

# National Strategy for Preventing Injuries from Skiing and Snowboarding in Switzerland

Giannina Bianchi<sup>1</sup>, Othmar Brügger<sup>1</sup>

<sup>1</sup> bfu – Swiss Council for Accident Prevention, Research Department, Berne, Switzerland

## Abstract

Skiing and snowboarding are very popular sports in Switzerland. However, every year, around 67,000 skiers and 18,000 snowboarders are injured so seriously that they need medical treatment. Moreover around 8 people die on the slopes in Switzerland. Therefore, there is a need to reduce the burden of injuries in snow sports. The Swiss Council for Accident Prevention (bfu) developed a strategy that utilized scientifically-based injury prevention, using an effect-oriented prevention cycle. The aim of this study is to present this systematic and evidence-based strategy for snow sports. Throughout the prevention cycle, the incidence and severity of injuries are established, risk factors and possible prevention measures are identified and rated, prevention goals are set, prevention programs are developed and implemented, and the success of the measures and processes are monitored. In addition, the effect-oriented prevention cycle involves collaboration with other prevention-minded partners. This strategy allows the bfu to carry out its legal mandate to prevent non-occupational accidents and to coordinate prevention measures throughout Switzerland that are effective, efficient, and practical. Furthermore, the collaboration with other prevention-minded agencies greatly improves the implementation.

**Keywords:** Sport Safety Policy, Injury Prevention, Skiing, Snowboarding, Snow Sports

## Zusammenfassung

Ski- und Snowboardfahren sind beliebte Sportarten in der Schweiz. Dabei verletzen sich jedoch jedes Jahr durchschnittlich 67 000 Skifahrer und 18 000 Snowboarder so schwer, dass sie ärztlich behandelt werden müssen. Zudem ereignen sich jedes Jahr rund 8 tödliche Unfälle auf Schweizer Schneesportpisten. Daher ergibt sich im Schneesport ein Präventionsbedarf. Zur effizienten Verletzungsprophylaxe stützt sich die Strategie der bfu – Beratungsstelle für Unfallverhütung auf einen wirkungsorientierten Präventionskreislauf. Ziel dieses Artikels ist, diese systematische und evidenzbasierte Strategie anhand des Schneesports aufzuzeigen. Im Verlauf des Präventionskreislaufes werden das Ausmass und der Schweregrad der Verletzungen ermittelt, Risikofaktoren und mögliche Präventionsmassnahmen identifiziert und bewertet, Präventionsziele gesetzt, Präventionsprogramme erarbeitet und implementiert sowie der Erfolg der Massnahmen und Programme evaluiert. Dabei werden alle Schritte des Kreislaufes in Zusammenarbeit mit Präventionspartnern umgesetzt. Dieses strategische Vorgehen ermöglicht es der bfu, ihren gesetzlichen Auftrag, Nichtberufsunfälle zu verhüten und wirksame, effiziente und umsetzbare Präventionsmassnahmen in der Schweiz zu koordinieren, wahrzunehmen. Zudem verbessert die Einbindung aller Akteure in den ganzen Prozess die Implementierung von Präventionsmassnahmen.

**Schlüsselwörter:** Sicherheitspolicy Sport, Unfallprävention, Skifahren, Snowboardfahren, Schneesport

## Introduction

Skiing and snowboarding are very popular sports in Switzerland with more than 1.7 million skiers and 350,000 snowboarders aged 10 to 74 years (Lamprecht et al., 2008a; Lamprecht et al. 2008b). Beside Austria and Andorra, Switzerland has the highest ratios of visiting skiers to inhabitants (1.66) and visiting skiers to foreign visitors (1.60) worldwide (Vanat, 2014). The 240 ski areas in Switzerland registered 24.8 million visiting skiers during the winter 2011/12 season.

Each year, around 400,000 men and women residents in Switzerland are injured in a sports accident either in or outside Switzerland (bfu – Swiss Council for Accident Prevention, 2013), with an average of 135 fatalities (Bianchi and Brügger, 2013). In addition, on average, there are 61 fatalities among foreigners who suffer a fatal sports accident in Switzerland. Accidents largely occur while skiing, snowboarding, biking, bathing, swimming, playing football, and hiking in the mountains (Brügger, 2012).

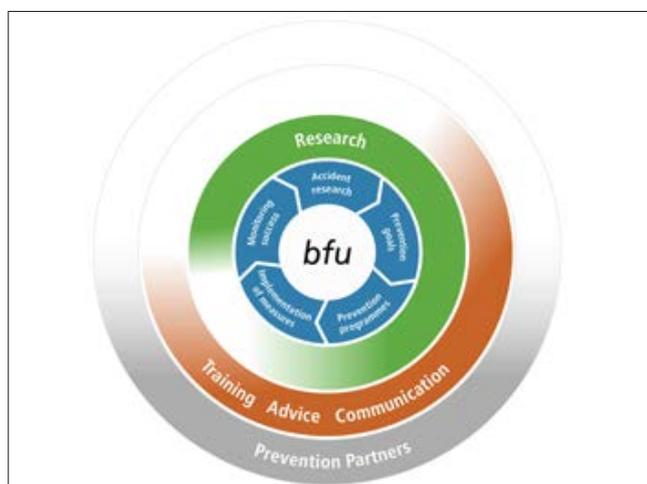
Accidents are avoidable; therefore, the Swiss Council for Accident Prevention (bfu) and like-minded organizations in Switzerland aim to reduce the frequency and/or severity of accidents and injuries by implementing effective prevention measures.

The bfu is a foundation and has a legal mandate to prevent non-occupational accidents in the sectors of sports, home and leisure, and road traffic, and to coordinate prevention measures throughout Switzerland. Thus, decisions are made without economic and political vested interests. The aims and key aspects of the bfu are based on the need for action and knowledge of effective prevention measures; however, social and political aspects and personal resources are considered.

The aim of this study is to present the systematic and evidence-based strategy of the bfu to prevent injuries in snow sports in Switzerland.

## Injury Prevention Strategy

The bfu designed a scientifically-based prevention strategy in Switzerland, using an effect-oriented prevention cycle composed of 5 steps (see *Figure 1*). First, a critical analysis of the incidence and severity of injuries is carried out, etiology and mechanisms of injury are established, and possible preventive measures are framed and rated. Based on this accident re-



**Figure 1:** Effect-oriented prevention cycle

search, realistic prevention goals are defined in consideration of the mission and resources. To outline national prevention programs and implement the measures, prevention-minded partners in Switzerland are involved. Here, bottom-up approaches are also considered. Finally, the success of the prevention process and its interventions are monitored and the findings provide the basis for a new prevention cycle. The different stages are not strictly separate from each other and sometimes a step must be repeated.

The steps of accident research and monitoring of success are carried out by the research department of the bfu. The training, advice, and communication departments of the bfu in collaboration with prevention partners plan and implement efficient programs. Prevention goals are set by the management of the bfu. However, each step involves all experts.

Injury prevention strategies have been described by other scientists. Van Mechelen and colleague's "sequence of prevention" is a four stage approach that identifies and describes the incidence and severity as well as the factors and mechanisms of sports injuries, while introducing and evaluating measures (van Mechelen et al., 1992). Finch et al. considered that the model insufficiently implemented the measures in the real-world and updated the model with two more steps (Finch, 2006). The TRIPP framework of Finch and colleagues complements the "sequence of prevention" by adding stage 5, which describes the intervention in the context of implementation strategies, and stage 6, which evaluates the effectiveness of preventive measures in the context of implementation. Van Tiggelen et al. extended the model of Van Mechelen by considering not only the efficacy, but also the efficiency, compliance, and risk taking behavior, since these factors influence the outcome of the prevention measure (Van Tiggelen et al., 2008).

These prevention strategies correspond in several aspects to the safety strategy of the bfu. However, none of the strategies quantify the clear goals that should be achieved. Each step of the bfu prevention cycle is discussed separately in the following sections.

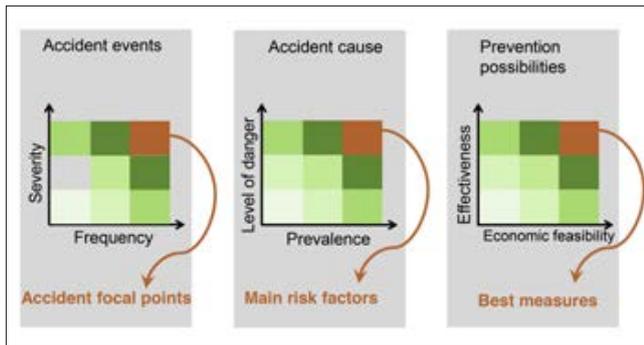
## Accident Research

Accident research detects problems, analyzes and rates the relating risk factors, and identifies and assesses effective prevention measures. Therefore, the following questions are addressed: "What happens?", "Why does it happen?", and "How can it be prevented?" (Brügger et al., 2012).

While a lot of studies report on the frequency and etiology of injuries, few evaluate preventive measures and their efficacy (Klügel et al., 2010). Even fewer studies evaluate the implementation and effectiveness of preventive measures. In addition to scientific, peer-reviewed articles, data are also obtained from surveillance systems in Switzerland and some existing grey literature. However, there was not enough information to quantitatively describe the risk factors and preventive measures. Therefore, the opinions of research and implementation experts and qualitative panel discussions were necessary to rate the risk factors and interventions.

## Accident analysis

To conduct target-oriented injury prevention, the need for action in Switzerland was first identified. The risk of injury and fatality rates as well as the severity of injuries for different



**Figure 2:** Systematic assessment

sporting activities identified the sports where preventive measures should be implemented. Thus, the injury prevention effort in Switzerland focused mainly on areas with high frequency and/or severe injuries and fatalities (Figure 2). Due to the injury frequency, skiing and snowboarding were one focal point of injury prevention in Switzerland (Brügger et al., 2012).

Three main sources provided data on the burden of injuries in snow sports in Switzerland: (1) a national injury surveillance system collected data about non-occupational injuries of employed people; (2) reports from ski patrols; and (3) another database gathered data on fatal sport accidents (bfu – Swiss Council for Accident Prevention, 2013; Bianchi et al., 2013). Finally, the bfu makes an extrapolation to estimate the number of injuries. Thus, this is a comprehensive set of data in contrast to studies based only on data from hospitals or emergency departments, since we also included less serious injuries; consequently, there is less risk of underestimating injury occurrences (Mitchell et al., 2010).

Every year, around 51,000 skiers and 15,000 snowboarders who reside in Switzerland are injured on slopes and require medical treatment (bfu – Swiss Council for Accident Prevention, 2013). An estimated 10% of skiers and 5% of snowboarders suffer their injuries on slopes outside of Switzerland. Moreover, around 40% of injured skiers and 25% of injured snowboarders visiting the rescue center are travelers from other countries (bfu – Swiss Council for Accident Prevention, 2011). Altogether, around 67,000 skiers and 18,000 snowboarders are injured on the slopes in Switzerland and require medical treatment. Moreover, approximately eight people die on slopes each year while skiing or snowboarding (Bianchi and Brügger, 2013). Thus, approximately 3.1 skiers or snowboarders (Swiss inhabitants or guests from foreign countries) are injured per 1000 skier-days on slopes in Switzerland (Vanat, 2014; bfu – Swiss Council for Accident Prevention, 2013). The Swiss Federal Office for Sports (FOSPO) and the bfu calculated in 2008 that skiing and snowboarding had incidence rates of 46 and 68 injured Swiss inhabitants, respectively, per 100,000 hours of activity (bfu – Swiss Council for Accident Prevention, 2013).

However, not only the incidence but also the severity of sports injuries influences the need for action. In Switzerland, the severity of snow sport injuries is defined by the length of the hospital stay. However, the national injury surveillance system also bases the severity on the medical diagnoses, and future efforts may consider the nature of the injury, as previously proposed (van Mechelen, 1997; Pless and Hagel, 2005). Every 20th injury in skiing and snowboarding leads to hospitalization for at least one week and can be classified as “severe” (bfu – Swiss Council for Accident Prevention, 2013). However, 86% and 93% of all injuries in skiing and snowboarding, respectively, do not require hospitalization.

| Temporal dimension | Human   | Vector   | Environment   |  |
|--------------------|---|--|---|--|
|                    |   |  | physical  | sociocultural  |
| Pre-event          | <ul style="list-style-type: none"> <li>– Lack of physical fitness</li> <li>– Inadequate skills</li> <li>– Unfavorable physiological condition (in particular overtiredness and alcohol consumption)</li> <li>– Poor eyesight</li> <li>– Insufficient awareness of danger and lack of self-regulation</li> </ul> | <ul style="list-style-type: none"> <li>– Inadequate or poor equipment</li> <li>– Ski binding set incorrectly</li> </ul>  | <ul style="list-style-type: none"> <li>– Poor trail area design including snowparks</li> </ul>  | <ul style="list-style-type: none"> <li>– Peer pressure</li> </ul>  |
| Event              | <ul style="list-style-type: none"> <li>– Age, gender</li> <li>– Fitness level</li> <li>– Previous injuries</li> <li>– Falling techniques</li> </ul>   | <ul style="list-style-type: none"> <li>– Excessive speed</li> <li>– Ski binding set incorrectly or ineffectively</li> <li>– Personal protective equipment not worn or ineffective</li> </ul> | <ul style="list-style-type: none"> <li>– Collision opponents</li> </ul>                         | <ul style="list-style-type: none"> <li>– Securing accident scene</li> <li>– First Aid</li> </ul>         |
| Post-event         | <ul style="list-style-type: none"> <li>– Age</li> <li>– Fitness level</li> <li>– Previous injuries</li> <li>– Adequate treatment and rehabilitation</li> </ul>  | <ul style="list-style-type: none"> <li>– Accident reporting system</li> <li>– Lifesaving equipment</li> </ul>  | <ul style="list-style-type: none"> <li>– Weather conditions</li> <li>– Accessibility</li> </ul> | <ul style="list-style-type: none"> <li>– Emergency medical services</li> <li>– Rehabilitation</li> </ul> |

**Table 1:** Identification of the main risk factors in skiing and snowboarding in Switzerland using the Haddon-matrix

## Risk analysis

As soon as the extent of injury is established, the question of the etiology arises. Risk factors for skiing and snowboarding injuries in Switzerland have been determined while considering that accidents involve multiple internal and external risk factors (Meeuwisse et al., 2007), as well as the inciting event (Bahr and Krosshaug, 2005). Risk factors can be classified temporally (pre-event, event, and post-event) and epidemiologically (human, vector, and environment) (Table 1) (Haddon, 1980).

| No.                 | Risk factor   | Rating |
|---------------------|---|--------|
| 1                   | Trail area design not optimal   | ⊗⊗⊗⊗⊗  |
| 2                   | Insufficient awareness of danger and lack of self-regulation                  | ⊗⊗⊗⊗⊗  |
| 3                   | Excessive speed   | ⊗⊗⊗⊗⊗  |
| 4                   | Lack of physical fitness and balance  | ⊗⊗⊗⊗⊗  |
| 5                   | Inadequate skill  | ⊗⊗⊗⊗⊗  |
| 6                   | Ski binding set incorrectly or inefficiently                                  | ⊗⊗⊗⊗⊗  |
| 7                   | Wrist protector not worn or its effectiveness is limited                      | ⊗⊗⊗⊗   |
| 8                   | Snowpark: Weak condition or inappropriate behavior of skiers and snowboarders | ⊗⊗⊗⊗   |
| 9                   | Unfavorable physiological condition (overtiredness in particular)             | ⊗⊗⊗⊗   |
| 10                  | Helmet not worn or its effectiveness is limited                               | ⊗⊗⊗    |
| 11                  | Inadequate visual acuity  | ⊗⊗⊗    |
| 12                  | Reckless skiing or snowboarding   | ⊗⊗⊗    |
| 13                  | Wrong falling technique   | ⊗⊗⊗    |
| 14                  | Excessive alcohol consumption   | ⊗⊗⊗    |
| 15                  | Material is inappropriate or in bad condition                                 | ⊗⊗⊗    |
| 16                  | Back protector not worn or its effectiveness is limited                       | ⊗⊗⊗    |
| 17                  | Incomplete policy for skiing and snowboarding safety                          | ⊗⊗⊗    |
| 18                  | Lack of release binding in snowboarding                                       | ⊗⊗⊗    |
| 19                  | Lack of warm up / concentration   | ⊗⊗     |
| 20                  | Hazard areas of cableways and lifts   | ⊗⊗     |
| 21                  | Using carving skis  | ⊗      |
| 22                  | Inefficient rescue  | ⊗      |
| Accident relevance: |   | Scale: |
|                     | very high   | ⊗⊗⊗⊗⊗  |
|                     | high  | ⊗⊗⊗⊗   |
|                     | moderate  | ⊗⊗⊗    |
|                     | low   | ⊗⊗     |
|                     | very low  | ⊗      |

**Table 2:** Main risk factors for injuries in skiing and snowboarding in Switzerland

Once, potential risk factors were gathered, they were rated by an expert group of the bfu based on available data, literature, and panel discussions and in cooperation with external specialists from snow sports in Switzerland. The relevance of each risk factor was based on the level of danger and prevalence (Figure 2, Table 2).

## Intervention analysis

The third step in accident research involves how accidents and injuries can be prevented. Using a top-down approach, detailed analyses of the accident event and injury, as well as the risk factors, indicate where preventive measures should be implemented.

To identify potential measures to reduce the frequency and/or severity of injuries in Switzerland, it was considered that interventions can influence the host (participant), the vector (sport or activity), and the environment (both physical and sociocultural) through three strategies: education, enforcement, and engineering (Gilchrist et al., 2007; Gielen and Sleet, 2006). To predict whether preventive measures may or may not work in a particular context, the effectiveness, efficiency, and feasibility of the measures were monitored in the safety strategy in Switzerland (Table 3) (Brügger et al., 2012). Thus, measures that reduce the frequency or severity of injuries in real world conditions, were considered based on financial, practical, and administrative implications including social acceptability, financial feasibility, technical limits, time resources, legality, and ethical aspects. Measures that were not effective or economically feasible were initially excluded (Figure 2). This assessment is partly consistent with methods described previously by Donaldson (2010), Van Tiggelen et al. (2008), and Runyan (1998).

In regards to risk factors, the main aim of the prevention strategy is to avoid an event. However, not every accident is preventable. Therefore, a lot of prevention strategies reduce the amount of energy transferred from the agent to the host (Pless and Hagel, 2005). Factors concerning care and rehabilitation after the accident were not evaluated by the bfu, since the mission of the bfu is to avoid accidents and injury and not to optimize recovery.

The prevention measures listed in table 4 were (highly) recommended for avoiding injuries on slopes in Switzerland, based on their effectiveness, efficiency, and the feasibility of implementing the measure (Brügger et al., 2012).

## Prevention Goals

The main goal in injury prevention is to reduce the frequency and/or severity of injuries. In a scientific-based strategy, prevention goals have to be defined. According to the top-down approach, targets arise from accident research. In Switzerland, most injury prevention measures are aimed at hazardous sports, involving lots of accidents and/or severe injuries. However, a bottom-up approach can also be used and the safety needs of the population must be considered, even if it is not a focal point of accidents. Moreover, accidents caused by outside variables have to be prioritized. In defining the objectives the mission, legal mandate, economic and ethical principles, and available resources (people, finances, time, knowledge, etc.) are taken into account. The prevention goal is to reduce the rate of injuries within a certain period of time.

Quantitatively, the defined goal in injury prevention in Switzerland between 2010 and 2015 is to reduce the burden of fatalities and severe injuries by 10%.

**Prevention Programs**

Preventive programs consist of different interventions and aim to translate scientific evidence into practical tools and frameworks that can be adopted e.g. by coaches, teachers, governments, industry, tourism, institutions, or participants. The results of the programs can be regulations, rules, guidelines, norms, material developments, training programs, instruction materials, handbooks, movies/radio spots, leaflets, posters, and more.

In Switzerland, measures are worked out in collaboration with all relevant national partners (around 50) in the field of snow sports. Evidence-based interventions are presented to an expert working group of stakeholders to critically review

measures, discuss advantages and drawbacks, and reach a consensus (Finch, 2010; Brussoni et al., 2006). However, with the “bottom-up” approach, measures that are identified as important by partners, including innovative ideas and approaches, are observed, reviewed, and supplemented, if necessary. Potential operators do not only provide content-related input (e.g. usability, format, and messages) (Winston and Jacobsohn, 2010), but also share their experiences with possible stumbling blocks and promising implementation strategies (Collard et al., 2010; Runyan and Freire 2007). Therefore, the prevention efforts and needs of all networkers in Switzerland can be coordinated, duplication can be reduced, more effective interventions can be developed, and a united strategy can be developed to convince target group (Christoffel and Gallagher, 1999; Finch et al., 2011).

Relevant stakeholders include e.g. the Swiss cable car association (SBS), the Swiss Commission for Prevention of Accidents on the Ski Slopes (SKUS), the association of ski- and snowboard schools, Swiss Snowsports, the Swiss Federal Of-

| No. of corresponding risk factor | Prevention goal                                   | Prevention possibilities  | Efficacy | Efficiency | Practicability | Recommendation     |
|----------------------------------|---|---|----------|------------|----------------|--------------------|
| 1                                | Optimization of trail area design                 | Development of a guideline by analyzing accident black spots as well as deficiencies in the trail area design, including possible optimization measures | High     | High       | High           | Highly recommended |
| 2                                | Improvement of risk awareness and self-regulation | Mass media communication and information  | Low      | Medium     | High           | Partly recommended |
|                                  |   | Education of risk awareness in snow sports lessons  | Medium   | High       | High           | Recommended        |
|                                  |   | Optimization of signalization and marking of slopes   | High     | Medium     | Medium         | Recommended        |
|                                  |   | Advising and educating skiers and snowboarders about behavior on slopes   | High     | Medium     | Medium         | Recommended        |

**Table 3:** Example assessment of prevention measures (total rated measures n = 58)

| Research   | Training  | Advice  | Communication  | Cooperation  |
|--|---|---|--|--|
| <ul style="list-style-type: none"> <li>- Accident research</li> <li>- Knowledge management</li> <li>- Statistics on the transportation of people injured</li> <li>- Survey on protection behavior</li> <li>- Study on wrist protection</li> <li>- Study on ski-binding-boot-complex</li> </ul> | <ul style="list-style-type: none"> <li>- Module “Awareness of danger/self-regulatory behavior”</li> <li>- Module “Protective equipment/sports equipment”</li> </ul> | <ul style="list-style-type: none"> <li>- Safe skiing areas</li> <li>- Skiing area design including snowparks</li> <li>- Product safety</li> </ul> | <ul style="list-style-type: none"> <li>- Checking the risk/rules of behavior</li> <li>- Physical fitness and physiological state</li> <li>- Skill</li> <li>- Wearing protective equipment</li> <li>- Optimum equipment</li> <li>- Glasses/eyewear</li> </ul> | <ul style="list-style-type: none"> <li>- Priority program in snow sports</li> <li>- Swiss Commission for the Prevention of Accidents on Snow sport Runs (SKUS)</li> <li>- International discussions</li> </ul> |

**Table 4:** Prevention recommendations for skiing and snowboarding in Switzerland

Office of Sport (FOSPO) that includes the program Youth+Sports (Y+S), the ski federation Swiss Ski, the Swiss National Accident Insurance Fund (Suva), the Swiss association of sport article shops (ASMAS), the sports offices of each canton, public schools, coaches, athletes, and more.

### Implementation of measures

To successfully implement and adopt measures in the real-world, a practical strategy is required (Finch, 2011). As mentioned above, promising interventions are developed in collaboration with relevant stakeholders to optimize the likelihood of success of the interventions. All stakeholders must move in the same direction to strengthen the credibility and importance of a measure, to convince target audiences, and to pool the efforts by communicating the same message (Christoffel and Gallagher, 1999).

A target group in Switzerland can be reached by different channels, e.g. the unique network of “bfu safety delegates” in cities and municipalities, by cable car companies, by rules and regulations, by campaigning on radio/television, print media and events, by product safety laws, by training in snow sport courses/camps, by public schools, sport clubs, and private fitness centers.

Studies about implementation of measures in sports are rare (about 1%) (Klügel et al., 2010); therefore, little information exists on how to effectively disseminate measures in sport communities. Institutions and participants are willing to adopt measures if they bring a benefit to their core business and do not conflict with their philosophy (Finch, 2006). For example, tourism is more likely to support a prevention program and implement measures if it brings in more guests; whereas, athletes are more willing to adopt a program if the measure helps them improve their performance. Interventions are also more likely to be implemented if the target group is fairly prepared, the measures are easy to adopt and accepted by peers and role models, and if consumers know the benefits of implementing the measures (Finch, 2006).

### Monitoring Success

The last step in the effect-oriented prevention cycle involves evaluating the program to identify problems that limit the effectiveness of measures and to monitor the success of an intervention strategy. To assess an intervention program within the safety strategy in Switzerland, four different kinds of evaluations are used: process, impact, outcome (Lowe et al., 2006) and concept. This allows the quality of implementing the intervention to be assessed as well as target-group attentiveness. In addition, we can find out how and why interventions took effect or not, measure if the defined long-term aim of the program has been reached, and estimate the effective potential of the intervention.

Although monitoring success is the last step in the prevention cycle, evaluation precedes the prevention process. For effective evaluation, a plan has to be made at the beginning of the program (Lowe et al., 2006).

Evaluations by the bfu are based on different qualitative and quantitative strategies and methods: analysis of project documentations, surveys (interviews and observations) of skiers and snowboarders on slopes as well in target groups, analyzing injury data, group discussions, media analysis, expert

panel discussions, etc. For example, a campaign to wear a snow sport helmet has been evaluated extensively by external experts on behalf of the bfu (Furrer and Balthasar, 2011; Bianchi et al., 2011). Analysis showed that the campaign concept had the necessary success potential and was implemented as planned. However, the impact of the campaign on the increase of helmet use is unclear. The results suggest that the campaign has reinforced and boosted the effects of various factors that promote helmet use.

### Conclusions

The strategy described in this paper involves a systematic approach to increase the level of safety, using the example of snow sports, in Switzerland. This effect-oriented prevention cycle involves steps from accident research to prevention implementation strategies, in collaboration with other prevention-minded partners in Switzerland. The integration of scientific knowledge and practical experience is often challenging and compromises may have to be made for the interventions to be successful. This effect-oriented prevention cycle provides a good systematic approach for preventing and reducing injuries.

#### Contributorship:

Both authors fulfill the criteria of authorship which are based on substantial contributions to conception and design, drafting the article or revising it critically for important intellectual content and final approval of the version to be published.

#### Corresponding author:

Giannina Bianchi, Research Department, bfu – Swiss Council for Accident Prevention, Hodlerstrasse 5a, 3011 Berne, Switzerland, E-Mail: g.bianchi@bfu.ch, Phone +41 31 390 21 59, Fax +41 31 390 22 30

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