, Valois, & Villeneuve, 1999; Hu et al., 2009; McBeth et al., 2009; Onik et al., 2014) have tried and some of these have succeeded in proving that accidents can also be caused by other factors, such as the condition of the ski run, environmental factors, ski equipment, skills and the physical condition of the skier, warming up before skiing, etc. Furthermore, several researchers, when studying the causes of an accident, place great importance on the skiers' knowledge and understanding of the international FIS regulations (Williams et al., 2007; Hildebrandt et al., 2011).

We now get to the important question on the cause of the steady increase in the number of accidents on the ski slopes. Are skiers only innocent victims of circumstances or are they themselves responsible for the increase as a result of a lack of understanding of the risks of skiing and their ignorance of the international FIS regulations applicable to ski slopes? A discussion about these questions will serve as a general overview of the accidents on Slovenian ski slopes during the ski seasons 2012/13, 2013/14, and 2014/15. We analysed our data for the three ski seasons and compared our conclusions with those of previous studies by other authors. Our study has contributed to an understanding of the safety and security conditions on Slovenian ski slopes and highlighted possible concrete improvements. Because we had a somewhat incomplete access to data regarding the circumstances surrounding the skiing accidents, we propose that a record is kept over the skier's equipment (ski model and manufacturer, presence of a helmet and its manufacturer) as well as other pertinent characteristics of the accident, such as weather conditions and snow quality, in order to get a more thorough overview of skiing accidents in the future ski seasons. Moreover, to date, we have not noted any study on Slovenian ski slopes that would evaluate the skiers' knowledge of FIS regulations.

The following questions were addressed in our evaluation of the safety standards on Slovenian ski slopes:

- Are there any statistical differences among the causes of ski accidents with minor bodily injuries?
- What is the age of the skiers involved in skiing accidents to determine which age group of skiers contributes to the largest number of accidents?
- What is the age of skiers with respect to the causes of accidents with minor bodily injuries?
- What is the influence of the age of the skiers on the severity of the accidents?
- Are there any statistical differences between the age of foreign skiers and local skiers in accidents with minor bodily injuries?

- Is there a correlation between the number of days of ski slope operation and the number of ski accidents?
- How do weather conditions affect the number of ski accidents?
- Is there a correlation between the number of accidents with minor bodily injuries and the causes of the accident?

METHODS

In our study we used a descriptive method based on local and international literature. In agreement with the General Police Office we analysed their statistical data on ski slope accidents and we also acquired some data from the Inspectorate of the Inspectorate for Internal Affairs of the Republic of Slovenia. We used the methodology of an explanatory case study that is based on a thorough description and study of the available data for each individual situation. We determined and explained the cause – effect relationship among the accidents occurring on Slovenian ski slopes. For our study we chose an analytic method in which we show the acquired data in a tabular or graphic format.

We collected our data from the evidence gathered from accidents with minor bodily injuries by the Inspectorate for Internal Affairs of the Republic of Slovenia and for accidents with severe bodily injuries, as well as for fatal accidents recorded by the Slovenian Police. The statistical results were verified with the Statistical Package for Social Sciences (SPSS), namely, with the statistical methods, the chi-square goodness of fit test, the Mann-Whitney U test, and the Kruskal-Wallis H test.

Skiers, Included in the Research

Our data sample consisted of skiers who were involved in skiing accidents on Slovenian ski slopes during three successive ski seasons: 2012/2013, 2013/2014, and 2014/2015, i.e., for a period from December 2012 to April 2015. The accidents are split into three categories: minor accidents, resulting in light bodily injuries; serious accidents, resulting in serious bodily injuries; and fatal skiing accidents. As shown in Table 1, the total number of injured skiers on the 47 Slovenian ski slopes during the three seasons was 2,804. Of these, 2,683 suffered minor bodily injuries and 121 severe bodily injuries, of which 4 were fatal.

Table 1. Number of accidents

Ski Season Type of accident	2012 / 2013	2013 / 2014	2014 / 2015	Total number of accidents for three seasons
Minor accidents	1,070	648	965	2,683
Serious accidents	40	28	49	117
Fatal accidents	2	1	1	4
Total # of accidents per ski season	1,112	677	1,015	2,804

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs* and from the *Police Academy.*

In the cohort of 2,683 minor injuries, 2,349 injured skiers were the residents of Slovenia, while 334 were from abroad (177 from Croatia, 69 from Hungary, 61 from the UK, and 27 from various other countries).

The ages of the injured skiers ranged from 2 years to 87 years. For greater clarity we split the age range into 8 age groups, as indicated in Fig. 1.

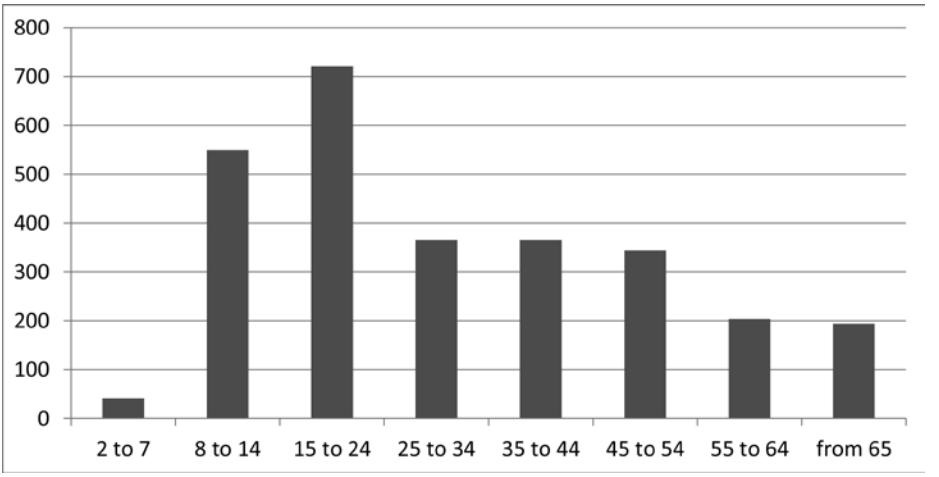

Figure 1. Number of accidents by age (Source: Authors, based on the data obtained from the Inspectorate of the Republic of Slovenia for Internal Affairs and from the Police Academy).

The highest accident rate occurred in the 15 to 24 age group of skiers (721 of 2,804 skiers or 25.9% of the total). Children in the 8 to 14 age group also form a relatively large accident rate of 550 (19.8%) of injured skiers. Next in size are two age groups (25 to 34 and 35 to 44) that represent 365 (13.1%) injured skiers each. The age groups of (45 to 54) and (55 to 64) consist of 344 (12.4 %) and 204 (7.3%) injured skiers, respectively. Skiers in the over 65-year age group were involved in 194 (7.0%) accidents, while children in the 2 to 7 age group had the lowest accident rate with 41 (1.5%) injured skiers. The total number of accidents for all age groups listed above adds up to 2,784, noting that we could not get the age data for 20 skiers injured in 20 ski accidents.

RESULTS

Official reports, in addition to the skiing injuries caused by the skiers to themselves (self-inflicted injuries), list 24 other causes of accidents. Based on the reports recorded for ski accidents with minor bodily injuries, we conclude that by far the largest component of these accidents falls into the category of self-inflicted injury. As evident from Table 2, the self-inflicted injuries amounted to about 50% of all minor injuries that happened during each of the three seasons analysed in our study.

Table 2. Number of minor accidents

Ski season **Accidents**	**2012 / 2013**	**2013 / 2014**	**2014 / 2015**	**Total for three seasons**
All **minor accidents** irrespective of fault	1,070 (100%)	648 (100%)	965 (100%)	**2,683 (100%)**
Minor accidents	588 (55%)	320 (49,4%)	520 (53,9%)	**1,428 (53,2%)**

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

Thus, during the three seasons (from December 2012 to April 2015), of the 2,683 skiers with minor injuries 1,428 (or 53.2%) of them had injurious falls that they caused themselves and the injuries were categorized as self-inflicted and minor. We summarize that a study of the 121 serious accidents (including the 4 fatal ones) would result in a similar conclusion; however, we cannot state this categorically because the data on the causes of serious accidents were not available to us. We recommend that this question be investigated to establish whether or not the probability for serious ski accidents as a result of skier error and lack of skill appropriate for a particular ski run is roughly the

same as the sum of the probabilities of serious accidents caused by all other possible causes.

A closer look into the data for the three ski seasons reveals, as summarized in Table 3, that the number of days of operation from December 2012 to April 2015 was highest during the 2012/13 ski season, amounting on the average to 47.1 days per ski slope or a total of 2,215 days for all 47 ski slopes. The 2013/14 ski season was the shortest of the three seasons studied with on average 26.2 ski days per ski slope and a total of 1,230 days for all 47 ski slopes. The following 2014/15 ski season showed some improvement over the second one with an average of 35.4 days per ski slope and a total of 1,665 days.

Table 3. Number of average operational days and total number of skiing accidents per operational day

Ski season	Average number of operation days per season	Number of skiing accidents per operational day
2012 / 2013	47.13	23.59
2013 / 2014	26.17	25.87
2014 / 2015	35.43	28.65

Source: Authors, based on the data obtained from the *Association of Ski Lift Operators of Slovenia* (GTZ) and the *Inspectorate of the Republic of Slovenia for Internal Affairs*.

Further study reveals on average a total (combined minor plus serious) of 23.6 accidents per day of operation on all Slovenian ski slopes combined during the first season studied, 25.9 accidents per day during the second season, and 28.7 accidents per day during the last season. These data clearly indicate a steady increase in the total average daily number of accidents from one season to the next.

As shown in Table 1, during the three seasons from December 2012 to April 2015 under our study we counted 2,683 accidents on Slovenian ski slopes that resulted in minor bodily injuries (minor accidents). In Table 4 we present for each individual season a comparison of the number of self-inflicted minor accidents with the number of accidents attributed to all other causes for each full day of the ski slope's operation.

Table 4. Number of minor injuries per operational day

Ski season Cause of accident	2012 / 2013	2013 / 2014	2014 / 2015
Skier's own fault	12.48	12.23	14.68
Other causes	10.22	13.64	13.97
Total number of accidents	**22.70**	**25.87**	**28.65**

Source: Authors, based on the data obtained from the *Association of Ski Lift Operators of Slovenia* (GTZ) and the *Inspectorate of the Republic of Slovenia for Internal Affairs*.

Irrespective of the accident causes, the total number of minor accidents during the 2012/13 season amounted to 22.7 per day of operation, during the 2013/14 season to 24.8 per day of operation, and during 2014/15 season to 27.2 per day of operation. It is clear that the highest total number of accidents occurred during the 2014/15 season, the last season in our study.

We verified our study using the chi-square test ($p = 0.196$; $\chi^2 = 5.99$; $df = 2$) whether or not from season 2012/13 to season 2014/15, the number of self-inflicted accidents in comparison to the accidents attributed to all other possible causes combined is increasing through the three seasons. Since the differences from season to season were not statistically significant and the connectivity of the variables is weak, we conclude that minor ski accidents from one season to the next cannot be characterized by a constant ratio between the number of self-inflicted accidents and accidents attributed to other causes.

Of special interest is the question focusing on the effects of the weather conditions on the number of skiing accidents. To investigate this issue, we concentrated on two time periods during which the ski slopes have the highest occupancy rate, namely during the winter school holidays (10 days) and Christmas – New Year holidays (10 days). The Weather Service of Slovenia summarized for us the weather conditions prevalent on the major Slovenian ski slopes during the two 10-day holiday periods for the three ski seasons included in our study.

Under the heading of weather conditions, we studied the wind speed, degree of clouding, height of new snow, presence of fog, and presence of rain. Data presented in Table 5 describe the number of minor accidents that occurred on the ski slopes of Slovenia during the period of Christmas – New Year 10-day holidays and winter 10-day school holidays for three ski seasons (2012/2013; 2013/2014; and 2014/2015) for a period from December 2012 to April 2015.

Table 5. Number of minor accidents for two ski periods

Ski season Ski period	2012 / 2013	2013 / 2014	2014 / 2015
Christmas – New Year holidays (10 days)	142	26	19
Winter school holidays (10 days)	134	158	314
Total number of accidents during the complete season	**1070**	**648**	**965**

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

It is shown that in the second (2013/2014) and third (2014/2015) season discussed in our study, the number of accidents during the 10-day school holidays exceeded those that happened during the 10-day Christmas – New Year holidays. Moreover, during the 10-day school holidays of the third season (2014/2015), the number of accidents amounted to almost a third of all accidents that occurred during the total season (i.e., 314 out of 965). A comparison of the weather conditions for the two holiday periods for a given ski season did not show any significant deviations. During the first ski season we noticed a difference in the average temperature of the ambient air (Christmas-New Year holiday: 0.1°C; winter holidays: -5.8°C); however, we cannot surmise that the higher air temperature during Christmas – New Year holiday caused a higher number of accidents. Even though we found a difference in the number of accidents between the second and the third ski season (Table 5), there were no large deviations in the weather conditions between the two seasons. Since there were no appreciable deviations in the weather conditions in the three ski seasons, we cannot postulate that weather conditions had an appreciable effect on the number of accidents for the individual seasons. A more thorough analysis of the seasons in which there are significant deviations in the weather conditions should be carried out and the conclusions should account for the number of skiers present on the ski slopes.

Of the total number of 2,683 minor accidents during the three ski seasons from December 2012 to April 2015 we obtained data on the causes for 2,314 accidents. The average age of the accident victims was 30.25 years. In **Table 6** we display the distribution of the accidents with regard to their cause based on the data available from the official records on ski accidents compiled on the sites of the accidents by the ski slope's supervisors and the police. Accident causes that appeared at least five times in the official records are specified in Table 6 as follows: (1) the skier fell because of his/her own fault; (2) represents the fall only; (3) the skier was stationary; (4) the skier had just started to move; (7) the skier skied at the tail end (of a group of skiers); (8) the skier

crashed (into a barrier); (10) the skier was stopping with a left turn or right turn; (12) the skier jumped; (15) the skier skied on a run marked with posts; (22) the skier collided with another skier; and (25) the skier was involved in an accident not listed above.

For example, accident category (25) typically includes a stationary skier; merging from the right or left; shadow skiing; rear skiing from the left or right side; passing; skiing in the reverse direction; lingering in a blind spot; sitting under a break-point; crossing the ski slope; skiing with an disconnected safety harness; skiing with unsuitable equipment; skiing with disconnected bindings; walking on the ski run without ski equipment; skiing on a closed ski run; sledding on a ski run; skiing on a ski run under the influence of alcohol or any other psychoactive substance; as well as any other cause of accident that has not yet appeared in the official documents.

Table 6. Number and percentage of light accidents

Designation	Cause of accident	Number of accidents	Percentage of total number	Rank average
(1)	Skier fell because of his/her own fault	1,440	62.2	1,127.28
(2)	Skier fell by no fault of his/her own	492	21.3	1,158.28
(3)	Skier was stationary	18	0.8	750.06
(4)	Skier had just taken off	29	1.3	1,139.53
(7)	Skier skied in the rear	16	0.7	1,431.53
(8)	Skier crashed	48	2.1	1,431.53
(10)	Skier was slowing down	50	2.2	1,432.30
(12)	Skier made a jump	33	1.4	1,157.99
(15)	Skier skied on a run marked with posts	49	2.1	982.83
(22)	Skier collided with another skier	28	1.2	1208.23
(25)	Other infrequent accident causes	111	4.8	1,250.18
Total number	**N/A**	**2,314**	**100.0**	**1,463.31**

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

We found a significant deviation for accidents caused by skiers who either were stationary or jumped resulting in ranks that were significantly lower than in other groups. This suggests that there are significant differences among the average age ranks for various causes of accidents ($p = 0.000$; $\chi^2 = 46.83$; $df = 10$).

Next, we focus on the average age of the accident victims who in their accidents suffered minor or serious (including fatal) bodily injuries and show results in Table 7

during the three consecutive winter seasons (2012/2013; 2013/2014; and 2014/2015) during the period from December 2012 to April 2015. We acquired age data for 2,779 skiers: data for serious accidents were available for all the age groups and we used the average value age values for each group. For the oldest group (age above 64 years) we did not have the maximum age, so we do not know the real median age. Based on our data for minor injuries, we assumed that in the severe injury category the average age for the highest age group was also 69 years.

Table 7. Number of accidents and age rank averages

Bodily injury	Number of accidents	Rank average	Sum of rank averages
Minor	2,658	1,386.43	3,685 142.50
Serious (incl. fatal)	121	1,468.33	177 667.50

Source: Authors, based on the data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs* and from the *Police Academy.*

We then used the Mann-Whitney U test to determine whether or not the seriously injured skiers were on average older than the skiers in the minor injury category. For minor accidents the rank average is 1,386.43, while for serious (including fatal) injuries it is 1,468.33). Our calculations show that differences among various ranks exist; however, we cannot claim that they are statistically significant ($p = 0.272$; $U = 151,331.5$). This means that the average ages of the accident victims with respect to the type of injury (minor versus serious including fatal) are essentially the same.

Since foreigners skiing on Slovenian ski slopes during the three winter seasons from December 2012 to April 2015 represented 12.45% of the total population that was included in the category of minor accidents, we now touch upon foreign skiers in Table 8. The average age of all skiers (local and foreign) was 30.37 years.

Table 8. Number of accidents and age rank averages

Injured skiers	Number of accidents	Rank average	Sum of rank averages
Local	2,069	1,291.40	2 671 910.00
Foreign	582	1,449.00	843 316.00

Source: Authors, based on data obtained from the *Inspectorate of the Republic of Slovenia for Internal Affairs.*

The Mann-Whitney U test was used to investigate whether or not there were any statistically significant differences in the ages of foreign skiers and domestic skiers involved in minor accidents on Slovenian ski slopes. The investigation results in a rank average of 1,291.40 for local skiers and 1,449.00 for foreign skiers. This result is based on almost null risk suggesting a statistically significant difference in rank averages between local and foreign skiers ($p = 0.000$; $U = 530495$) and we conclude that the foreign skiers injured on Slovenian ski slopes during the past three ski seasons were, on average, older than the local skiers.

DISCUSSION

As stated above, Goulet et al. (1999) showed that two of the possible factors affecting the risk of a skiing accident are insufficient knowledge of and the fitness needed for skiing. In Slovenia, the responsible functionaries are not mandated to deal with these issues; however, despite this drawback, our study shows that in more than a half of all minor ski accidents the injuries suffered by the skier are self-inflicted, i.e., are the skier's own fault and caused by the skier's own error.

Our finding that the average number of accidents per day of ski slope operation is increasing from one season to the next is comparable to the situation on North-American ski slopes, as shown by Hu et al. (2009). Both studies showed a steady increase in the accident rates for minor and severe (including fatal) bodily injuries from one season to the next and suggest that for the benefit of tourism and recreational skiing, strong measures will be required to stop this disturbing trend on ski slopes around the world.

Based on our finding that the largest proportion of injuries is attributed to the age group of youngsters and young adults between the ages of 15 and 24 years, we propose an educational innovation: a ski examination that would likely improve the general knowledge of skiing rules and regulations. Educational institutions could introduce this project into special education curricula in a similar manner that they already use with cycling examinations in which Slovenian school-attending children must exhibit a certain knowledge of traffic rules to make their cycling safer.

The ski examination would consist of two components. The theoretical component would focus on the FIS regulations on skiing and the practical component would be part of the already existing programme under the auspices of winter schools in nature or special school days concentrating on various sport activities. Thus, ski examinations would promote skiing as a Slovenian national sport and would also decrease the number of ski accidents that are on ski slopes often caused by the skier's own fault.

Several years ago, one of the Slovenian elementary schools (Osnovna Šola Rovte) already introduced a pilot programme on formal ski education based on theoretical and practical examinations as part of winter school in nature. The programme was very successful and greatly improved children's knowledge of the international FIS rules and understanding of the consequences that can arise from carelessness and ignorance of the rules while skiing (Grom, 2009).

We also investigated the age of skiers for a given minor accident and found that more than one age group fell into a rank average that differed from the other ones. Based on these deviations it has become clear that there are statistically significant differences in rank averages and that age affects the cause of minor accidents. The effect of the age of injured skiers on the type of injury was also of interest to us and we found that both categories of injury (minor and serious including fatal) were roughly the same average age.

We need to mention foreign skiers who visit Slovenian ski slopes and represented 12.45% of the total cohort of skiers with minor injuries. Despite our findings that there are differences between the average age of foreign and local skiers, we believe that it would make sense to modernize the pictograms on ski trails as well as post information on ski slopes in the major foreign languages to decrease accident risks for foreign skiers.

Following the statements above, we believe that our research can contribute to the overall safety on Slovenian ski slopes. Regarding the findings, slopes should promote and ensure that all skiers understand the possible consequences that may result from crazy and irresponsible skiing. It would be advisable to modernize the pictograms that exhibit the FIS rules on Slovenian ski hills, since this move would definitely be attractive to local and foreign skiers, and a larger exposure of skiers to modern pictograms would eventually bring the international FIS rules into the skiers' sub-consciousness.

CONCLUSIONS

Based on the available literature and our results we cannot unequivocally state whether or not skiers on Slovenian ski slopes follow the international FIS ski regulations and the unwritten etiquette of skiing adequately. However, we can safely state that in the majority of ski accidents the skiers are responsible for causing their own injury as well as putting other skiers in danger. In concrete terms, the self-inflicted injuries during the last three seasons on Slovenian ski slopes accounted for 1,428 minor accidents out of a total of 2,683 minor accidents.

Safety on ski slopes is strongly affected by various educational activities for children attending elementary schools during the winter months. Research has shown that children and youngsters are often injured in accidents on ski slopes. Therefore, increasing the awareness of safety issues on ski slopes with a ski examination would clearly result in an improved level of understanding of the FIS rules. Special programmes on ski instruction in elementary schools would also improve the work of commercial ski schools and ski associations, thereby, contributing to an elevated level of knowledge of skiing, understanding the FIS rules, as well as appropriate behaviour on the ski slopes. This would result in increased safety on ski slopes and a concurrent decrease in the occurrence of skiing accidents.

To follow the safety situation on Slovenian ski slopes as well as skiing accidents trends, it would make sense to continue collecting accident statistics in future ski sea-

sons. This would allow us to verify whether or not the number of skiing accidents continues to increase; however, the various governmental agencies involved in the collection of accident data must unify their accident investigation processes and data keeping. This would give a more efficient supervision over the causes of skiing accidents and enable the same data analysis for both minor and serious (including) fatal accidents. As regular users of ski slopes, we believe that ski slope safety is of great importance for the promotion of skiing as a component of the tourism industry. Based on the modest opportunities for the development of the skiing industry in Slovenia, we cannot expect that Slovenia will become competitive with the skiing superpowers Austria and Italy in the near future. However, we believe that Slovenian ski slopes have an optimistic future, provided that the safety of the skiers is strengthened and modernized. This will decrease the number of skiing accidents and help to leave a positive impression on the visitors to the ski slopes.

As for future work, we believe that the area of ski slope safety would benefit from a study of the correlation between weather conditions, ski slope conditions, and skiing accidents, since these factors undoubtedly affect the occurrence of accidents and should be, in the future, recorded in accident reports.

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