

Analysis of an injuries database in Italian ski resorts

Saverio Giampaoli¹, Lorenzo Lupi¹, Luigi Faccia², Antonio Tessitore¹, Sabrina Demarie¹

¹ University of Rome "Foro Italico", Department of Movement, Human and Health Sciences, Piazza Lauro De Bosis, 6, 00135 Rome, Italy

² Scuola Italiana Sci Assergi - Gran Sasso, s.s. 17 bis, 79, 67100 Assergi (AQ), Italy

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Abstract

Background. Italy is one of the main destinations for winter tourism. Specifically, the country can currently count on more than 5.700 km of ski runs, served by more than 1.700 lift facilities

Objective. The purpose of this study has been the analysis of injuries in ski resorts in a continuous period spanning over several seasons (17 years). In addition, the possible effect of safety law enforcements, introduced in the selected period, were considered.

Material and methods. A ski injuries database, prepared as a duty of policemen involved in rescue activity and consisting of 246616 records of injuries for the period from 7th December 2002 to 31st December 2019, has been analysed for qualitative and quantitative variables.

Results. The majority of injuries (58%) occurred on slopes with medium difficulties. After the introduction of national ski safety law (Law 363/2003), a strong diffusion of protective helmet has been noticed. The adoption of the helmet has significantly reduced cranio-facial injuries both in children and in adults. Moreover, no death events were recorded in the database after the introduction of Law 363/2003. The diffusion of ski accident insurance programs is slowly increasing, even if in the year 2019 approximately 38% of skiers still didn't have an insurance program.

Discussion and Conclusions. It is possible to speculate that the introduction of a national ski safety law had a positive effect on injuries reduction. At the same time, collected data underlined several critical points that seem, at least in part, addressed by the law revision performed in 2021.

Riassunto

Background. L'Italia è una delle principali destinazioni del turismo invernale. Nello specifico, può contare attualmente su oltre 5.700 km di piste, servite da oltre 1.700 impianti di risalita.

Obiettivo. Lo scopo di questo studio è stato l'analisi degli infortuni nelle stazioni sciistiche in un periodo continuo che copre diverse stagioni (17 anni). Sono stati

considerati, inoltre, i possibili effetti degli obblighi imposti da norme in materia di sicurezza, introdotte nel periodo prescelto.

Materiali e metodi. Un database predisposto da forze dell'ordine impegnate nell'attività di soccorso e composto da 246616 registrati nel periodo dal 7 dicembre 2002 al 31 dicembre 2019 è stato analizzato per variabili qualitative e quantitative.

Risultati. La maggior parte degli infortuni (58%) si è verificata su pendii di media difficoltà. Dopo l'introduzione della legge nazionale sulla sicurezza dello sci (Legge 363/2003), si è notata una forte diffusione del casco protettivo. L'adozione del casco si è accompagnata ad una notevole riduzione delle lesioni cranio-facciali sia nei bambini che negli adulti. Inoltre, dopo l'introduzione della Legge 363/2003, non sono stati registrati eventi di morte nella banca dati. La diffusione dei programmi assicurativi infortuni sugli sci è in lento aumento, anche se nel 2019 circa il 38% degli sciatori non aveva ancora un programma assicurativo.

Discussione e Conclusioni. L'introduzione di una legge nazionale sulla sicurezza dello sci sembra abbia avuto un effetto positivo sulla riduzione degli infortuni. Allo stesso tempo, i dati raccolti hanno evidenziato alcune criticità che sembrano, almeno in parte, affrontate dalla revisione di legge operata nel 2021.

INTRODUCTION

Since the beginning of the 20th century, the historical change of mountains' economic development, the shifting of attitudes toward nature, and at the same time a progressive expansion of a culture of leisure time in society, skiing has progressively become popular and reflective of the dynamics of modern times (1). After the first ski lift was put into operation in 1908, with the end of the First World War and the opening of the first ski schools in the 1920s skiing became rapidly more popular. However, it will be since the post-World War II economic development, with many goods and services connecting sport and tourism, that skiing became more and more attractive for tourists, leading it into a leisure sport for the masses. Then, the organization of the First Winter Olympic Games, held in 1924 in Chamonix (France), in a cross-border area between France, Italy, and Switzerland, has contributed to the spread of interest for this new sport in northern Italy and Europe.

In Italy, since the first official ski resort opened to the public in 1934, the modernization of the Alps and the expansion of tourist centres, has led to the construction of new stations for winter sports in all country, with ski resorts that have continued to develop, attracting visitors from all over the world and thousands of sport practitioners every day, meaning also that a ski holiday is about more than just skiing (2,3). Specifically, the country can currently count on more than 5.700 km of ski runs, served by more than 1.700 lift facilities (www.skiresort.it database, last access 30th March 2021).

However, this continuous evolution of skiing into a recreational sport activity for a high number of practitioners poses also different factors as potential risk of a skiing injury, which need to be identified (e.g. also in terms of trail design, as architecture, grooming and sites of slopes) (4). Since many injuries depend on the skiing equipment, particularly when the ski acts as a lever that turns or twists the leg, the last years have also been characterized by technical innovations and new devices that have made skis easier to be

handled and more reliable (5). In this regard, most of the advantages come from construction involving many different materials disposed in different arrangements between various parts. Currently, the most used and well-known constructions are those called “sandwich” and “cap”, even if there are also skis presenting a hybrid configuration (6). Moreover, in the last few years research has also focused on clothing improvement, with fabrics and technical features that have improved warmth and comfort, developing new materials and methods to adapt the shape of the outer shell of the ski boot to the skier anatomy (7,8). Thus, to increase skiers safety, prevention rules and recommendations have been drawn up on modes of conduct and for beginners to attend ski schools, such as for children and adolescents to use protective helmets, the work for skiing safety offered by skiing-related organizations-voluntary standards have probably been important in this respect (9). Moreover, a plethora of products and techniques are currently employed at commercial ski areas to help prevent or reduce injuries from impact with man-made structures and other obstacles. The design and function of these products and techniques range from warnings and education to impact prevention, but also to better slope preparation (10).

As already described, the increase of ski tourism has underlined the need for safety regulations. In Italy, the Law 363/2003 (24th December 2003) represents an important milestone in the adoption of standardized procedures all over the country (11). In fact, for the first time a European nation has adopted a national framework for the safety of all ski tourists practising winter sports in ski resorts. In particular, the law focused the attention on the identification of areas dedicated to specific winter sports, on the duties of ski resorts managers, on safety signs, and on the correct conduct of ski tourists (i.e. the requirement to wear the helmet for young skier under 14 years old). While the adoption of Law 363/2003 represented an important step in the prevention of ski injuries, many safety aspects of the different activity in ski resorts were not fully addressed. Particularly, there was a lack of regulations for cross-country ski and for accidents insurance, and only the recent Decree of Law 40/2021 (28th February 2021) has solved these issues with specific duties for the ski area managers, including the implementation of specific insurance programs for the alpine skiers present in the slopes of each ski resort (12).

The value of a safety regulation can be assessed through epidemiological investigations. In this regard, several studies have presented the incidence of injuries in ski, selecting specific seasons or geographical regions. However, due to the lack of a uniform methodology, it is not easy to analyse the variation of specific parameters in a period spanning over several seasons. The lack of continuity of the epidemiological investigations do not allows a critical analysis of prevention tools. The present paper represents a retrospective study based on a historical Italian ski injuries database for the period from December 2002 to December 2019. The availability of this database, composed of approximately 250000 records, allowed a fine and statistically robust analysis of injuries in ski resorts. As far as the Authors know, this is the longest continuous monitoring of injuries in ski resorts ever performed. In addition, considering that Law 363/2003 required a few years for its full implementation, it has been possible to evaluate the situation before law enforcements (years 2003-2005) and the present condition.

MATERIALS AND METHODS

A ski injuries database has been kindly provided by the alpine section of the Italian State Police (Centro di Addestramento Alpino, Polizia di Stato; PS). The database consists of 246616 records of injuries for the period from 7th December 2002 to 31st December 2019. The database has been prepared as a duty of policemen involved in rescue activity in ski resorts (served by 73 police stations) on Alps and Apennines. It has been implemented during rescue activity of Italian State Police on the ski slope: every time that a policeman acted as a rescuer, the database was filled in place with information on the injured person (sex, age, nationality), on the location (including slope type, snow and weather conditions), the winter sports activity of the injured (ski, ski mountaineering, snowboard, other), the kind of injury, the cause of the accident (collision between people, collision with fixed/mobile obstacles, accidental fall, sudden illness, ski lifts accident), the adoption of protective helmet, the availability of accidents insurance.

Slope difficulty in Italy is classified in: ski-baby or ski-school, very easy slopes with maximal slope grade up to 20%; blue, easy slopes with maximal slope grade up to 25%; red, intermediate slopes with maximal slope grade up to 40%; black, difficult slopes with slope grades 40% and up.

The database was provided by Italian State Police to Authors (Rif. Prot. 649, 05/11/2020) in an anonymous format, in accordance with National Privacy Law and European Privacy Regulation, which does not require ethical committee approval (13).

The dimension of ski resorts presented in the database has been estimated considering the km of slopes annotated on the site www.skiresort.it (last access 30th March 2021). Considering that ski resorts were closed in March 2020 as a consequence of the covid-19 pandemic emergency, the collected data can be approximated to the ski resorts situation present in year 2019. Unfortunately, the site www.skiresort.it do not showed the km of slopes in the previous years, and for this reason the analysis of injuries per km was performed only with the data for the year 2019.

The statistical analysis has been performed using percentage values for qualitative variables, average values and standard deviation for quantitative variables. The Student's T Test was used to compare categorical variables between different database subsets.

RESULTS

The analysis of the 246616 records of the PS injuries database for the period December 2002 - December 2019 showed that the majority of rescued persons were males (males 54.7%; female 45.3%) and that the average age was 33 years. Table 1 shows all records divided by severity of injury and winter sports activity. The majority of injured persons were skiers (78.7%). The deaths represented the 0.0068% of the rescues, while sprains represented the most frequent injuries (29.08%). All deaths were recorded in the period December 2002 - December 2003.

Starting from public data ski resorts (slopes annotated on the site www.skiresort.it), it was possible to relate the injuries present in the database with the km of slopes monitored by the rescue service. Figure 1 represents the distribution of injuries in the different Italian regions during year 2019: a total of 15968 injuries were recorded, on an estimation of 3150 km of ski slopes (5.07 injuries per km, i/km). The majority of injuries were recorded

in the area of Trento and Bozen, where there is one of the highest concentrations of ski resorts: 5913 injuries on 764 km of ski slopes (7.74 i/km). The region with the lowest number of injuries was Latium with only 32 events recorded or year 2019: at the same time, it is important to underline that in Latium the PS injuries database considered only 9 km of ski slopes. The lowest injuries per km rate was reported for Aosta valley (western Alps): 1488 injuries on 698 km of ski slopes (2.13 i/km).

Considering the period from 1st January 2003 to 31st December 2019, the average value of injuries per year was 14407 (standard deviation ± 1184) (Figure 2). The data underline a slow increasing trend of the number of injuries per year. The distribution of injuries type is similar in every year: it is remarkable that no deaths are reported in the database starting from year 2004.

The majority of injuries (58%) occurred on slopes with medium difficulties (red slopes), while on high difficulty slopes (black slopes) only 8% of injuries occurred (Figure 3).

Starting from the year 2005, the Italian Law 363/2003 enforced the adoption of safety procedures, including the prevention of injuries from collision with fixed obstacles and the wearing of protective helmets for skiers and snowboarders under 14 years old. Figure 4a shows the percentage of injured persons wearing helmet for each year in the period 2007-2019, considering the category under 14 and the category over 14 (not enforced by law). From the data it is clear that there is a large compliance with law for the category under 14 (more than 95% for year 2019). At the same time, the diffusion of protective helmets in users over 14 years old is slowly increasing, with a value over 77% for year 2019. Unfortunately, these values are not uniform over the country, with higher values of helmet adoption in northern and central Italy, and lower values in southern Italy (Figure 4b).

The value of ski helmet in injuries prevention can be underlined by the reduction of cranio-facial (CF) damages reported after the law enforcement. When incidents before and after law enforcement were compared, data showed that the percentage of CF injuries for the period 2017-2019 was significantly lower than for the period 2003-2005 ($p < 0.01$) both for under and over 14 years old injured person (Figure 5a): in the period 2003-2005 the values were 15.4% (standard deviation ± 1.2) for under 14 and 14% (standard deviation ± 0.6) for over 14 years old; in the period 2017-2019 the values were 11.6% (standard deviation ± 0.7) for under 14 and 9.8% (standard deviation ± 0.6) for over 14 years old. Comparing the two periods, a significant ($p < 0.01$) reduction of rescue activity after collisions with fixed obstacles was reported (Figure 5b).

The diffusion of ski accident insurance programs is slowly increasing. Figure 6 shows the percentage of injured persons without insurance, with an insurance included in the skipass, and with another insurance. In the period 2003-2006 the 60.4% of injured persons was not protected by an accident insurance, while in the period 2017-2019 the value was reduced to 38.8% ($p < 0.01$). This reduction seems mainly the consequence of increased external insurance programs and not of the adoption of skipass insurances.

DISCUSSION

Ski tourism is an important economy sector of mountains regions. Three European nations, Austria, France, and Italy, together with Japan and the United States, represent a

relevant percentage of world's ski tourism: in Italy, approximately 27 million users frequent 349 skiable areas (14). These numbers are the result of a strong growth of ski tourism during the last few decades of XX century, reaching saturation levels in certain mountain tourist destinations and leading to the expansion of other ski resorts (15). Recent difficulties, raised by climate change, lead to adaptation of strategies that are mainly linked to the installation of snowmaking facilities and on the diversification of the main tourist product (16-18). The COVID-19 pandemic emergency has strongly affected tourism worldwide, and several countries closed ski areas: also for this reason, the present study was limited to December 2019 (19). At the moment, the implementation of preventive measures and the increase of vaccinations allowed the reactivation of winter tourisms.

Injury's prevention requires a multisectoral effort involving managers, public health authorities, clinicians, lawyers, and sports technicians (20). In addition, safety programs need evaluation processes, performed through specific epidemiological studies (21). The absence of an international regulatory framework for winter sports tourisms is partially compensated by local regulations. To our knowledge, Italy has been the first European nation that has proposed a national law for safety on ski slopes.

The epidemiological data presented in the present paper are in line with those presented by other Authors: in particular, most injuries are associated with activities on red slopes (moderate difficulties) (22). Red slopes are probably more crowded than other slopes, and this can lead to a higher number of accidents. The slow increase of injuries per year is probably the result of the increasing number of skiers.

The availability of an Italian ski injuries database for the period 2002-2019 can support an analysis of the effect of Law 363/2003 on ski safety. The most evident effect is the reduction of deaths on ski slopes. In fact, the only death events reported in the database occurred in year 2002 and 2003. Probably this result is linked to the enforcement of rules on ski slope management. From the collected data, it seems that the new rules led also to the diminution of collisions with fixed obstacles, an important aspect for the determination of injury severity. In addition, also the adoption of ski helmets has affected the type of injuries, with a significant reduction of CF damages. This is in line with other studies that underlined how safety helmets decreased the risk and severity of head injuries (23,24).

The percentage of skiers using helmet is slowly increasing also in adults, but with a strong variability in different regions. The increase of ski helmet adoption in adults (no mandatory) is still inconsistent in other European nations also, and probably is the result of public discussion and not completely efficacious information campaign (25,26). The national datum on ski helmet usage seems higher than that one reported in other European counties (27).

It is worth also recalling the level of diffusion of accident insurance programs. Even as insurance programs cannot reduce the incidence of injuries, they can support post-accident activities. In Italy the National Health Service guarantees to everyone a medical support, but in case of ski accident, injured people can claim for damages (damaged materials, psychological and social suffering, limitation on own activities) to the person responsible for the event. For this reason, an insurance program for accident responsibilities can be useful. While the percentage of injured skiers without an insurance program has been reduced in the last few years, the year 2019 datum underlined room for

improvement. This aspect has been considered by the new ski safety law recently adopted in Italy (Decree of Law 40/2021): starting from year 2022, any skier (with the exclusion of cross-country skiers) will need to buy a ski insurance program. The new law in addition, is improving safety regulation also for other winter sports activities, ski mountaineering (ski mountaineering) and cross-country. Furthermore, the requirement to wear the helmet is extended to every slope user (alpine skier, sled user, snowboarder, telemark skier) under the age of 18.

It is worth pointing out that the new law also includes the prohibition of skiing under the influence of alcohol. According to epidemiological data, alcohol abuse was often discovered in ski injured persons; alcoholic intoxication leads to reduced perception of danger, increasing the likelihood for serious damage (28,29). Based on an Austrian pilot study, alcohol consumption and behaviours reducing attention (like listening to music during downhill skiing) are more frequent in injured skiers (27).

Considering that several skiers display insufficient safety knowledge in given situations, the decree of law 40/2021 reinforces the importance of a good information on the appropriate behaviour to be maintained on the ski slope. Resort's managers must arrange safety signals and reminders to the rules for safe skiing/snowboarding (30,31).

The main limitation of the PS injuries database analysed in the present paper is probably the missing datum on the number of skiers present on the slopes. Without that datum it is not possible to normalize the number of injuries to the influx of tourists. The attempt to normalise the injuries per km of slopes showed not completely clear results: higher rates are present in eastern Alps and lower in western Alps. Nevertheless, this difference could be linked to a higher affluence in eastern Alps more than to differences in ski resorts.

CONCLUSIONS

As far as the authors know, this is the longest (17 years) continuous epidemiological study on ski injuries. The value of the analysis of a database for the period 2002-2019 is linked to the evolution of winter sports tourism at the beginning of XXI century and to the adoption of safety regulations. The collected data underlined the importance of a national ski safety law, and in particular the adoption of protective helmets. The reduction of CF damages and deaths are valuable results for the safety of skiers. Starting from these considerations, the new recent Italian safety regulation (Decree of Law 40/2021), and in particular the extension of the requirement to wear the helmet to every skier under the age of 18, seems appropriate. Also, other new law requirements, like the introduction of insurance programs, seem to find correct support on the collected data. It will be important to monitor epidemiological data in the next years to perform a technical evaluation of the effect of the new national law.

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DECLARATION OF INTEREST

The Authors declare that they have no conflict of interest.

CORRESPONDING AUTHOR:

Saverio Giampaoli
Università degli Studi di Roma "Foro Italico",
Dipartimento di Scienze Motorie, Umane e della Salute
P.zza L. De Bosis, 6, 00135 Roma
Tel : +39-06-36733478
Email: saverio.giampaoli@uniroma4.it

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Figure 1. Regional distribution of accidents recorded during year 2019 (from 1st January to 31st December; 15968 records on an estimation of 3150 km of ski slopes). For every region the injuries are presented in relationship with the km of ski slopes.

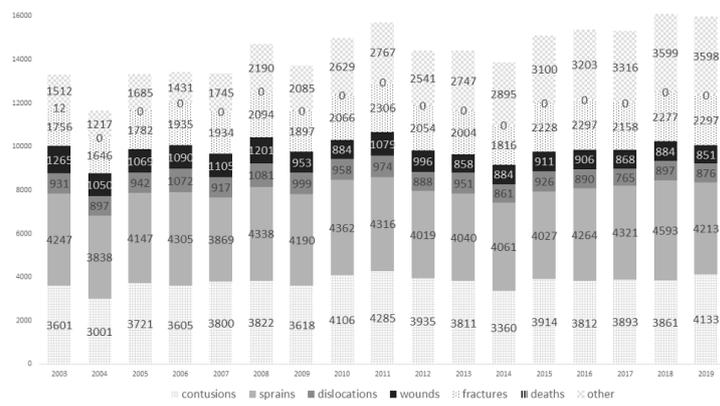


Figure 2. Injuries analysis for the years 2003-2019. For every year the injuries are divided in contusions, sprains, dislocations, wounds, fractures, deaths, other. Raw data are reported on the bars.

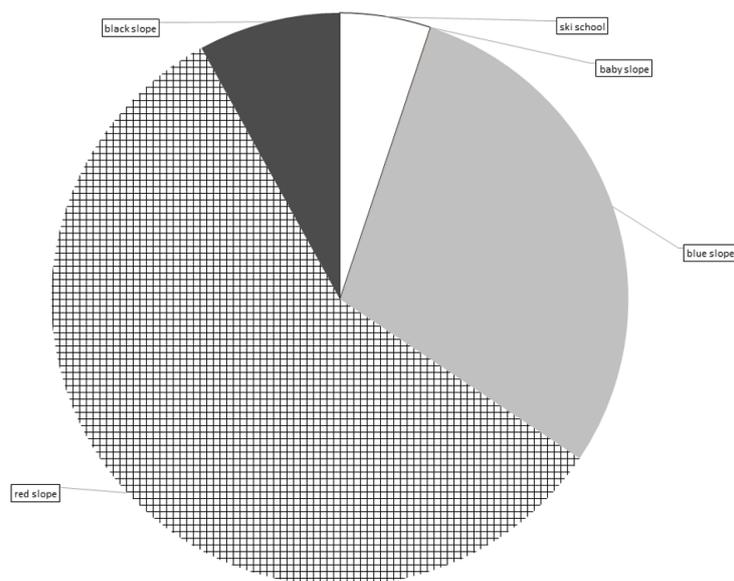


Figure 3. Distribution of injuries per slope type (years 2003-2019): ski-baby, very easy slopes; blue, easy slopes; red, intermediate slopes; black, difficult slopes.

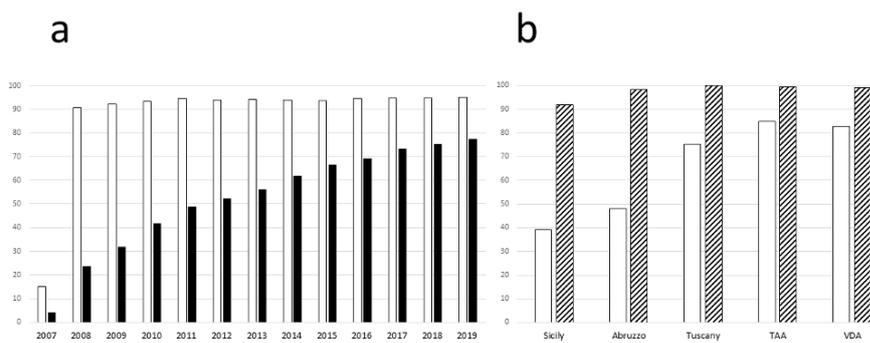


Figure 4. Ski helmet adoption in injured persons. a) Percentage of injured persons wearing helmet considering the period 2007-2019 and the under 14 (white columns) and over 14 years old (dark columns) categories. b) Percentage of injured wearing helmet in under 14 (striped columns) and over 14 years old persons (white columns) in different regions: Sicily, Tuscany, Trent and Südtirol (TAA), Aosta Valley (VDA).

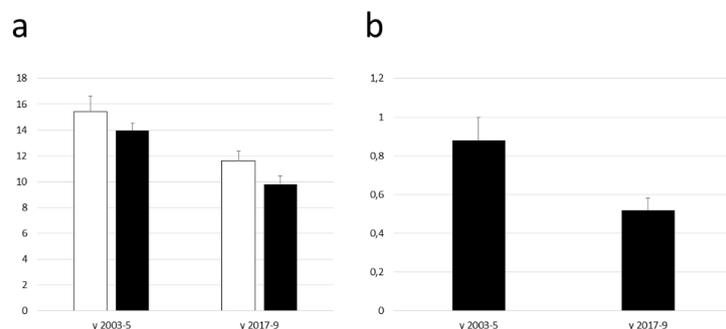


Figure 5. a) CF injuries average values in under 14 (white columns) and over 14 years old (dark columns) for years 2003-2005 and 2017-2019. b) Average values of injuries for collisions with fixed obstacles for years 2003-2005 and 2017-2019.

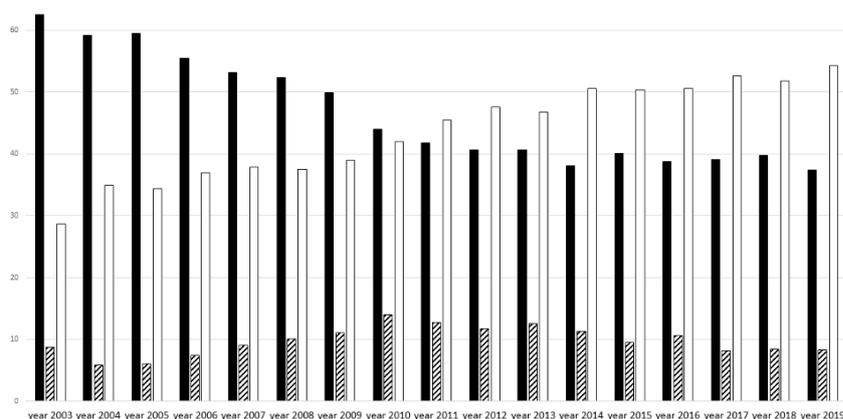


Figure 6. Presence of accident insurance programs: percentage values for injuries recorded in every year (period 2003-2019). Black columns, no insurance. Striped columns, skipass insurance. White columns, other insurance.

	ski	skimo	snowboard	other
contusions	48809	52	13054	2767
sprains	64711	53	6067	884
dislocations	11222	23	4437	274
wounds	13093	43	2577	1327
fractures	23192	52	10277	1229
deaths	11	0	1	5
other	33128	135	5638	3555
TOT	194166	358	42051	10041

Table 1. Classification of injuries recorded in the period December 2002 - December 2019. The 257900 records of accidents are divided for severity/type of injury and activity: ski, ski mountaineering (skimo), snowboard, other. All deaths were recorded in the period December 2002 - December 2003.