Sauvetage héliporté médicalisé en Suisse : une étude épidémiologique rétrospective de 15 ans d'activités de la Garde aérienne suisse REGA

Lehmann, Michael

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Université de Genève

Faculté de Médecine
Section de Médecine Clinique
Département de Santé
Médecine Communautaires
Policlinique de Médecine

Thèse préparée sous la direction du Professeur Roberto Malacrida

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Thèse présentée à la Faculté de Médecine de l'Université de Genève pour obtenir le grade de « Docteur en Médecine »

Par

Monsieur Michael LEHMANN

de Lugano

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Genève, Octobre 2007

Helicopter Emergency Medical Service in Switzerland - A retrospective epidemiological 15 year analysis of Swiss Air Rescue REGA activities

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Vorrei ringarziare Prof. Dr. Roberto Malacrida, professore di medicina à l'Università di Ginevra per il supporto ricevuto e l'assistenza datami durante la stesura di questo lavoro.

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Zürich im Oktober 2007

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List of Abbreviations

ACLS	*advanced cardiac life support*
ALS	*advanced life support*
APLS	*advanced pediatric life support*
ATLS	*advanced trauma life support*
CHF	*Swiss Franc*
CNS	*Central Nervous System*
GSC	*Glasgow Coma Scale*
HEAS	*Helicopter Emergency Ambulance Service*
HEMS	*the Helicopter Emergency Medical Service*
ICAR	*International Commission for Alpine Rescue*
ILCOR	*International Liaison Committee on Resuscitation*
ISS	*Injury Severity Score*
n	*number*
NACA	*the National Advisory Committee of Aeronautics*
OR	*odds ratio*
PHTCS	*prehospital trauma life support*
REGA	*the Swiss Air Rescue Service*
SPSS	*Statistical Package for Social Science*
UHV	*Ultra High Frequency*
VHF	*Very High Frequency*
NVG	*Night Vision Goggles*
HAPE	*High Altitude Pulmonary Edema*

1. Introduction

The use of helicopters in emergency medical service has had a significant and positive impact on the outcome of critical patients and injury care (Coats and Wilson 1992). The helicopter emergency medical services improve patient care by reducing the time of transfer to hospital, improving the skills available at the scene, or increasing the choice of hospital to which patients can be transferred (Nicholl et al. 1995).

Helicopters were first used for aero medical casualty evacuation in the context of wars fought in the second half of the 20th century, and following the success in the battlefield, civilian services in the United States began to consider their use for transport of the critically injured (Thomas 1988). Following pilot studies conducted in the USA in the late 1960s, the US Department of Transport concluded that the use of the helicopter could provide only limited medical benefits and might be costly (Thomas 1988). Despite this report, civilian Helicopter Emergency Ambulance Services (HEAS) increased in number from just two dedicated HEAS operating in the United States in 1976 to 189 in 1990. Studies have shown that morbidity and mortality can be significantly reduced if prehospital care is rendered quickly and appropriate transfer provided to a tertiary facility (Baxt et al. 1985). Over the years, almost all nations have shown a vastly increased interest in developing helicopter rescue and transport programs. The numerous services which exist today are very different in design due to variations in geography, meteorological conditions, and political traditions (Wegmann et al. 1990).

In the USA, the pre hospital medical transport is based on paramedics and technicians. Some programs also have a flight nurse, and hospital-to-hospital transport also can carry a physician. In the European countries such as Italy, Great Britain and the Netherlands, most of the helicopters are staffed by a physician and a technician. In Switzerland, the helicopters are staffed by a full-time employed physician and a paramedic.

The objective of this study is to present 15 years experience of Swiss Air Rescue Service, REGA´s experience.

1.1. Helicopter as a mode of transport

Advantages

The obvious advantage of using a helicopter is the short transport time. The helicopter is beneficial when time is critical for the patient's arrival at the hospital. More rapid transport to the hospital provides earlier definitive care that is life saving or likely to result in an improved quality of life (Schneider et al. 1992). Another advantage is the ability to access scenes that would otherwise be inaccessible and where the helicopter is the first responder on scene.

The helicopter has a crew with advanced medical skills, experience and medical equipment. The flight is smooth and has fewer vibrations and bumps, which can be beneficial for certain patients, such as those with spinal cord injuries. Most helicopters permit 2 - 5 care team members to access the victim. In addition, important elements of medical care can be transported rapidly by helicopter such as pharmaceuticals, blood, etc. The likelihood of a crash is statistically significantly less important with a helicopter than in a ground ambulance (Schneider et al. 1992, Wills et al. 2000).

Disadvantages

The disadvantages using a helicopter in urban areas are the fact that a helipad is required. If a helipad is not available, the time which is required to access the landing zone may reduce the helicopter's advantage of speed (Schneider et al. 1992). The space and weight limitations of helicopters dictate their use, especially with smaller single engine helicopters. Twin-engine helicopters occupy more than 60% of the emergency medical system helicopter market.

All helicopters have increased difficulty with lifting capability in warmer temperatures (Schneider et al. 1992).

Noise and vibration of the helicopter may interfere with monitoring of the patient. The decibel levels during air transports have been recorded as ranging from 90 to 110 dB (Lachenmeyer 1987). Headsets and helmets are always worn by the medical crew and a headset can be offered to conscious patients to communicate with the crew.

Vibrations having a frequency less than 10 Hz can induce more rapid tiring of muscle, pain, headaches, nausea, vomiting and fatigue (Lachenmeyer 1987).

Weather may limit flights because of decreased ceilings and visibility in fog, rain, sleet, heavy snowfall and thunderstorms. Altitude can be a factor affecting the patient in helicopters that fly over 2500 m.

The cost of operating the helicopter is significantly higher than those of a ground ambulance (Schneider et al. 1992, Snooks et al. 1996).

1.2. Geography of Switzerland

The Swiss Confederation is a landlocked nation state in Central Europe.

The country has an area of 41,285 square kilometers. The geography is characterized by a great diversity. There are three main divisions:

The Jura-mountains (10%) are characterized by their lime-stone composite. They are not as high as the Alps and more simply built. The arch of the Jura spreads over 300 km. The landscape in Jura is divided in three zones: chains, high plains and waved hills.

The Swiss Plateau (30%) is the zone where two-thirds of the population lives. It stretches from Lake Geneva in the south west to Lake Constance in the north east, with an average altitude of 580 m. River valleys, lakes and some plains, but some small mountains are also encountered.

The Alps cover about 60% of the southern part of the country. They are formed by masses of granite and gneiss, of crystalline massifs and limestone. The average height of the mountains in the Swiss Alps is 1,700 m over sea level. The snow line begins at 2,500 m. There are 74 mountains which are 4,000 m or higher, 55 completely inside the Swiss territory and 19 on the border to Italy. There are about 1,800 glaciers in Switzerland. The highest peak in Switzerland is Dufourspitze with 4,634 m in the Monte Rosa massif.

The geography implies that the climate varies significantly from one region to another.

Switzerland enjoys a continental climate, strongly influenced by the mountainous territory varying according to altitude. The valleys and plains have hot summers and cold winters with the mountains colder throughout the year. Temperatures in the Ticino region in the south tend to be warmer, as does the western part of Lake Geneva. The Alpine geography creates a series of regional microclimates: from the Italian-speaking Canton of Ticino with almost a Mediterranean climate, to permanent glaciers and snow fields in the high Alps.

Switzerland has one of the oldest National Parks in Europe. This is in the eastern part of Switzerland in the canton of Grisons.

The population of Switzerland was estimated at 7,489,370 residents in July 2005. With much of the land area being mountainous and one fifth of the country covered by lakes, glaciers, rocks and permanent snow, Switzerland is densely populated, with 237 people per square km in the productive area. In the agglomerations, which cover about 20% of the total surface area, the density is 590 people per square km. There are major differences between the geographical regions.

Switzerland consists of 26 cantons or small states each of which have their own constitution and elected regional assembly. Each canton consists of a number of districts (Bezirke) and each district consists of a number of municipalities (Gemeinden).

1.3. Rescue organizations in Switzerland

Switzerland has many helicopter companies. Eighteen helicopter rescue bases allow them to reach any site of an accident within 15 min. flights after the alarm has been raised. There are three helicopter rescue organizations. REGA (Swiss Air Rescue) is a professional rescue company and AIR GLACIERS (AIRGLS) and Air Zermatt (AIRZMT) are two helicopter companies in the southwest (Valais) which perform rescues in addition to their commercial flying work (Durrer 1993).

1.4. Swiss Air Rescue, REGA

The Swiss Air Rescue Service, REGA, is an independent, non-profit, private organization serving the public. REGA was founded by private initiative in 1952 and since 1982 it is a corporate member of the Swiss Red Cross.

The name "REGA" is made up of the initials "**RE**" from the German word, "**Re**ttungsflugwacht", and "**GA**" from the French name "**G**arde **A**érienne". REGA is a unique organization because it has no financial state assistance.

The foundation is supported by the Swiss population; more than 2.0 million members and patrons to REGA pay an annual fee of CHF 30 per capita or 70 CHF per family. These donations cover more than half of the financial requirements, while the remaining amount is covered by payments from insurance companies for accomplished rescue missions.

In return, REGA does not charge their patrons for services if insurance companies, sickness compensation funds, or automobile insurances do not cover the costs of a rescue mission.

This also applies to extensive search operations in the mountains or cost-intensive repatriations from abroad. The Swiss Air Rescue Service is acting completely on a humanitarian non-profit basis.

REGA occupies in 2007 about 306 full-time employees, among them 36 helicopter pilots, 25 jet pilots, 35 physicians, 18 nurses (for jet operation), 34 medical flight assistants (for helicopter operation), and 38 operators.

The REGA helicopter doctrine states that any location in Switzerland – with the exception of the canton of Valais - should be reached within 15 minutes of flight time.

(Approx. 15 min action radius shown in Fig. 1)

REGA helicopters do not conduct commercial flights. This permits the rescue helicopters to be on permanent stand-by and thus able to respond immediately in case of request.

This doctrine has been accomplished by establishing 10 helicopter bases located throughout Switzerland (in Basel, Berne, Erstfeld, Gsteigwiler, Lausanne, Locarno, Samedan, St. Gallen, Untervaz and Zürich).

In addition, there are three bases – in Mollis, Zweisimmen and Geneva – which are operated by partner organizations (Fig.1)

These bases may be characterized as independent satellites operating on a high level of independency. At its own bases, REGA operates twin-engine helicopters. Agusta A 109 K2, powered by Arriel 1K1 assigned to operation in high altitude environment, or Eurocopter EC 145, powered by 1E2 engines operating on lower terrain, north of the Alps. For missions in rough terrain, the helicopters are fitted with rescue hoists. The Agusta A109K2 is fitted with a 50 meter long cable; the Eurocopter EC145 has a 90 meter long cable. A helicopter base is manned by a pilot, a physician and a paramedic, all of them full-time employees of the REGA.

The Eurocopter EC 145 (Fig. 2) has plenty of space to accommodate patient, physician, pilot and paramedic. It is economical to operate, has a long range and is equipped with a high-performance hoist system. The EC 145 is the completely revised successor of the well-known BK 117 and EC 135 models.

Technical data: 2 engines (Arriel 1E2): 2 x 771 PS, Rotor diameter 11.00 mm, Length: 13.03 m, Height: 3.95 m, rescue hoist with 270 kg max load, 90 m cable, max. flying speed: 240 km/h, operational altitude up to 5,400 meters above sea-level.

The A 109 K2 (Fig. 3) has been customised in line with REGA´s special requirements. It is basically a combination of the well-known and established A 109 C commercial helicopter and the military version, the A 109 K.

Technical data: 2 engines (Arriel 1K1): 2x726 PS, rotor diameter: 11 m, Height: 3.40 m, Length: 13.05 m, max. flying speed: 263 km/h, operational altitude up to 4,500 meters above sea-level, rescue hoist for 2 persons, with a 50 m long cable.

REGA´s philosophy is primarily to transport the physician on scene of the accident, where he can administer first treatment to the patient. The helicopter pilots' secondary task is to transport the patient by air, ensuring that the patient is taken to the hospital which is most suitable for dealing with his or her injury.

REGA´s head office is located at the REGA Center at Zürich-Kloten Airport. Also located here is its Operations Center, which can be contacted around the clock by dialing an emergency number known all over Switzerland. Three dispatchers are on duty in daily shifts 24 hours a day. In addition, there are always up to two physicians on duty at the Operation Center. The Operation Center has at its disposal a country wide emergency radio network, which enables it to coordinate the REGA units throughout Switzerland.

In alpine regions, REGA is primarily called out to assist during mountain rescue missions, skiing accidents, search and rescue flights and evacuation. In the lowland, the majority of the helicopter operations involve road accidents, followed by sports and occupational accidents and finally medical illness-related emergencies.

REGA also flies so-called "secondary missions". These involve transferring emergency patients from one hospital to another. In addition, REGA transports organs; blood, pharmaceuticals, medical manpower and medical equipment in case of urgent request (Stuenzi 2000).

1.4.1. Special equipment

Operations with rescue winches belong to the special missions of the REGA mountain bases. In case that the helicopter is unable to land near the accident's site, a physician or a rescuer is set down from the helicopter near to the patient using the winch. After evacuation the patient and the rescuer are flown to the next landing place, were they are lifted into the cabin and subsequently flown to an appropriate hospital. REGA is one of few private organizations in the world that operates after sunset and during the night using night vision goggles (NVG) for navigation.

The air rescue bag

In the case that the helicopter is not able to land near the site of the accident, and the patient is so severely injured that he cannot be evacuated in an upright sitting position, the physician is set down near to the patient using the hoist. Once he has administered first aid, he lays the patient in the air rescue bag on a vacuum mattress. Both physician and patient are hauled up with the hoist just underneath the helicopter. The patient lies at the level of the doctor's chest, which enables the physician to monitor the patient's condition during the short intermediate evacuation flight. The helicopter flies to the nearest possible landing place, where the patient is transferred into the cabin and flown as rapidly as possible to the next adequate hospital.

The horizontal net

The horizontal net is used to rescue patients with less severe injuries, or even if he has to be evacuated rapidly. It can be used for victims suffering spinal injuries due to the stable net structure even while lifting up the patient in the net. The advantage of the horizontal net versus the air rescue bag is that it can be easily pulled under the patient's body.

The patient, lying completely horizontally in the net, is hooked on to the hoist cable underneath the helicopter and flown, together with the physician, to the nearest landing area. Here the patient is placed onto a stretcher and fixed using a vacuum mattress, then loaded on the stretcher in the helicopter, and flown to the next appropriate hospital.

Arova Rescue belt

This device is used for evacuating a patient rapidly in an upright position. The belt is pulled under the arms and legs and hooked together with a karabiner. The rescuer pulls the patient towards him and is evacuated by means of the winch in a sitting position stabilizing the patient, who comes to rest with his legs just over the rescuer's legs. Many patients with less severe injuries are evacuated with this device.

Long-line rescue system

The long-line system was developed by REGA in collaboration with the Swiss Alpine Club and Air-Zermatt. It is used to rescue injured mountain-climbers from vertical or overhanging rock faces.

An up to 200-meter long rope is suspended from the helicopter, which enables the rescuer to reach the injured person even on steep, vertical rock faces. The rescuer gives the pilot instructions by radio.

If the injured person is located under an overhanging rock, the rescuer can pull himself towards the rock using a telescopic pole. The rescuer hooks the end of the pole onto the rock next to the patient and pulls himself forward him.

Then, he hitches the injured person to the helicopter rescue line. Now, both are transported to the next suitable landing place, where they are transferred into the helicopter (Malacrida et al. 1993).

1.5. The costs of the use of rescue helicopters

The reasons for helicopter use in emergency medical service (EMS) are (Lechleuthner et al. 1994):

- to install a rescue system covering a wide area rapidly, which can be supported by an ambulance system,
- to achieve shorter transportation times to trauma centers in special geographic regions,
- to provide a better quality of medical care, because the staff is more experienced, has better equipment and can reduce morbidity and/or mortality,
- to improve cost-effectiveness. This assumes that specific tasks can be realized more cost-effectively by the use of a helicopter.

In this study we have analyzed the costs and revenues for 2004 comparing the annual report of the year 2004 with the overall balance. Thanks to their annual contributions, the patrons enable REGA to build up a suitable infrastructure to carry out the air-rescue operations. The direct operational costs are covered by health and accident insurances.

For example, in 2004, REGA carried out a total of 12,029 missions. 8,771 operations were performed by means of helicopter of which 5118 were primary missions. REGA employed its own aircraft for 776 repatriation flights, whereby ill or injured patients were flown from a foreign country back to Switzerland. The medical enquiries carried out by REGA´s Medical Service during 2004 resulted in 1,083 patients, which were flown back home from locations abroad.

In the field of primary helicopter missions 1,347 rescues (26.2%) were due to winter sport activity that topped the mission statistics.

Altogether 3,878 (75.2%) of the 5,118 victims transported by REGA in 2004 suffered traumatic injuries. 938 (18.3%) of the transported patients had medical problems. 249 patients (4.9%) were neither ill nor injured. In 2004, 6.5% of the victims (n=331) were found dead on scene (NACA 7).

In 2004, aircraft costs rose in comparison to 2003 as a result of the increase in kerosene prices. In addition to an increase of workforce, the total payroll was raised by 1.5%, leading to a growth in personnel costs from CHF 45.3 million in 2003 to 47.4 CHF million in 2004. Maintenance costs (gasoline, oil, service, replacement and depreciation) of CHF 1.4 million were calculated and compared in accordance to the actual flight operation carried out. Thus, the total costs in 2004 amounted to CHF 105.3 million (Fig. 4).

The REGA´s revenue for 2004 was principally attributable to patron's contributions (CHF 70,477,000) and flight operations (CHF 50,222,000) (Fig. 5). The total revenue for the year under review was a total of CHF 131,370,000.

Thus, the year 2004 closed with a gratifying overall result of CHF 26.1 million. This signified an increase of CHF 5.6 million (+27.3%) in comparison with 2003. With a plus of CHF 1.1 million (1.5%), revenue from patrons´ contributions, donations and legacies exceeded the average growth rate by previous years of approx. 1%.

This development was intensified by a marked increase in the number of flying hours in the field of repatriations, which compensated for the decline in the number of helicopter missions flown. It is notable, that the payments received from insurance companies for missions carried out by REGA cover around 1/3 of the total expenditure; the main financial burden is therefore carried by its patrons.

REGA is an organization which, due to the fact that it operates in two very costly areas, aviation and medicine, needs considerable financial resources and is therefore dependent on public support. The operational deficit is covered by private funds, and above all by annual contributions from patrons.

For missions to be guaranteed, the creation of reserves for the purchase of new aircraft is vital for the fleet, which is continually brought up to date with the latest technological levels in regards to safety and medical equipment. The lowland helicopter fleet has been replaced during the past few years. This means that the total investment volume for helicopters amount to over CHF 120 million and the cost of replacing the 3 ambulance aircrafts was around CHF 100 million. Within the next two years REGA plans to substitute the entire AGUSTA 109 K2 helicopter fleet on mountain bases with the new AGUSTA GRAND helicopter.

Taking into account a period of depreciation of 15 years, the CHF 200 million invested in this way give rise to an annual volume of investment of around CHF 13 million for aircraft alone (Stuenzi 2000).

<u>In conclusion:</u> the key to success in Swiss air rescue lies in the combination of idealism, state-of-the-art technology, personal commitment and a background of people financing all of the above with their annual contributions.

2. The study objectives

The study objectives were:

- to analyze prehospital air care system of whole Switzerland within the past 15 years and its epidemiology changes;
- to discuss the costs associated with HEMS use in Switzerland;
- to determine whether differences exist between pediatric and adult victims transported by helicopter.

Data regarding pediatric helicopter transport are sparse. Moront et al (2002) found that children transported by helicopter were often more seriously injured than children transported by ground. In contrast to this, Tortella et al. (1996b) found no difference between injured children transported by ground and air. Even more lacking is the direct comparison between adult and pediatric aero medical transports. Kotch et al. (2002) noted no difference between adult and pediatric patients transported by helicopter. One of the purposes of this study was to determine whether differences exist between pediatric and adult victims transported by helicopter.

We evaluated correlations between the NACA index and the site of accident and between the NACA index and the accessibility of emergency.

3. Material and Methods

All recorded incidents were analyzed with regard to their frequency, their place of occurrence and their nature.

Selection of Participants

All trauma victims from January 1st, 1991 to December 31st, 2005 with moderate to severe traumatic injury were included in this retrospective study. All primary missions in which a physician accompanied the helicopter, and in which it was possible to reach the destination and transport the patient, were assessed. Patients undergoing secondary transport to a trauma center were excluded from this analysis. During the 15 year period covered by the study, a total of 64,246 patients were treated (an average of 4,283 patients per annum). A medical report, which included information on the emergency situation and the location, was written for each mission.

The data was analyzed by using the Statistical Package for Social Science (Windows version 13.0; SPSS Inc., Chicago, United States).

National Advisory Committee for Aeronautics - NACA scale

The National Advisory Committee for Aeronautics (NACA) developed a simple scoring system for patients receiving air transport during the Vietnam War. It was subsequently modified to incorporate other injuries and acute illnesses.

The NACA-Scale is used in many Swiss, German and Austrian emergency medical systems for demographic description of emergency patients. With certain modifications, REGA adopted this index system in 1982 in effort to standardize the assessment of gravity without recourse to over-complicated calculations and evaluations, thus facilitating an easy on-the-spot assessment (Tab. 1).

It has been shown that the NACA-Scale adequately describes life threat in trauma victims and correlates well with morbidity and mortality (Weiss et al. 2001). Thus it is a valuable tool for demographic purposes in emergency medical systems. The scale can be used to determine the need for intervention by an emergency physician. With this score, trauma patients and patients with medical emergencies were classified at the end of the emergency mission.

Patients´ activity

For each case, we noted the category of activities in which the victims were injured, such as climbing or walking on mountain paths or during free hang-gliding flights, traffic, occupational or skiing accidents, etc. In order to interpret this information, it is important to take into account the topography of Switzerland and its role as a major area for mountain activities.

Area Index

REGA´s own area index is an indicator of the topographical difficulty to access the site of an incident. It takes into account the topographical difficulties associated with reaching a location as well as the accessibility of the location, the possibility of reaching it and the complexity and risk associated with this type of rescue. The index has seven categories (Tab. 2).

Rescue Index

The helicopter flight operations have to establish access to the incident environment, and the method of gaining access to the scene is classified by the REGA's own rescue index shown in Table 3.

In case that the helicopter is not able to land at the scene of the accident, complex flight maneuvers are required. This includes rescue flights where in-and-out hover is practiced as well as winch operations.

In-and-out hover is performed on a sloping surface where it is impossible to land due to the incline. In this situation, the pilot wedges the front of the helicopter tire or ski on the soil.

Afterwards the rescue team disembarks and reloads while the helicopter is in stable hover. Winch operations were required in case of severe inclines or very difficult or even impossible access.

Mechanisms of injury

The mechanisms of injury are presented in Table 4.

4. Results

Between 1st of January, 1991 and 31st December, 2005 REGA helicopter teams carried out a total of 64,245 missions. The amount of helicopter missions rose in this period from 3,481 in 1991 to 5,326 in 2005 (+65%) (Fig. 6).

During the study period, 43,141 (67.3%) male patients and 20,871 (32.6%) female patients were rescued with a median age of 37.0 ± 21.0 years. For 233 victims no data on gender are available. The age of rescued victims ranged from newborn to the oldest with 105 years of age.

8,847 patients (13.8%) were under 15 years (Fig. 7). The average age of the boys was 9.5 ± 4.6 years and for girls 10.0 ± 4.6 years. Boys (n = 5,230; 59.1%) were involved in rescue operation on average about 1.5 times as often as girls (n = 3,617; 40.9%).

4.1. Distribution of operation among cantons

There are no data available on the operation cantons for the period from the 1st of January 1991 to the 31st of December 1992. REGA transported 56,960 victims between January 1993 and December 2005.

The regions of accident of emergency cases are shown in Table 5. The majority of cases were on Swiss territory, while rescues from abroad accounted for approximately 10% (5,880 / 56,960) of all cases during the study period 1993-2005.

The REGA helicopter flew most of the rescue missions in the cantons of Grisons and Bern (20, 8% and 17, 2%), followed by the cantons of Vaud, Ticino and St. Gall (8.0%, 7.1% and 5.8%).

The mountainous regions cover 28,946 km^2 of the country with an average of 136 people per square km. The Swiss Plateau, the plains and hills cover 12,338 km^2 of the Swiss surface with 284 people per square km. During the study period, there were 39,790 helicopter rescue missions in the mountains and 11,290 missions in lowland regions. Thus, the average rate of missions per km^2 in mountains was 1.37 per km^2 and in lowland regions 0.92 per km^2.

REGA flew most of the rescue missions per km^2 in the cantons Appenzell Inner Rhodes (3.6/ km^2), Geneva (3.5/ km^2), Nidwalden (2.7/km^2) and Obwalden (2.4/km^2).
There are remarkable differences in REGA missions flown due to different topographical regions. Figure 8 demonstrates differences in on-scene REGA missions per km^2 between 1991 and 2005 (Fig. 8).

REGA flew 10.3% of its missions in neighbouring countries, most in France and Germany. Most of the 2,647 missions flown outside the Swiss territory without specification were night flights in Germany (Tab. 5).

In the „Dreiländereck", where Switzerland shares its borders with Germany and France, the Basel REGA helicopters are called on by their emergency service partners to transport injured persons, as well as to deal with accidents on the road, at work and during leisure activities.
The Basel helicopter base flies more than half of its missions in the Southern Baden region of Germany, as well as about 5% in Alsace, France.

4.2. Reasons for patient transport

Only 2,269 people (3.5%) transported by REGA helicopters in this period were suffering from conditions not related to trauma or illness.

Trauma

Altogether 53,087 (82.6%) of the 64,245 victims transported by REGA between January 1991 and December 2005 were suffering from traumatic injuries (Tab. 6): 24.2% (n=15,529) of the injured suffered head injuries. 14,722 of these patients (22.9%) had cerebral cranium fractures and 808 patients (1.3%) had other head injuries. 8,010 casualties (12.5%) rescued in the 15 year period suffered from spine injuries and 6,778 (10.6%) had upper limb injuries. Lower limb injuries were found in 11,729 patients (18.3%).
Two third of the patients in the trauma category were men (Fig. 11). 11.6% (n=7,447) of our collective were under 15 years of age.

Multiple injuries

18,551 patients (34.9%) suffered multiple injuries. The most common pattern of injuries is a double combination (n=11,852; 63.9%), followed by a triple combination of injuries (n=5,717; 30.8%) and finally a combination of four or more injured body parts (n = 982; 5.3%).

Head injury occurred most frequently as double combination with spinal injury (n = 1,958; 16.6%). Head injury combined with thorax injury were the second most frequent combination (n = 1,311; 11.1%). The combination head plus upper limb injury was with 1,244 cases (10.5%) only slightly more frequent than the combination head plus lower limb injury with 1,148 cases (9.7%) as shown in Fig. 9.

The most common triple combination consists of head, thorax and spinal injury (n=574; 10%), followed by the triple combination of head, thorax and abdominal/lumbar injuries (n=510; 8.9%). Head injury in combination with both upper and lower limb injuries were diagnosed in 419 patients (7.3%) with a triple injury pattern (Fig. 10).

Medical conditions

10,500 (16.3%) of all transported patients were suffering from medical problems. The most common diagnosis was cardiac disease (n=4,790). 3.6% (n=2,310) of the patients were suffering CNS-diseases.

4.2.1. Body parts injured by study year

There was no statistically significant decrease in patients with injuries to the head. Throughout the study period the majority of injured (between 26% -22%) sustained injuries to the head (Tab. 7).

Lower limb injuries were the second most common, occurring, depending on study year in 14% to 17% of the injured. Limb injuries (upper and lower) taken together represent the majority of all cases (28.9%) (Tab 6).

4.3. Diagnosis in relation to age

Figures 7 and 8 show the distribution of possible causes for rescue operations in relation to age categories in the study collective of 63,403 individuals.
The frequency of accidents increased by age and reached a peak in the 16-30 years of age group (n=15,604; 24.6%). The most frequent reasons for rescue operation in this age group were head injuries (n=4,785; 7.5%), followed by spinal injuries (n=2,925; 4.6%) and lower limb injuries (n=2,642; 4.2%). The frequency of trauma decreased by age and reached a proportion of 18.2% (n=11,565) in the >60 years of age group (Fig. 12).

The number of medical indications instead of trauma as cause for rescue operations also increased by age and predominated in the > 60 years of age group. Thus, the incidence of cardiovascular events in the > 60 years of age group accounted for 3.9% (n=2,452) of all rescue operations. In 0.9% (n=597) of the cases, the second most frequent medical reason for rescue operations in the > 60 years of age group was a neurological disorder (Fig. 13).

The number of injuries in children increased by age and reached a maximum in the 11-15 years of age group (n=4,386; 7.0%). The most frequent trauma in the 11-15 years of age group was head injury (n=1,334; 2.1%), followed by spinal injury (n=1,075; 1.7%) (Fig. 12).

Medical reasons for rescue operations predominate in the ≤ 5 years of age group. Thus, the most frequent medical indications for HEMS transport were CNS disorders (n=210; 0.3%), followed by respiratory diseases (n=143; 0.2%) (Fig. 13).

4.4. Circumstances of incident

The main reason for primary interventions was sport activities: 33.5% (n=21,535) of injuries occurred during winter sport activities, mainly downhill skiing and snowboarding.

24.1% of injuries (15,507 patients) were the result of traffic accident: motor vehicle accident accounted for 6,929 trauma incidents, motor bike accident accounted for 3,376 incidents, 1,701 incidents involved cyclists, 1,664 incidents involved pedestrians and 429 incidents were caused by agricultural means of transport.

The home sector was responsible for 8,402 incidents (13.1%), of which 5,910 were attributable to gardening.
10.2% of patients (n=3,366) were injured during climbing or walking on mountain paths.
6.8% of injuries (4,376 patients) resulted from occupational accidents, mainly at roadwork and during economic activities.

The categories are presented as percentages in Figure 14.

4.4.1. Circumstances of incident by study year

Figure 15 summarizes the categories of activities during the study period. These data show that the frequency of injuries that occurred during winter sports activities decreased from 47.4% in the years 1994 to 1996 to 24.5% in the years 1997 to 1999.
This decrease is very important given that it represents a 58% reduction of injuries during winter sports, and it is also statistically significant ($p<0.001$).
The decrease in the proportion of patients injured by winter sports activities was accompanied by an increase of patients reporting an accident during climbing or walking on mountain paths. This proportion increased slightly to 13.8% in the years 1997 to 1999 and it remained stable until the end of the study.

4.5. Mechanisms of injury

The mechanisms of injuries for the transported patients are shown in Table 8.
The majority of injuries (34.1%) occurred in falls (n=21,889). In 7,998 cases (12.4%), injuries were caused by a collision. 10.5% (n=6,755) of the transported patients suffered from an illness. Various other mechanisms accounted for 28.3% (n=18,207) of injuries.

4.6. Area Index

In 37.4% (n=23,753) of cases, the accident sites were accessible via a normal trafficable roadway. Unsealed roads (n=17,271), which include ski slopes, agricultural roads and lakes, represent the second largest group (27.2%). In 22.7% (n=14,438) of cases, the accident sites were difficult to access (i.e. alpine refuges), whilst 9.8% (n=6,222) of accident sites were very difficult to access (Fig. 16). During rescue operations in these difficult zones, highly trained mountaineers provided technical assistance on request.

4.7. National Advisory Committee for Aeronautics – NACA scale

Figure 17 shows the allocation of 63,409 cases (98.7%) to the NACA scale. The scale is used to determine the indication of the emergency physician's intervention (NACA grade ≥ 3).
2,184 patients (3.4%) were neither ill nor injured but precautionary evacuated (NACA grade 0). Minor injuries (NACA grades 1 and 2) were seen in 12.1% (n=7,665). 26,219 patients (41.3%) were NACA grade 3, while severe or life-threatening injuries (NACA grades 4, 5 and 6) were seen in 37% (n=23,456) of the victims.
Overall, 6.1% (n=3,885) of the victims were dead at the scene (NACA 7).

Figure 18 shows the allocation of 8,759 children (99.0%) to the NACA scale. 5,301 patients (60%) had moderate injuries or illness (NACA index 1-3); 3,026 (34.2%) were in severe condition (NACA index 4-6); and 271 (3.1%) were found dead on rescue team's arrival.

4.8. Special helicopter flight operations – Rescue Index

In 81.3% (n=53,366) of all missions, landing near the accident site was possible. Special helicopter flight operations were often required to gain access to the victim in the alpine environment. Thus, in 15.9% (n=10,105) complex flight operations were required. This included 2,336 rescue flights (3.6%), where in-and-out hover was required, 3,780 rescue flights (5.9%) using the horizontal net, and 893 rescue flights (1.4%) using the air rescue bag.
Winch operations applying Arova belt or similar were required in 2,987 rescue flights (4.6%), while the long-line system was used in 109 rescue flights (0.2%).

On 131 occasions (0.2%) during the 15-year period presented, terrestrial runs by local mountain rescue guides were the only possible route of access (Fig. 19).

4.9. Accident site by NACA index

Table 9 shows the distribution of the NACA index in relation to the accident site.

Patients rescued on normal streets accessible by conventional rescue vehicles, and with a NACA index 3 or lower, represent only 9.9% (n=6,280) of the total, while 21.5% (n=13,635) of the patients with NACA index 3 or lower were rescued on accident sites difficult to reach (e.g. ski slopes). 24.0% (n = 15,171) of the patients with NACA index 3 or lower were rescued on far accident sites. 7.1% (n = 4,909) of these patients were rescued on accident sites difficult or very difficult to access.

27.5% (n=17,421) of the patients with severe injuries were rescued on normal street, while 14.4% (n=9,150) of the patients with NACA index ≥ 4 (i.e. as acute cases) were rescued on remote accident sites difficult to reach or inaccessible.

1,881 patients (3.0%) died in road traffic accidents.

4.10. Special helicopter flight operations by NACA index

In the great majority of cases, landing near the accident site was possible.

During winch rescue operations in difficult areas, patients with life-threatening conditions (NACA 4-6) were most frequently rescued using the horizontal net (n=849; 1.2%), followed by the air rescue bag (n=335; 0.5%) and AROVA belt or similar (n=224; 0.4%). There was a total of 883 casualties with NACA index 7 that were recovered using the winch (n=883; 1.4%) (Tab. 10).

4.11. Medical diagnoses by NACA index 3 and accident site

Table 11 shows the diagnosis in patients with NACA index 3 who were rescued on "normal roads". Although the lives of patients categorised as NACA index 3 are not considered to be at risk, 25.1% (n=1,426) of our study group rated NACA 3 had head injuries and a further 22.2% (n=1,265) had lesions of the spine. Lower limb injuries accounted for 14.2% of diagnoses (n=806), whilst upper limb injuries accounted for 8.7% of diagnoses (n=496). 5.8% of diagnoses were related to the thorax injuries (n=331). Only 0.1% of the transported patients were not injured (n=5).

In the present study, 913 patients with NACA index 3, who were rescued on normal roads, were less than 15 years old. Head injuries were by far the most common diagnose (30.3%), followed by spine injuries (19.4%). 9.6% (n=88) of the children had lower limb injuries, while 5.8% (n=53) had upper limb injuries. 27 patients (3.0%) were suffering from burns. Each eighteenth of the children (2.0%) suffered thorax or abdominal trauma.

181 children (19.8%) were suffering from medical problems. 95 patients (10.4%) were described in the reports to be suffering from CNS diseases and 31 patients (3.4%) had respiratory problems. 6.0% (n=55) of the transported children had various other medical problems (Tab. 12).

5. Discussion

5.1. Types and frequencies of injuries caused by accidents

The present study helps to clarify the types and frequency of injuries that occur on Swiss territory. Knowledge about injury patterns is important for a thorough clinical and radiological evaluation in the emergency hospitals as well as for injury prevention.

Major trauma is the most common cause of premature death in industrialized countries (American College of Surgeons Committee on Trauma, 1993). In low-income countries, death and permanent disability after traumatic injury are a growing public health problem (Murray and Lopez 1997). In 1990, approximately 5 million people died worldwide as a result of injury (Murray and Lopez 1996). For people younger than 35 years, injury is the leading cause of death. By 2020, death from injury will probably increase to 8.4 million (Murray and Lopez 1997b).

Prevention efforts must continue to be a main target of public health systems to reduce trauma deaths. However, despite all efforts, the death toll resulting from trauma remains high (in industrialized countries) or is still increasing (in low-income countries). Emergency medical systems (EMSs) must address this problem and must propose solutions for handling major trauma effectively by means of prehospital and in-hospital services and strategies (Ummenhofer and Scheidenegger 2002).

Most injured patients in the present study were male (67.3%) and in their late 20s or early 30s, though the age range was broad (few weeks to 105 years). This illustrates the attraction and appeal of mountains to different age groups.
The demographics of the present study population reflect the findings in earlier reports of serious winter sport injuries (about 60% - 80% male injured persons) (Hagel et al. 2005, Hotvedt et al. 1996, Lubillo et al. 2000, Prall et al. 1995, Sacco et al. 1998).

In the present study, lower limb injuries (18.3%) were more common than upper limb injuries (10.6%). These differences are logical due to the fact that victims fall feet-first and reduce the speed and absorb the impact of the landing with their lower extremities. Fractures of the ankle involving the tibia and fibula were the most common lower limb injuries (Schindera et al. 2005).

This finding has been consistently reported throughout the literature with variations in incidences. Thus, Hagel et al. (1999) reported a similar incidence of lower extremity injuries in skiers in South Alberta, Canada (22,8%), while Sacco et al. (1998) noted an increased rate of lower extremity injuries in skiers in Vermont, USA (78%).

Ankle and foot injuries were the most common in a Swedish ski area (28% of injuries), followed by knee (20%) and head plus neck injury (17%) (Made et al. 2001).

A prospective study of skiing injuries in Australia showed that lower extremity injuries also were slightly more frequent represented than upper extremity injuries: 42% and 36% of the total number of injuries, respectively (Sherry 1984).

In all these studies, lower extremity injuries were more frequent diagnosed than upper extremity injuries among skiers.

These differences in incidences may be related to many factors, including small sample size, differences in ski equipment or skier experience levels, or different study populations in this retrospective survey vs. prospective survey of patients seeking medical care at ski area.

Although fractures are the most common injuries resulting from winter sport accident, the physician must be alert to other, more severe, potentially life-threatening injuries such as thoracic (4.8%) and abdominal injuries (1.7%), which occurred in the study collective.

Our findings show that head injury is the most frequent injury during winter sport activities (24, 2%). Similar frequencies were also obtained by other investigators (Diamont et al. 2001, Marsigny et al. 1999, Skokan et al. 2003). Head injuries have been previously reported as a leading cause of severe winter sport injury in skiers and snowboarders of all ages (Diamond et al. 2001, Hagel et al. 1999, 2004, 2005, Levy et al. 2002, Macnab et al. 2002, Morrow et al. 1988, Prall et al. 1995, Sherry et al. 1984, Skokan et al. 2003). The incidence of head injuries in winter sport-related activity vary between 20% (Chow et al. 1996, Hackam et al. 1999) and 50% (Prall et al. 1995, Furrer et al. 1995). Differences in percentages of head and facial injuries in other studies may be due to the high speeds attained during the falls, the unforgiving nature of icy objects or the different mechanism of the accident (Schindera et al. 2005).

Head injuries reported in the present study were due to simple falls (34.1%), collisions with some sort of obstacles like other skiers, trees or rocks, posts, pylons, barrier and moving objects such as slope machines and ski lifts (12.4%), with no single predominant mechanism. A similar observation has been reported in skiers and snowboarders in 1 northwestern state, USA, over a 7-years period (Federiuk et al. 2002).

In contrast, Levy et al. (2002) reported that skier-tree collision was the most common mechanism for head injuries and resulted in the most severe injuries and the highest mortality rate.

Nakaguchi et al. (1991) studied head injuries in snowboarders and also found that a simple fall or fall while jumping caused all major head injuries. They also reported that the ground was covered with ice, packed snow in all cases and that none of their head-injured patients wore a helmet. Unfortunately, we do not have information about the quantity of head injured individuals that wore a helmet.

The proportion of patients with injuries to the head decreased during the study period by 15%. The 58% reduction of injuries during winter sports activities in the year 1997 to 1999 suggests that better material such as helmets could have contributed to a reduction of injuries.

In that sense, the US Consumer Product Safety Commission (CPSC) has conducted a survey of patients with head injuries treated in emergency departments and concluded that helmet use could potentially decrease head injuries by 44% (US Consumer Product Safety Commission 1999).

A study of ski injuries in Sweden reported that head injury among skiers wearing helmets was 50% lower than for skiers who did not wear helmet, which confirms the effectiveness of helmets in preventing head injuries (Sandegaard et al 1991). Helmets have also been shown to be protective against head injury in other sports, such as bicycling (Thompson et al. 1996).

Macnab et al. (2002) conducted a case-control study to determine whether helmets protect skiers and snowboarders against head injuries. The researcher evaluated combined head, face, and neck injuries in participants aged less than 13 years. After adjustment for activity, helmets were associated with a 43% reduction in the risk of head, face, and neck injuries no serious neck injury occurred in those that wore a helmet.

Hagel et al. (2005) found in a case crossover study, that wearing a helmet while skiing or snowboarding may reduce the risk of head injury by 29% to 56%.

A case-control study at 8 Norwegian alpine resorts during the 2002 season showed that helmet use was associated with a 60% reduction in the risk of head injury, when comparing skiers with head injuries with uninjured controls (Sulheim et al. 2006).

The effect of helmet use on neck injuries is less clear.

Although controversy remains, helmets are rapidly diffusing as a safety device. Experts and more frequent skiers and snowboarders are more likely to wear helmets, which may indicate that helmets are recognized as a safety device (Andersen et al. 2004).
In the present study, we cannot provide data regarding the use of helmets among alpine skiers and snowboarders. But we believe that the decrease of head injured patients during the study period is due to the increased use of ski helmets on Swiss skiing slopes.

Injury pattern differ significantly between Europe and the United States. Road injuries with resulting blunt trauma still represent the overwhelming majority of deaths in Europe. A survey from Scotland showed an overall incidence of 93% for death after injuries that were the result of blunt trauma (Wyatt et al. 1996). In the United States, on the other hand, penetrating injuries such as gunshot wounds have outnumbered motor vehicle deaths in certain states (Pepe and Maio 1993). Different mechanisms of trauma potentially include different hazards for trauma patients and may require different strategies for treatment.

5.2. The impact of response time on survival of the injured

Time from injury to delivery of advanced care at the accident site has major effect on mortality and morbidity from trauma as shown by numerous studies. In regions where Emergency Medical Services are particularly efficient, reported times from injury to definitive care usually do not exceed 60 minutes (Moeschler et al. 1992).

The term “golden hour” was originally introduced by Cowley (1976, 1977), who is regarded as the pioneer of modern trauma care. Cowley advocated that most trauma patients die of shock, which comes from sluggish or non-existent circulation and the resulting chemical changes in the body. He claims that most trauma patients could be saved if he could stop the bleeding and restore blood pressure within one hour. Patients who have experienced shock for more than one hour will likely die. Surgical intervention within that one hour, therefore, is critical for increasing the patient’s chance of survival. This hour, called “The Golden Hour”, begins the moment the injury occurs.

Given that pre-hospital and initial hospital treatment programs are comparable, experience in the USA has shown that the trauma/EMS regional system will more expeditiously transfer

critical trauma patients with better inter-hospital medical care; the patient will arrive at the advanced level trauma service center in a more physiologic state (Boyd et al. 1982).
In the Springfield region of Illinois, Boyd et al. (1982) reported that hospital categorization and designation of a selected number of trauma centers reduced highway fatalities by 15%. The use of comparable time periods before initiating the trauma program and 2 years later, showed a 29% reduction in highway fatalities for the same region (Boyd 1977). The number of patients with critical injuries directed to trauma centers increased by 60% after designation of these centers and 75% of all non-surviving accident victims went to the regional trauma center.
Cowley documented the effectiveness of a statewide helicopter program, and reported a progressive fall of mortality rate for patients transported by helicopter to a Trauma-Center from 50% to below 20% for a very seriously injured group (Cowley et al. 1973).
Meyer et al. (1976) demonstrated the effectiveness of HEMS by decreased morbidity, length of hospital stay, and medical care cost of spinal cord injured "systems" patients treated within 6 hours through the Illinois trauma and spinal cord injury system, as compared to "non-systems" or delayed entry patients.
Frey et al. (1978) has shown that mortality and morbidity are clearly lower in the trauma patient when he or she is delivered to a more experienced hospital with a greater volume of experience. The experience in Germany and in various counties of the United States showed that 25% or more of patients dying of trauma could be saved (Frey 1983).
Boyd et al. (1983) concluded in an overview article that hospitals having extensive experience with injured patients offer better care to these patients than hospitals receiving only an occasional such patients. Mortality and morbidity rates are lower in more experienced hospitals, where interdisciplinary teams provide coordinated resuscitation, evaluation, and definitive operative management. The skills and teamwork employed in this complex task are improved by practice and repetition, which come only with a large volume of injured patients.

Sampalis et al. (1993) also found a significant reduction in mortality rates following the introduction of a new regional trauma system, and a trend towards shortening prehospital times. Thus, mortality rate during the phases of regionalization decreased from 52% (phase 0) to 18% (phase III). During this period, mean prehospital time significantly decreased, from 62 to 44 minutes.
Mortality increased by 5% for each minute of the prehospital time that elapsed until institution of definitive treatment measures in hospital.

In a meta-analysis, the outcome of prehospital advanced trauma life support (ATLS) was compared to basic trauma life support. An odds ratio (OR) of death of 2.59 for ATLS was attributed to longer on-scene times (Liberman et al. 2000).

Pepe et al. (1987) found that longer rescue times (greater than 40 min) albeit within the first hour did not affect the outcome. This finding was true even for the most severely injured patients. In addition, time used for prehospital interventions such as endotracheal intubation, venous access, or immobilization should save time in emergency room treatment and thus not necessarily increase the injury-to-operating room interval. Cayten et al. (1986), Reines et al. (1988), and Spaite et al. (1991) also were unable to establish a relationship between increased mortality rates and longer prehospital periods.
Perhaps the lack of designated emergency departments and less well-structured in-hospital performance in Europe accounts for the loss of time that is expected to be gained by these accident scene procedures.

Osterwalder (2002) found that the mortality in blunt polytrauma patients with prehospital rescue periods ≤ 60 minutes (group 1) was 14% and was not statistically significantly higher than the 10.2% observed in blunt trauma patients with rescue periods > 60 minutes (group 2). The researcher concluded, that in this trauma system, where emergency physician often are deployed, the "golden hour of shock" can be extended safely in many blunt polytrauma patients, since this was associated with better survival figures than in those patients for whom the time was ≤ 60 minutes.
A series of other publications confirm these results (Cayten et al. 1986, Hedges et al. 1988, Pepe et al. 1987, Petri et al. 1995, Reines et al. 1988).
The Swiss experience in the prehospital care could serve as an example for other countries, and is based on the success of the REGA (Stauffer 1995).

Moeschler et al. (1992) showed that on Swiss mountains, delays before admission to the hospital can be very long, greatly exceeding those in urban or rural areas.
In the Alps of Switzerland, the mean time from call to the deposit of the rescue team with the winch was 21.5 minutes. Very long response times (>30 minutes) were the result of very difficult access, making direct deposit of the team on scene impossible even with the use of the winch, or of the need to search for the accident site that had not been described precisely. Mean scene time was 37.8 minutes. Severity of disease and performance of advanced proce-

dures affected scene time significantly: 34.5 ± 2.6 minutes for NACA grade 1-3 cases versus 44.5 ± 2.7 minutes for NACA grade 4-6 cases ($p<0.05$). Difficulty of access did not affect time spent at the scene. Mean flight to the hospital was 10.5 minutes (range: 3-27 minutes) (Moeschler et al. 1992).

In this study, the response time was not analyzed, since previous studies from REGA showed that, generally, every place in Switzerland can be reached within 15 minutes flight by a rescue helicopter (Durrer 1993). Consequently, physicians are frequently confronted with severely injured patients who would not have survived otherwise (Rohrer 1999/1991). Physicians have to be physically fit and must be trained in alpine technique as well, since almost two thirds of all rescue missions (n=24,788) between 1991 and 2005 were topographically rated D-G (Tab.2/ Fig.16).

Treatment starts even in difficult sites if rescue risks allow it and the degree of injury (NACA>3) demands it. The assignment of trained air rescue physicians improves the efficiency of first treatment at the scene of accident even in difficult and extremely inaccessible mountain areas (Durrer 1993).

REGA's experience in the prehospital time supports the literature data.

5.3. Helicopter mountain rescue

The main reason for rescue flights in this study was winter sport activities (33.5%; n=21,535). 10.2% of patients (n=3,366) were injured during climbing or walking on mountain paths. In 15.9% (n=10,105) of accidents, complex flight operations were required. REGA was responsible for two thirds of all rescues in the off-road areas (38,797 cases; 61%) (Fig. 9).

All REGA rescue missions are registered according to medical (National Advisory Committee for Aeronautic (NACA)) and topographical index.

The NACA scale is used to indicate the overall assessment of a trauma as well as of an acute internal medicine disease. Of the total flights, transportation was also provided for 2,184 non trauma persons (3.4%). In 22.7% (n=14,438) of cases, flight operations take place in difficult accessible sites of accidents, while 9.8% (n=6,222) of the accident sites were very difficult to access. 1.4% (n=866) of flight operations were extremely difficult rescues, e.g. upon the north faces of the Eiger or the Matterhorn.

For winch-rescued persons with NACA index >3, medical assistance is considered to be necessary at the site of accident. The assignment of experienced emergency physicians, trained in alpine techniques, improves quality of preclinical treatment even in difficult sites, although clinical demands are not always completely practicable in the field and possibilities of treatment are often limited by adverse climate and/or topography.

An efficient medical-assisted helicopter rescue service has an important impact on the survival chances following alpine sport accidents.

Rapid transport of a trained physician to the patient can save precious time and allows prompt control of respiration and circulation at the scene of the accident (Malacrida et al. 1993). Malacrida et al. (1993) showed that in Southern Switzerland fast rescue by a helicopter equipped with a winch and with an experienced emergency physician on board can prevent secondary cerebral damage after accidents in remote mountain areas.

5.4. Role of physician in prehospital trauma care

The composition and training of the EMS crew is an important component that affects the success of the transport (Snow et al. 1986). The transport team should be able to continue or to increase a level of sophisticated medical care. Team members such as physicians or nurses skilled in the transport of critically ill or injured patients can be added to the crew if necessary. Factors that affect the selection of medical transport team members include (Schneider 1986):

- Experience of personnel,
- General physical condition,
- Physical agility,
- Weight and height requirements,
- Response to stress,
- Ability to handle fatigue,
- Leadership, teaching, good communication expertise, and
- Enthusiasm, motivation, and dedication.

The medical transport team in the aircraft represents a higher level of care brought to the patient than the normal ground ambulance.

The vehicle orientation should include the use and location of essential equipment and other vital supplies such as oxygen hook-up, breathing-apparatus, and cardiac monitor. Training

should review how to secure and release mounting systems, evacuate patient and crew if a crash or fire were to occur and use radio equipment.
Formal training includes didactic and skills sessions. The training course content includes care and monitoring of adult and/or pediatric patients during transport; technical skills such as insertion of chest tube, central lines, intraosseous infusions, pericardiocentesis, intubation, and cricothyroidotomy, operation of transport equipment, knowledge of and adaptation to the physical environment of the transport vehicle, and physiologic consequences of the transport on the patient (Blumen et al. 1989, Schneider 1986, Stohler and Jacobs 1989). Additional training or certifications that most EMS helicopter medical transport teams acquire include advanced cardiac life support (ACLS), pediatric advanced life support (PALS), advanced trauma life support (ATLS), and prehospital trauma life support (PHTLS).

There has been controversy and debate if a physician can impact the mortality and morbidity of patients compared to an intervention of a well-trained nurse/other combination team.
Data from adult and neonatal transports suggest that physicians are not always required as a part of the team (Baxt and Moody 1987, McCloskey and Orr 1991, Rhee et al. 1984, Snow et al. 1986). Most pediatric transport teams continue to use physician because of the variety of ages and illnesses involved in pediatric transports and the scarcity of data to refute the necessity of a physician (McCloskey and Johnston 1990, McCloskey and Orr 1991).
A physician may fly as a regular member of the team or only on special flights (e.g. neonatal, pediatric, high-risk obstetric, cardiac, trauma, or at the request of the referring physician). Sending an inexperienced resident may not be beneficial for patient care or as a training experience for the physician (Schneider 1992). The debate continues over the optimal composition of the team that will yield the greatest decrease in mortality and morbidity.

Rescue flight personnel in the United States are paramedic based, whereas in many European countries, emergency physicians are part of the prehospital team. European emergency medicine, except for the United Kingdom, is practiced exclusively in the prehospital setting (Arnold 1999). Although emergency physicians receive special education and training for their prehospital work, possible advantages of this model are flawed by several disadvantages. Emergency medicine is not an officially recognized specialty within central Europe and, accordingly, there is no commonly accepted basis for standards of care, standard operating procedures, guidelines, or algorithms for the prehospital setting. There is considerable fluctuation in physicians who staff EMS units, which is associated with a constant loss of experience and acquired routine (Arnold 1999, Ummenhoffer and Scheidegger 2002).

It has been demonstrated that emergency physicians perform invasive procedures more efficiently and rapidly than paramedic teams (Baxt and Moody 1987, Demartinez et al. 1992). In contrast, Sampalis et al. (1993) found no advantage for the prehospital use of physicians for patient's outcome. The care provided by paramedics was more consistent and standardized.
Moreover, a comparison between a German and an American air rescue system that evaluated prehospital procedures and outcome of patients with multiple injuries found that, although invasive techniques were more often performed in the physician-staffed German system, overall mortality of patients did not differ between the two countries (Schmidt et al. 1993).

The results of Hotvedt et al. (1996) suggest that emergency helicopter services staffed by physicians may provide substantial benefits in terms of life-years and QUALYs gained, but the benefits are not evenly distributed across patients´ groups. It was concluded that such a costly and risky service should be reserved for patients who are likely to obtain a substantial benefit, i.e. patients with obstetric emergencies and young patients with acute respiratory problems and life-threatening infections (Hodvedt et al. 1996).

Different systems have specific advantages and disadvantages.
Paramedics with years of prehospital experience may be better adapted to the effects of witnessing violence, making urgent decisions, and trying to deliver optimum care with limited resources. Paramedics are more familiar with the influences of weather, noise, darkness, hazardous conditions, communicable disease, and interactions with hostile or upset citizens at the accident scene (Pepe and Stewart 1986).
Physicians, on the other hand, are well trained in skills relevant for the prehospital trauma scenario, which include airway management, venous access, sedation, and pain control (Ummenhofer and Scheidenegger 2002).

It is essential that all air medical transport services have a medical coordinator who is responsible for quality control of patient care and who has developed good communication and relationships between referring and receiving physician (Cooper 1983, Frew 1993). The medical coordinator must be an experienced emergency physician licensed to practice in the country where the transport service is based. He or she also must be well trained in the types of patients transported and knowledgeable as to the medical awareness and skills of the medical transport team and the capabilities or limitation of the transport vehicle. The medical coordinator must also be actively involved in training the personnel, establishing standing medical orders, reviewing transport records and charts, and continuous evaluation of transport team members (Schneider et al. 1992).

In our study, REGA physicians on board conduct triage on scene according to the scheme recommended by the ATLS subcommittee (1997) and has a thorough knowledge of the geography, distribution and staffing of the hospitals. The fact that no patient needed secondary transport indicates high triage accuracy, which is valuable for optimal management (Schoettker et al. 2001). Furthermore, patients treated by physicians prior to arrival in the emergency department may have shorter times to definitive management, because the focus in the emergency department switches from life saving procedure to imaging and disposition (Baxt and Moody 1987, Davies 1998).

A survey of emergency medical services in mountain areas of 14 countries in Europe and North America to compare emergency medical services showed following results:
Around 37,535 ground rescuers and 747 helicopters are ready for evacuation of accident victims and patients in mountain areas. 1,316 physicians and 50,967 paramedics take part in ground and air mountain rescue operations.
In Europe, 63.2% of helicopters have a physician on board, 17.8% are staffed with a paramedic, and 19% have no medically trained personnel on board.
In North America, 31.6% of helicopters are staffed with a doctor, 59.3% with a paramedic, and 9.1% have no medical personnel. The percentage of on-site treatment varies among all countries and is positively related to the percentage of physician-staffed helicopters.
Paramedics in 90.9% countries are obliged to be medically trained, but physicians need to have a standardized training in emergency medicine in only 50% of them.
On-site treatment according to the recommendations of the International Liaison Committee on Resuscitation (ILCOR) or International Commission for Alpine Rescue (ICAR) is performed more often in countries where physicians are regularly involved in mountain rescue operations. The results of the survey show a lack of medical education in specific mountain rescue-related problems (Brugger et al. 2005).

It should be mentioned that most physicians at the REGA bases are in their last year of specialty training. In addition some REGA bases are part of education program of the Swiss University Hospitals. Therefore, there is a considerable fluctuation in physicians who staff REGA bases, which may be associated with a loss of experience and acquired operating routine.

5.5. Special equipment

Swiss Air Rescue (REGA) teams execute more than 4000 rescue missions annually, of which 15.9% require the use of a winch. In difficult rescue conditions, time to call, response time, and scene times are particularly long. Since rescue actions are particularly long and difficult, the performance of advanced procedures at the scene and during transportation is of great value (Moeschler et al. 1992). For difficult missions (e.g. low visibility, night missions, high angle rescues and extension of the winch cable) rescue risks have to be evaluated in relation to the degree of injury. Another mentionable difficulty during the approach of the accident site is to determine from the helicopter, whether the patient is still alive (Durrer 1993).
Winch rescues at night demand excellent meteorological conditions and a highly experienced crew. These rescues are only possible if exact information about the site of accident is available. REGA helicopter are equipped with night vision devices and powerful search lights (Durrer 1993).

5.6. Health benefits from helicopter versus ground ambulance transport

Despite an increasing use of aero medical transport for Emergency Medical Services, the overuse of rescue helicopters for no critically injured patients is an increasing criticism of EMS systems. The alternative option in this situation is to delay helicopter dispatch until after the patient has been assessed by the responding ground ambulance. This approach likely improves selection of the most critically ill patients for air transport, but it adds precious time to the EMS phase of care (Diaz et al. 2005).
Others have reported ground ambulance to be faster than air in short-distance urban transports, attributing this to more accessible roadways: nearby ambulance stations; and delays associated with helicopter dispatch, landing and loading (Lerner et al. 1999, Nicholl et al. 1998, Rhodes et al. 1986, Stanhope et al. 1997, Tortella et al. 1996a).

The time advantage for longer distance transports may explain the trends toward mortality reductions in trauma patients evacuated by helicopter, as well as the lack of benefit when air-transported patients had no time advantage over their ground-transported patients (Brathwaite et al. 1998, Freilich et al. 1990, Lerner et al. 1999, Owen et al. 1999).

Although several studies have demonstrated reduced mortality in trauma patients transported by helicopter, the benefit seems to exist only in the most critically injured (Biewener et al. 2004, Boyd et al. 1989, Cunningham et al. 1997, Moront et al. 1996). Helicopter flight is a costly resource, with patient charges that in the USA may exceed 5 to 10 times that of ground transport. For economic availability and safety reasons, air transport should be allocated with discretion. Although helicopter transport is expensive, the marginal cost of additional flights when the helicopter and crew are already in place is not. The decision should not be made on the basis of cost alone, because there may be some benefit in delivering a higher level of care to an accident scene even if transport is not faster (Diaz et al. 2005).

Other authors have used calculations to estimate if helicopter flight is faster than ground transport. Nicholl et al. (1994) concluded, on the basis of linear regression and predicted ground transport times, that helicopter transport should provide on average 10 minutes faster transport in "roughly half" of their air-transported patients. Smith et al. (1993) used sample time measurements of EMS transports in mathematical formulas for distances at which helicopter transport should be expected to be faster than ground transport. These studies did not directly compare measured ground and helicopter EMS times as a function of distance from the hospital.

Using logistic regression analysis Davis et al. (2005) demonstrated decreased mortality and an increase in good outcomes with use of rescue helicopters. This benefit appeared to come from patients with more severe injuries. In addition, out-of-hospital intubation among helicopter transported patients resulted in better outcomes than emergency department intubation among ambulance transported patients.

Wang et al. (2004) also documented improved outcomes with aero medical performance of endotracheal intubation compared with patients undergoing intubation in the emergency department. This was in distinct contrast to outcomes in ground-transported patients undergoing endotracheal intubation.

The study of Di Bartolomeo et al. (2004) failed to show a significant benefit of a helicopter transport care on long-term survival of blunt trauma victims found in cardiac arrest. However, patients transported by helicopter had significantly more chances to resuscitate blunt trauma victims found in cardiac arrest as compared with a ground basic life support.

In the study of Diaz et al. (2005), the trauma hospital arrival intervals for three transport methods were compared: ground, helicopter dispatched simultaneously with ground unit, and helicopter dispatched non-simultaneously after ground unit response. Ground ambulance transport provided the shortest hospital arrival interval at distances less than 10 miles (16 km) from the hospital. At distances greater than 10 miles (16 km), simultaneously dispatched air transport was faster. Non-simultaneous dispatched helicopter transport was faster than ground if greater than 45 miles (72 km) from the hospital.

Moront et al. (1996) found that children transported by air were often more seriously injured than children transported by ground. Helicopter transport was associated with better survival rates among children transported to their urban level I pediatric trauma center but found an 85% rate of misusage.

Letts et al. (1999) found the helicopter flight program for children to be effective, but in their system a helicopter is dispatched if clinical criteria are met to establish its superiority over the ground ambulance. These parameters included hypotension, respiratory distress, a GSC-score <10, major traumatic injuries as well as mechanisms of injury.

Hodvedt et al. (1996) found that 89% of the patients they studied would have done just as well with a ground ambulance and that 96% of the total health benefit was achieved in 2% of the patients transported by air. Only 15% of the total number of patients in this study was children.

Tortella et al. (1996b) found no difference in ISS between pediatric traumatic patients transported by ground and air. No difference was noted when comparing the ISSs of adult and pediatric patients transported by helicopter. They also noted no difference in ISSs between pediatric patients transported by air and ground, while adults appeared to have a significant difference (18.0 vs. 13.6, $p < 0.0001$).

The study of Kotch et al. (2000) closely resembles the work by Tortella et al.

In conclusion, some studies have suggested that helicopter rescue flights do improve patient mortality (Baxt et al. 1983, Baxt et al. 1985, Baxt et al. 1987, Davis et al. 2005, Kristiansen et al. 1993, Schwartz et al. 1990, Urdaneta et al. 1984, Wang et al. 2004), whereas others have found no survival advantage in patients attended by helicopter ambulance (Di Bartolomeo et al. 2004, Fischer et al. 1984, Graf et al. 1992, Magnus et al. 1992, Nicholl et al. 1994, Nicholl et al. 1995, Schiller et al. 1988). It is estimated that there may be some additional survivor amongst patients with very severe injuries attended by the helicopter, but that overall there is no improvement in survival (Snooks et al. 1996).

Over 90 % of alpine rescues in the Swiss Alps are carried out by air. Of the remainder, 5% are combined ground/air rescues and 5% are pure ground rescues.
The special geographic problems of mountains, islands and other special regions in Switzerland demand helicopter coverage in emergency conditions independent of costs (Moeschler et al. 1992).
The unique system of financing REGA's activities with patron's donations enables this Helicopter Emergency Medical Service to remain operative.

5.7. Paediatric helicopter transport

Data regarding pediatric helicopter transport in the literature are sparse. Between January 1991 and December 2005, the Swiss helicopter rescue service transported 4,386 injured and 1,151 sick children. The main reason for rescue operations was head injury, followed by the spinal injury. The majority of the sick children were severely ill with CNS diseases.
34.2% (n=3,026) of the sick or injured children were severely ill with life-threatening disease (NACA 4-6).

Similar pattern of injury (head > long bone > abdominal injuries) were also reported by other studies (Hackam et al. 2000, Sharma et al. 2006, Shorter et al. 1996).
Head and spine injuries in children vary in the literature between 6% (Blitzer et al. 1984) and 50% (Bulut et al. 2006, Ortega et al. 2005).
In the present study 30.3% of all transported children suffered head injury and 19.4 % spinal injury.

Harrison et al. (1997) found that pediatric patients were transported more rapidly by helicopter to a trauma center than adults with similar injuries. They measured a 34-minute mean difference in aircraft activation between adults and children with similar GCSs.

These results may reflect the overall comfort level of the emergency physician dealing with children who are victims of trauma.

In the present study, pediatric patients transported from the accident site have injury characteristics similar to those of adults. Several studies suggest that survival probability is slightly greater, while hospital length of stay is less for pediatric patients. These data suggest that the prehospital selection criteria for helicopter transport are similarly utilized for the two groups.

The aim for primary care of children with traumatic brain injury is to move the intensive care period to the site of accident. The main problem is the lack of typical symptoms in children, which may result in misjudgment of the situation and exclude the necessary immediate action. An intensive personnel training may result in improvement of the therapy success rates in traffic accidents involving children. This may be responsible for reduction of follow-up costs, which occur in cases of permanent disability requiring long-life treatment (Sefrin et al. 2004).

5.8. Medical benefit of helicopter transport

Helicopter transport may increase survival rates in selected groups, such as those with severe injuries (Biewener et al. 2004, Boyd et al. 1989, Cunningham et al. 1997, Moront et al. 1996) as well as pediatric emergencies and pregnant women (Hackam et al. 2000, Sharma et al. 2006, Shorter et al. 1996).

Hotvedt et al. (1996) used expert panels to assess additional benefit due to helicopter transport. The panels used modified Delphi technique to reach consensus in life-years gained. The patients were randomized to the mode of transport. One panel assessed case reports for children and the other assessed case reports for adult patients.

For each patient, the gained life-years were assessed by multiplying the remaining life-expectancy by the probability that these life-years were attributable to the helicopter transport, afterwards compared with potential consequences of ground-ambulance transport. Life-expectancy was adjusted downwards for chronic diseases.

The gain of life-years was adjusted for quality of life by multiplying the average expected quality of life and the expected remaining life-years. This product expresses the health benefit in quality-adjusted life-years (QUALYs) (Hotvedt et al.1996).

In 90 of 370 patients (24%), the researcher found an additional health benefit due to helicopter transport versus transport in ground ambulance. For 41 of these 90 patients (45.6%), one or more of the panellists indicated medical benefit. For example, in patients with acute myocardial infarction, earlier use of thrombolysis and earlier hospital admission may have benefits. Here, the panel assumed that a case-fatality rate of 15% would be reduced to 11% if the therapy was initiated at the onset of the symptoms.

The patients arrived on average after 69 min. earlier in hospital in helicopter than in ground ambulance. In 55 patients aged below 15 years of age the estimated total life-year-gain was 238.7. Among the 315 adults, a total of 51.9 life-years were gained.

The maximal sum of estimated life-years gained was 290.6. Nine patients transported by helicopter achieved 96% (280) of the maximal health benefit. Most of them were children (six under 7 years old) with respiratory problems and infections. Thus, in adult injured patients, the benefit was small. The estimated total number of QUALYs gained in the 370 patients was 314.1.

In emergency situations involving newborn babies or children, the medical benefit is great and the use of helicopter should be coordinated accordingly. The mean response time of the helicopter was 21 min.

The researcher concluded that the different groups of patients influenced the benefit from helicopter transports and injured patients are likely to benefit most. The highest proportion of such patients occurs in urban areas (Baxt and Moody 1983, Baxt et al. 1985). However, the validity and reliability of panel assessment can be questioned. The costly and risky air-ambulance service should be reserved for patients who are likely to obtain a substantial benefit, i.e. patients with obstetric emergencies and children with respiratory problems and infections. For patients with cardiovascular disease, the medical benefit is small. Therefore routine use of helicopters to transport patients with cardiovascular disease is questionable
(Hotvedt et al.1996).

In another study, the expert panels found life years gained in every 14th patient (74 of 1106; 7%) assisted by an anaesthesiologist-manned prehospital EMS (Lossius et al. 2002). The major cause was cardiac disease (including cardiac arrest) in 61% of the 74 patients with benefit. The estimated medical benefit was of 504 gained life-years. There was no difference in gained life years between helicopter and the ground ambulance missions (Lossius et al. 2002).

5.9. Cost-effectiveness of helicopter ambulance services

Air transport is a costly resource, with charges that may exceed several times the costs of ground transport. Do the potential health benefits of REGA justify the cost?
For instance, charges for a ground ambulance in Zurich include the journey time, plus the length of stay at the accident site. Variable charges are for urgency, night, and weekend missions. Important additional charges are related to the fixed costs for physician and driver. The average cost for a terrestrial ambulance mission varies widely throughout the country, for example in Zürich average cost is of 650 CHF and instead in Ticino it costs 850 CHF per mission without physician. When a physician is needed cost rise easily over 1000 CHF per mission. (Pfeffer, Lurà)
Employments of a physician to crew the helicopter increases rescue flight expenditures. Costs of helicopter for primary intervention vary by flight time (e.g. maintenance, kerosene costs) and costs for secondary interventions are related to the distance between hospitals (Tab. 13).
Costs for helicopter rescue in Switzerland are twice as high as for ground-based rescue. The current average charge for a rescue mission carried out by REGA is of CHF 3,165 per patient due to new helicopters in use with different costs (Meierhans, REGA Accounting service). However, considering the relatively high percentage of severely injured or life-threatening sick children involved, air rescue and its higher costs appear to be justified (Ummenhoffer et al. 1996).

REGA's activities are financed only partially by operating revenue, as shown for example in Fig. 5 for the year 2004. The remaining operational deficit is covered by private funding, and above of all by annual contributions from patrons. These donations keep REGA operative (Stuenzi 2000).

The presence of a physician in the REGA helicopter allows fast in-field care. A study in Basel between 1986 and 1988 with 999 patients demonstrated that 687 (70.5%) were injured and of those 53.9 % were treated directly on the scene. Mortality at the site of accident was low with 2.6% and during transport only 0.3%. Fast and intensive in-field care decreases lethality among patients with severe trauma (Demartines et al. 1990).
Most of the studies that support the use of helicopters in prehospital care could demonstrate a benefit for injured individuals.

In Kuopio, Finland, 588 helicopter transported patients were evaluated retrospectively, and in 7.6% of all missions, patients benefited from helicopter medical service (Kurola et al. 2002). The benefit was related to early on-scene care. These patients were estimated to have been saved due to procedures on-scene or during transportation which clearly saved the patients life. Average cost per completed mission was of € 3,605. When rapid on-scene care was provided, costs even rose up to € 6,156 (Kurola et al. 2002).

In the United States 1 to 12 victims were additional survivors due to helicopter emergency medical service transports. Transport costs in 1997 were of $ 2,214 per patient, and each additional survivor's hospitalization amounted to an average of $ 15,883 per casualty. Sensitivity analysis revealed that discounted cost per year of year of life could be as high as $9,672 or as low as $1,400 and that it was most dependent on the surviving benefit. These findings suggest that helicopter emergency medical service is a cost-effective option for the treatment of non-juried patients. The magnitude of the survival benefits is the most important factor determining cost-effectiveness (Gearhart et al. 1997).

In London, there was only weak evidence, that patients with severe injuries may have an improved chance of survival if rescued by the helicopter (Snooks et al. 1996). It was estimated that there may be one extra survivor each month amongst patients with severe injuries transported by London Helicopter Ambulance Service, but there was no improvement in survival. Cost per completed mission in the early 90s was of £1,689 (CHF 3,986). This service does not fly at night. Taking in consideration that REGA charges an average of CHF 3.156 per mission and is also operative at night, the Swiss Helicopter Emergency Medical Service does not appear to be expensive in comparison to other European services.

In conclusion: Helicopters are used widely throughout Europe as emergency ambulances in a primary responder role in post-impact care. They are useful, improving response times and removal times to and from the accident scene, giving a more appropriate level of response and may provide access to more appropriate hospitals. Studies show that using helicopters to transport patients does not influence greatly their probability of survival; they are costly and not without significant crash risk (European Transport Safety Council, 2003).

Although the sparse European literature is broadly supportive of claims for benefits in all these areas, the review of Nicholl (1997) showed that the effectiveness of helicopter emergency ambulance services in some regions is doubtful. Their results show that if helicopters are operated, it should be on a regional basis in a secondary responder role in which they are called out at the request of emergency personnel at the scene or at a primary receiving hospital.

Since the geography and demography of Europe is so variable it would not be possible to recommend a uniform European system.

As distances increase, or access becomes more difficult in other ways, the advantages of helicopters may quickly come to outweigh their disadvantages. In Switzerland there is a greater need for HEMS due to the difficult topography with mountainous areas that are difficult to access. REGA's activities have constantly increased over the past 15 years. REGA covers the wholesome of the country in just short flight time and provides a high level of rescue possibilities and medical care to the entire population, who is willing to finance that by their annual donations.

REGA is a unique institution due to its financing system with patrons and international recognition with 55 years of experience in alpine helicopter rescue; therefore it may serve as example for other nations.

6. Abstract

Key Words: REGA, helicopter, medical transport, traumatic injury, diagnosis, mechanism of injury, types and frequencies of injuries, NACA, area index, accident site, rescue index, special helicopter missions, costs, benefits

The Swiss Air Rescue Service, REGA, is an independent, non-profit, private organization serving the public. REGA was founded by private initiative in 1952 and since 1982 it is a corporate member of the Swiss Red Cross.

The study's objective is to analyze air prehospital care system of whole Switzerland within the past 15 years and its epidemiological changes.
We have evaluated the locations of accident scene/ illnesses, the mechanisms of injury, geography of accident site, NACA Index as well as the difficulty to access the location by using the REGA' s own location index for each transported patient.
Correlations between the NACA index and the site of accident and between the NACA index and the accessibility of emergency were analyzed.

Data regarding pediatric helicopter transport are sparse. Thus, another purpose of this study is to determine whether differences occur between pediatric and adult victims transported by helicopter.
In a series of 64,245 rescue operations between 1 January 1991 and 31 December 2005, a helicopter staffed by an emergency physician and equipped with a winch was used. During the study period, 43,141 (67.3%) male patients and 20,871 (32.6%) female patients were rescued with a median age of 37.0 ± 21.0 years. 8,847 patients (13.8%) were less than 15 years of age.
The amount of helicopter missions during this period rose from 3,481 to 5,326 (+65%).
REGA helicopters flew most of the rescue missions in the cantons of Grisons and Bern (n=11,856; 20, 8% and n=9,785; 17, 2%), followed by the cantons of Vaud, Ticino and St. Gall (8.0%, 7.1% and 5.8%). REGA also flew 10.3% (n=5,880) of its missions in neighbouring countries, mostly in France and Germany.
2,269 people (3.5%) transported by REGA helicopters during this period were suffering from conditions not related to trauma, such as neonates and pregnant patients, and persons that were evacuated in dangerous meteorological and/or topographical situations.

53,087 (82.6%) of the 64,245 victims transported by REGA were suffering from traumatic injuries. 24.2% (n=15,529) of the patients had head injuries, 8,010 patients (12.5%) suffered from spinal injuries. Limb injuries (upper and lower) taken together represent the majority of all cases (28.9%).

10,500 (16.3%) of the transported patients were suffering from medical problems. The most common diagnostic was a cardiac disease (n=4,790; 7.5%), followed by CNS-diseases (n=2,310; 3.6%).

The frequency of accidents increased with age and reached a peak in the 16-30 years age group (n=15,604; 24.6%). The frequency of medical indications for rescue operations also increased with age and predominated in the > 60 years age group. The frequency of injuries in children reached a maximum for the 11-15 years age group (n=4,386; 7.0%). Medical reasons for rescue operations of children predominated in the ≤ 5 years age group.

The main reason for primary interventions was winter sport activities (n=21,535; 33.5%). 24.1% of injuries (15,507 patients) were the result of traffic accident. The home sector recorded 8,402 incidents (13.1%), while 10.2% of patients (n=3,366) were injured during climbing or walking on mountain paths. The frequency of injuries occurred during winter sports activities decreased significantly from 47.4% in the years 1994 to 1996 to 24.5% in the years 1997 to 1999.

The majority of the injuries (34.1%) occurred during falls (n=21,889). In 7,998 cases (12.4%), injuries were caused by a collision. 10.5% (n=6,755) of the transported patients suffered medical illness.

In 37.4% (n=23,753) of the cases, accident sites were accessible via roadway. Unsealed roads (n=17,271), which include ski slopes, agricultural roads and lakes, represent the second group (27.2%). In 22.7% (n=14,438) of the cases, accident sites were difficult to access (i.e. alpine refuges), while 9.8% (n=6,222) of the accident sites were very difficult to access.

26,219 patients (41.3%) were NACA grade 3, while severe or life-threatening injuries (NACA grades 4 and 6) were seen in 37% (n=23,456) of the victims.

5,301 children (60%) had moderate injuries or illness (NACA index 1-3), and 3,026 (34.2%) were in severe condition (NACA index 4-6).

In 81.3% (n=53,366) of the cases, landing near the accident site was possible. In 15.9% (n=10,105) of the cases, complex flight operations were required: hovering, horizontal net and rescue bag. During rescue operations in difficult areas, the patients with life-threatening conditions were most frequently recovered by the horizontal net (n=849; 1.3%), followed by the rescue bag (n=335; 0.5%) and finally by winch operation (n=224; 0.4%). 883 casualties rated NACA 7 were recovered by winch (1.4%).
Patients rescued on normal streets rated NACA index 3 or lower, represent only 9.9% (n=6,280) of the total, while 21.5% (n=13,635) of the patients rated NACA index 3 or lower were rescued on accident sites difficult to reach (e.g. ski slopes). 24.0% (n = 15,171) of the patients with NACA index 3 or lower were rescued on far accident sites; 7.1% (n = 4,909) of these patients were rescued on accident sites difficult or very difficult to access. 27.5% (n=17,421) of the patients with severe injuries were rescued on normal street, while 14.4% (n=9,150) of the patients with NACA index ≥ 4 (i.e. as acute cases) were rescued on remote accident sites difficult to reach or inaccessible.
25.1% (n=1,426) of the patients with NACA index 3 who were rescued on “normal roads” had head injuries and a further 22.2% (n=1,265) had spinal lesions. Lower limb injuries accounted for 14.2% of diagnoses (n=806), whilst upper limb injuries accounted for 8.7% of diagnoses (n=496). 913 patients with NACA index 3, who were rescued on normal roads, were less than 15 years old. Head injury among this group was by far the most common diagnose (30.3%), followed by spine injury (19.4%).

Benefits and costs associated with HEMS use in Switzerland are discussed.

The REGA helicopter doctrine states that any location in Switzerland – with the exception of the canton of Valais - should be reached within 15 minutes flight time.
In the Alps of Switzerland, the mean time from call to the deposit of the rescue team with the winch was 21.5 minutes. Very long response times (>30 minutes) were the result of very difficult access, making direct deposit of the team on scene impossible even with the use of the winch, or of the need to search for the accident site that had not been described precisely. Mean scene time was 37.8 minutes.
In our study, the REGA physician on board conducts triage on scene according to the scheme recommended by the ATLS subcommittee (1997) and has a thorough knowledge of the geography, distribution and staffing of the hospitals. The fact that no patient needed secondary transport indicated a high triage accuracy which is valuable for optimal management.

Costs for helicopter rescue are twice as high as for ground-based rescue. REGA charges an average of CHF 3.156 per mission and is also operative at night; the Swiss Helicopter Emergency Medical Service does not appear to be expensive in comparison to other European services. As distances increase, or access becomes more difficult in other ways, the advantages of helicopters may quickly come to outweigh their disadvantages. Considering the relatively high percentage of severely injured or life-threatening sick children involved, air rescue and its higher costs appear to be justified.

7. References

1. American Association of Neurological Surgery (1995): Guidelines for the management of severe head injury. Brain Trauma Foundation

2. American College of Surgeons Committee on Trauma (1993): Advanced Trauma Life Support (ATLS) course for Physicians, edn 5. Chicago: American College of Surgeons

3. American College of Surgeons Committee on Trauma (1997): Advanced Trauma Life Support Instructor Manual, Chicago

4. Andersen PA, Buller DB, Scott MD, Walkosz BJ, Voeks JH, Cutter GR, Dignan MD (2004): Prevalence and diffusion of helmet use at ski areas in Western North America in 2001-02. Inj Prev 10(6): 358-362

5. Arnold J (1999): International emergency medicine and the recent development of emergency medicine worldwide. Ann Emerg Med 33: 97-103

6. Baxt WG, Moody P (1983): The Impact of a Rotorcraft Aeromedical Emergency Care Service on Trauma Mortality. J Am Med Assoc 249(22): 3047-3051

7. Baxt WG, Moody P, Cleveland HC et al. (1985): Hospital-based rotorcraft aeromedical emergency care services and trauma mortality: a multicenter study. Ann Emergency Med Sept, 859-864

8. Baxt WG, Moody P (1987): The impact of a physician as part of the aero medical pre-hospital team in patients with blunt trauma. JAMA 257: 3246-3250

9. Baxt W G, Moody P (1987): The impact of advanced pre-hospital emergency care on the mortality of severely brain-injured patients. J Trauma 27 (4): 365-369

10. Blitzer CM, Johnson RJ, Ettlinger CF, Aggerborn K (1984): Downhill skiing injuries in children. Am J sports Med 12(2): 142-147

11. Blumen IJ, Gordon RS (1989). Taking to the skies. Emergency, Nov., pp 33-38

12. Boyd CR, Corse KM, Campbell RC (1989): emergency interhospital transport of the major trauma patient: air versus ground. J Trauma 29: 789-793

13. Boyd DR (1977): Efforts to improve emergency medical services experience. J Am Coll Emerg Phys (JACEP) 6(5): 209-217

14. Boyd DR (1973): A symposium on the Illinois trauma program: A system approach to the care of the critically injured. J Trauma 13: 275-276

15. Boyd DR, Cowley RA (1983): Comprehensive regional trauma/emergency medical services (EMS) delivery systems: the United States experience. World J Surg 7: 149-157

16. Brathwaite CEM, Rosko M, McDowell R, Gallagher J, Proenca J, Spott MA (1998): A critical analysis of on-scene helicopter transport on survival in a statewide trauma system. J Trauma 45: 140-146

17. Brugger H, Elsensohn F, Syme D, Sumann G, Falk M (2005): A survey of emergency medical services in mountain areas of Europe and North America. High Altitude Med Biol 6(3): 226-237

18. Bulut M, Koksal O, Korkmaz A, Turan M, Ozguc H (2006): Childhood falls: characteristics, outcome, and comparison of the Injury Severity Score and New Injury Severity Score. Emerg Med J 23(7): 540-545

19. Cayten G, Longmore W, Kuehl A, Gifford B (1986): Prolongation of scene time by advanced life support (ALS) in an urban setting. J Trauma 25(7): 679

20. Chesnut RM, Marshall LF, Klauber MR et al. (1993): The role of secondary brain injury in determining outcome from severe head injury. J Trauma 34(2): 216-222

21. Chow TK, Corbett SW, Farstad DJ (1996): Spectrum of injuries from snowboarding. J Trauma 41: 321-325

22. Coats TJ, Wilson AW (1992): Utilization of the Helicopter Emergency Medical Service. J R Soc Med 85: 725-726

23. Cowley RA, Hudson F, Scanlan E, Gill W, Lally RJ, Long W, Kuhn AO (1973): An economical and proved helicopter program for transporting the emergency critically ill and injured patient in Maryland. J Trauma 13: 1029-1038

24. Cowley RA (1976): The resuscitation and stabilization of major multiple trauma patients in a trauma center environment. Clin Med 83: 14-22

25. Cowley RA (1977): A new concept for the delivery of critical care. J Med Soc N Jersey 74: 979-986

26. Cunningham P, Rutledge R, Baker CC, Clancy TV (1997): A comparison of the association of helicopter and ground ambulance transport with the outcome of injury in trauma patients transported from the scene. J Trauma 43: 940-946

27. Davies G (1998): Helicopters in the urban environment. Prehosp Immed Care 2: 117

28. Davis DP, Peay J, Serrano JA, Buono C, Vilke GM, Sise MJ, Kennedy F, Eastman AB, Velky T, Hoyt DB (2005): The impact of aeromedical response to patients with moderate to severe traumatic brain injury. Emerg Med Serv 46(2): 115-122

29. Demartines N, Castelli I, Scheidegger D, Harder F (1992): Development of a concept for air-rescue by helicopter in an urban area. Schweiz Rundschau Med 81: 405-410

30. Diamond PT, Gale SD, Denkhaus HK (2001): Head injuries in skiers: an analysis of injury severity and outcome. Brain Inj 15: 429-434

31. Diaz MA, Hendey GW, Bivins HG (2005): When is the helicopter faster? A comparison of helicopter and ground ambulance transport times. J Trauma Injury Infect Crit Care 58: 148-153

32. Di Bartolomeo S, Sanson G, Nardi G, Michelutto V, Scian F (2005): HEMS vs. round-BLS care in traumatic cardiac arrest. Prehosp Emerg Care 9(1): 79-83

33. Durrer B (1993): Rescue operations in the Swiss Alps in 1990 and 1991. J Wilderness Med 4: 363-373

34. European Transport Safety Council (ETSC) (2003): Transport safety performance in the EU – a startistical overview. Brüssels

35. Federiuk CS, Schueter JL, Adams AL (2002): Skiing, snowboarding and sledding injuries in a Nothwestern state. Wilderness and Environmental Medicine 13(4): 245-249

36. Fischer RP, flynn TC, Miller PW et al. (1984): Urban helicopter response to the scene of injury. J Trauma 24(11): 946-951

37. Freilich DA, Spiegel AD (1990): Aeromedical emergency trauma services and mortality reduction in rural areas. NY State J Med 90: 358-365

38. Frey CF (1984): Accidents and trauma care – 1983. Surg Annu 16: 69-98

39. Frey CF Blaisdell W, Davis J, Gann D, Trunkey D, Walt A (1978): Hospital care of the trauma patient. JAMA 240 (16): 1723-1724

40. Frew SA (1991): Patient transfers- How to comply with the law. American College of Emergency Physicians, Dallas, Texas, pp 15-18, 23-28, 29-31

41. Furrer M, Ekhart S, Frutiger A, Bereiter H, Leutenegger A, Ruedi T (1995): Severe skiing injuries: a retrospective analysis of 361 patients including mechanism of trauma, severity of injury, and mortality. J Trauma 39: 737-741

42. Gearhart PA, Wuerz R, Localio AR (1997): Cost-effectiveness analysis of helicopter EMS for trauma patients. Ann emerg Med 30(4): 500-506

43. Graf M, Demartinez N, Harder F, Scheidegger D (1993): Polytrauma: comparison of the hospital course after air- (with emergency physician) versus ground transport (without emergency physician). Helv Chir Acta 59(4): 649-653

44. Hackam DJ, Kreller M, Pearl RH (1999): Snow-related recreational injuries in children: assessment of morbidity and management strategies. J Pediatr Surg 34(1): 65-68

45. Hagel BE, Meeuwisse WH, Mohtadi NG, Fick GH (1999): Skiing and snowboarding in the children and adolescents in Southern Alberta. Clin J Sport Med 9(1): 9-17

46. Hagel BE, Goulet C, Platt RW, Pless IB (2004): Injuries among skiers and snowboarders in Quebec. Epidemiology 15(3): 279-286

47. Hagel BE, Pless IB, Goulet C, Platt RW, Robitaille Y (2005): Effectiveness of helmets in skiers and snowboarders: case control and case crossover study. BMJ, doi:10.38314.480035.7C (published 4 January 2005)

48. Harrison T, Thomas SH, Wedel SK (1997): Interhospital aeromedical transport: air medical activation intervals in adult and pediatric trauma patients. Am J Emerg Med 15: 122-124

49. Hedges JR, Feero S, Moore B, Shultz B, Haver DW (1988): Factors contributing to paramedic onscene time during evaluation and management of blunt trauma. Am J Emerg Med 6(5): 443-448

50. Hotvedt R, Kristiansen IS, Førde OH, Thoner J, Almdahl SM, Bjørsvik G, Berge L, Magnus AC, Mamen K, Sparr T, Ytre-Arne K (1996): Which groups of patients benefits from helicopter evacuation? Lancet 347: 1362-1366

51. Jones SE, Brennes AT (1991): study design in prehospital trauma advanced life support-basic life support research: A critical review. Ann emerg Med 20: 857-860

52. Kotch SJ, Burgess BE (2002): Helicopter transport of pediatric versus adult trauma patients. Prehosp Emerg Care 6(3), 306-308

53. Kristiansen IS, Thoner J, Almdahl SM et al. (1993): Cost-Effectiveness of an Emergency Helicopter in a Sparsely Populated Area of Norway. Paper presented to the Health Economics Study Group, January 1993

54. Kurola J, Wangel A, Uusaro A, Ruokonen E (2002): Paramedic helicopter emergency service in rural Finland – do benefits justify the cost? Acta Anaesthesiol Scand 46: 779-784

55. Lachenmyer, J (1987): Physiological aspects of transport. Inter Anesthesiol Clin 25: 15-41

56. Lerner EB, Billittier AJ IV, Sikora J, Moscati RM (1999): Use of a geographic information system to determine appropriate means of trauma patient transport. Acad Emerg Med 6: 1127-1133

57. Letts M, McCaffrey M, Pang E et al. (1999) : An analysis of an air-ambulance program for children. J Pediatr Orthop 19: 240-246

58. Levy AS, Hawkes AP, Hemminger LM, Knight S (2002): An analysis of head injuries among skiers and snowboarders. J Trauma 53: 695-704

59. Liberman M, Mulder D, Sampalis JS (2000): Advanced or basic life support for trauma: Meta-analysis and critical review of the literature. J Trauma 40(4): 584-599

60. Lossius HM, Soreide E, Hotvedt R, Hapnes SA, Eielsen OV, Forde OH, Steen PA (2002): Prehospital advanced life support provided by specially trained physician: is there a benefit in terms of life years gained? Acta Anaesthesiol Scand 46(7): 771-778

61. Lubillo S, Burillo-Putze G, Alonso E, Herranz I, Gomez A, Gomez N (2000): Helicopter emergency medical service in Canary Islands, Spain. Eur J Emerg Med 7: 55-59

62. Macnab AJ, Smith T, Gagnon FA, Macnab M (2002): Effect of helmet wear on the incidence of head/face and cervical spine injuries in young skiers and snowboarders. Inj Prev 8: 324-327

63. Made C, Borg H, Thelander D, Elmqvist LG (2001): Telemark skiing injuries: an 11-year study. Knee Surg Sports Traumatol Arthrosc. 9(6): 386-391

64. Magnus AK, Kristiansen IS, et al. (1992) : Legehelikopter og Transport Av Pasienter Med Akutt Hjerteinfarkt. Tidsskr Nor Loegeforen 112: 512-514

65. Malacrida RL, Anselmi LC, Genoni M, Bogen M, Suter PM (1993): Helicopter mountain rescue of patients with head injury and/or multiple injuries in southern Switzerland 1980/1990. Injury 24: 451-453

66. Marsigny B, Lecoq-James F, Cauchy E (1999): Medical mountain rescue in the Montblank massif. Wilderness and Environmental Medicine 10: 152-156

67. McCloskey KA, Johnston C (1990): Pediatric critical care transport survey: Team composition and training, mobilization time, and mode of transportation. Pediatr Emer Care 6(1): 1-3

68. McCloskey KA, Orr RA (1991): Pediatric transport issues in emergency medicine. Emerg Med Clin North Am 9(3): 475-487

69. Meyer P, Rosen HB, Hall W (1976): Fracture dislocations of the cervical spine: Transportation, assessment and immediate mamagement. Am Acad Orthop Surg 25: 171

70. Moeschler O, Refondini S, Höflinger C, Freeman J (1992): Difficult aeromedical rescue situations: experience of a Swiss pre-alpine helicopter base. J Trauma 33(5): 754-759

71. Moront ML, Gotschall CS, Eichelberger MR (1996): Helicopter transport of injured childeren: system effectiveness and triage criteria. J Pediatr Surg 31: 1183-1188

72. Morrow PL, McQuillen EN, Eaton LA Jr, Bernstein CJ (1988): Downhill ski fatalities: the Vermont experience. J Trauma 28(1): 95-100

73. Murray CJ, Lopez AD (1997): Mortality by cause for eight regions of the world: Global Burden of Diseases Study. Lancet 349: 1269-1276

74. Murray CJ, Lopez AD (1996): Global Health Statistics: A compendium of incidence, prevalence, and mortality estimates for over 200 conditions. Boston: Harvard University Press

75. Murray CJ, Lopez AD (1997b): Alternative projections of mortality and disability by cause 1990-2020: global burden of disease study. Lancet 349: 1498-1504

76. Nakaguchi H, Fujimake T, Ueki K, Takahashi M, Yoshida H, Kirino T (1991): Snowboard head injury: prospective study in Chino, Nagano, for two seasons from 1995 to 1997. J Trauma 46: 1066-1069

77. Nicholl JP (1997): The role of helicopters in pre-hospital care. Prehospital and immediate. Care 1: 82-90

78. Nicholl JP, Beeby NR, Brazier JE (1994): A comparison of the costs and performance of an emergency and land ambulances in a rural area. Injury 25: 145-153

79. Nicholl JP, Snooks H, Brazier JE (1995): Effects of the London helicopter emergency medical sevice on survival after trauma. Br Med J 311: 217-222

80. Ortega HW, Shields BJ, Smith GA (2005): Sledding-related injuries among children requiring emergency treatment. Pediatr Emerg Care 21(12): 839-843

81. Osterwalder JJ (2002): Can the „golden hour of shock“ safely be extended in blunt poly-trauma patients? Prehosp Dis Med 172): 75-80

82. Owen JL, Phillips RT, Conaway C, et al. (1999): One year´s trauma mortality experience at Brooke Army Medical Center: is aeromedical transportation of trauma patients necessary? Mil Med 164: 361-365

83. Pepe PE, Maio RF (1993): Evolving challenges in prehospital trauma services. Prehosp Disast Med 8: 25-34

84. Pepe PE, Steward R (1986): Role of the physician in the prehospital setting. Ann Emerg Med 15: 1480-1483

85. Pepe PE, Wyatt CH, Bickel WH, Bailey ML, Mattox KL (1987): The relationship between total prehospital time and outcome in hypotensive victims of penetrating injuries. Ann Emerg Med 16: 293/85-297/89

86. Petri RW, Dyer A, Lumpkin J (1995): The effect of prehospital transport time on the mortality from traumatic injury. Prehosp Disast Med 10(1): 43/24-48/29

87. Pfeffer, Lurà, F.; Ambulance Services Sanität Zürich, SAM Mendrisio

88. Prall JA, winston KR, Brennan R (1995): Spine and spinal cord injuries in downhill skiers. J Trauma 39: 1115-1118

89. Reines HD, Bartlett RL, Chudy NE, Kiragu KR, McKnew MA (1988): Is advanced life support appropiate for victims of motor vehicle accidents: The South Carolina Highway Trauma Project. J Trauma 28(5): 563-569

90. Rhee KT, Burney RE, Mackensie JR, et al. (1984): Is the flight physician needed in helicopter emergency medical services? J Trauma 24: 680, 174-177

91. Rhodes M, Perline R, Aronson J, Rappe A (1986) : Field triage for on-scene helicopter transport. J Trauma 26 : 963-969

92. Rohrer W, Klemmer U, Durrer B, Jacomet H, Höflinger C (1990/1991) : Swiss Air Rescue Medical Statistics.

93. Sacco DE, Sartorelli DH, Vane DW (1998) : Evaluation of alpine skiing and snowboardiinjury in a northeastern state. J Trauma 44: 654-659

94. Sampalis JS, Lavoie A, Williams JI, Mulder DS, Kalina M (1992): Standardized mortality ratio analysis on a sample of severely injured patients from a large Canadian city without regionalized trauma care. J Trauma 33(2): 205-212

95. Sampalis JS, Lavoie A, Williams JI, Mulder DS, Kalina M (1993): Impact of onsitecare, prehospital time, and level of in-hospital care on survival in severly injured patients. J Trauma 34(2): 252-261

96. Sampalis JS, Lavoie A, Salas M, Nikolis A, Williams JI (1994): Determinants of onscene time in injured patients treated by physicians at the site. Prehosp Disast Med 9(3): 178-188

97. Sandegaard J, Eriksson B, Lundkvist S (1991): Nationwide registration of ski injuries in Sweden. In: Mote CD, Johnson RJ, eds. Skiing Trauma and Safety. Philadelphia, PA: Eighth International Symposium, American Society for Testing and Materials. 170-176

98. Sherry E (1984): Skiing injuries in Australia. Med J Aust 140(9): 530-531

99. Schiller WR, Knox R, Zinnerker K et al. (1988): Effect of helicopter transport of trauma victims on survival in an urban trauma center. J Trauma 28(8): 1127-1131

100. Schindera ST, Triller J, Steinbach LS, Zimmermann H, Takala J, Anderson SE (2005): Spectrum of injuries from glacial sports. Wilderness Med Soc 16(1): 33-37

101. Schmidt U, Muggia-Sullam M, Holch M et al. (1993): Primärversorgung des Polytraumas. Vergleich eines deutschen und amerikanischen Luftrettungssystems. Unfallchirurg 96: 287-291

102. Schneider C (1986): Hospital-based emergency air medical service programs. In: Trauma Nursing: Principles and Practice. Norwalk CT, Appleton-Century-Crofts, pp 419-443

103. Schneider C, Gomez M, Lee R (1992): Evaluation of ground ambulance, rotor-wing and fixed-wing aircraft services. Crit Care Clin 8(3): 533-563

104. Schoettker P, Ravussin P, Moeschler O (2001): Ejection as a key word for the dispatch of a physician staffed helicopter: the Swiss experience. Resuscitation 49: 169-173

105. Sharma OP, Oswanski MF, Stringfellow KC, Raj SS (2006): Pediatric blunt trauma: a retrospectiv analysis in a Level I trauma center. Am Surg 72(6): 538-543

106. Shorter NA, Jensen PE, Harmon BJ, Mooney DP (1996): Skiing injuries in children and adolescents. J Trauma 40(6): 997-1001

107. Skokan EG, Junkins EP, Kadish H (2003): Serious winter sport injuries in children and adolescent requiring hospitalization. Am J Emerg Med 21(2): 95-99

108. Schwartz R J, Jacobs L M, et al. (1990): A Comparison of Ground Paramedics and Aeromedical Treatment of Severe Blunt Trauma Patients. Connecticut Medicine 54 (12): 660-662

109. Smith JS, Smith BJ, Pletcher SE, Swope GE, Kunst D (1993): when is air medical service faster than ground transportation? Air Med J 12: 258-261

110. Snooks HA, Nicholl JP, Brazier JE, Lees-Mlanga S (1996): The costs and benefits of helicopter emergency ambulance services in England and Wales. J Publ Health Med 18 (1): 67-77

111. Spaite DW, Tse DJ, Valenzuela TD, Criss EA, Meislin HW, Mahoney M, Ross J (1991): The impact of injury severity and prehospital procedures on scene time in victims of major trauma. Ann Emerg Med 20(12): 1299-1305

112. Stanhope K, Falcone RE, Werman H (1997): Helicopter dispatch: a time study. Air Med J 16: 70-73

113. Stauffer UG (1995): surgical and critical care management of children with life-threatening injuries: the Swiss experience. J Pediat Surg 30(7): 903-910

114. Stuenzi W (2000): Swiss air rescue Rega. Internet J Aeromed Transport. http://www.ispub.com/ostia/index.php?xmlFilePath=journals.xml

115. Sulheim S, holme I, Ekeland A, Bahr R (2006): Helmet use and risk of head injuries in alpine skiers and snowboarders. JAMA 295(8): 919-924

116. Thomas F (1988): The development of the nation´s oldest operation civilian hospital-sponsored aeromedical helicopter service. Aviat Space Environ Med 59: 567-570

117. Thompson DC, Rivara FP, Thompson RS (1996): Effectiveness of bicycle helmets in preventing head injuries. A case-control study. JAMA 276: 1968-1973

118. Tortella BJ, Lavery RF, Kamat M, Ramani M (1996a): Requiring on-line medical command for helicopter request prolongs computer-modeled transport time to the nearest trauma center. Prehospital Disaster Med 11: 261-262

119. Tortella BJ, Sambol J, Lavery RF, Cudihy K, Nadzam G (1996b): A comparison of pediatric and adult trauma patients transported by helicopter and ground EMS: managed care considerations. Air Med 15: 24-28

120. Ummenhofer W, Frei A, Kern C, Frei F (1996): Swiss air rescue service: helicopter interventions for children. Schweiz Med Wochenschr 126: 1785-1791

121. Ummenhofer W, Scheidegger D (2002): Role of the physician in prehospital management of trauma: European perspective. Curr Op Crit Care 8: 559-565

122. Urdaneta L F, Sandberg M K, et al. (1984): Evaluation of an Emergency Air Transport Service as a Component of a Rural EMS System. Am Surg 50: 183-188

123. US Consumer Product Safety Comission. CPSC satff recommends use of helmets for skiers, snowboarders to prevent head injuries. (cpsc.gov/cpscpub/prhtml99/99046.html).

124. Veldman A, Fischer D, et al. (2001): Proposal for a new scoring system in international interhospital air transport. J Travel Med 8: 154-157

125. Wang HE, Peitzman AB, Cassidy LD, et al. (2004): Out-of-hospital endotracheal intubation and outcome after traumatic brain injury. Ann Emerg Med 44: 439-450

126. Wegmann F, Kromann-Andersen B, Johansen TS, Jessen K (1990): Sixteen years with the Danish search and rescue helicopter service. Aviat Space Environm Med 60: 436-439

127. Weiss M, Bernoulli L, Zollinger A (2001): The NACA-scale. Construct and predictive validity of the NACA-scale for prehospital severity rating in trauma patients. Anaesthesist 50: 150-154

128. Wills VL, Eno L, Walker C, Gani JS (2000): Use of an ambulance-based helicopter retrieval service. Aust NZ J Surg 70: 506-510

129. Wyatt JP, Beard D, Gray A et al. (1996): Rate, causes and prevention of deaths from injuries in south-east Scotland. Injury 27: 337-340

Figures

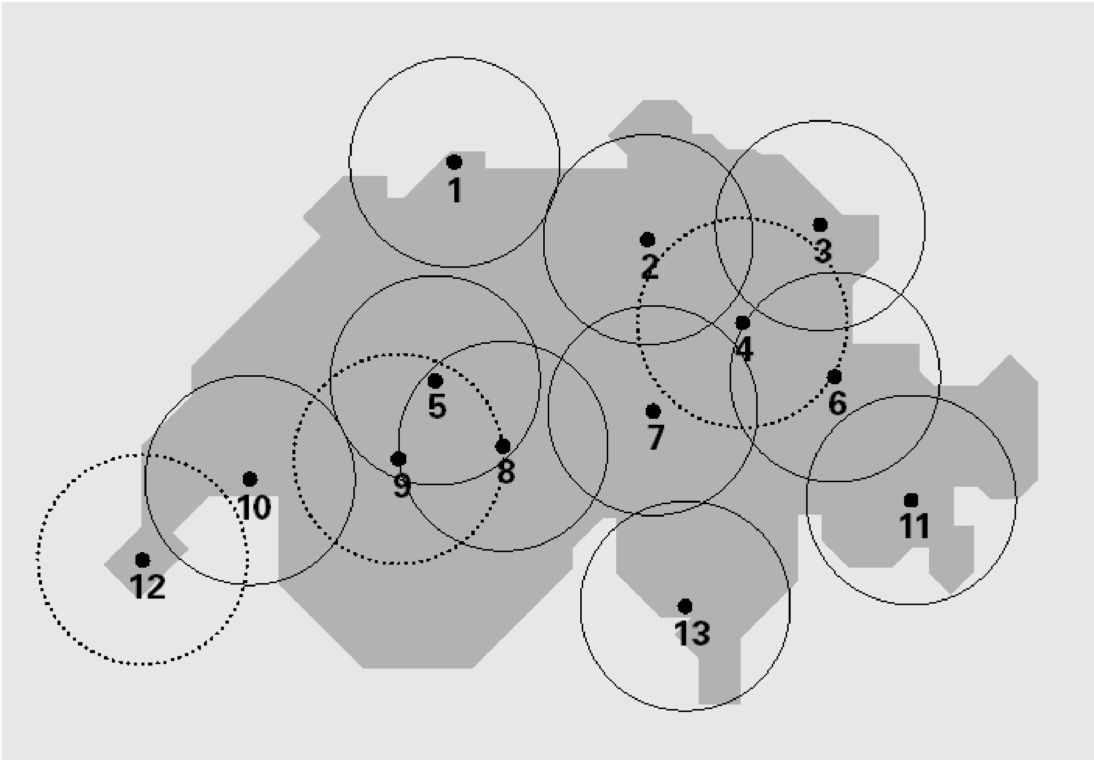

Figure 1: *REGA helicopter and partner bases*

1: Basel, 2: Zürich, 3: St.Gallen, 4: Mollis, 5: Bern, 6: Untervaz, 7: Erstfeld, 8: Gsteigwiler, 9: Zweisimmen, 10: Lausanne, 11: Samedan , 12: Genf, 13: Locarno

(dot-line circles = partner bases)

Figure 2: Eurocopter EC 145

Figure 3: Agusta A 109 K2

Expenditure for 2004 (in CHF 1,000)

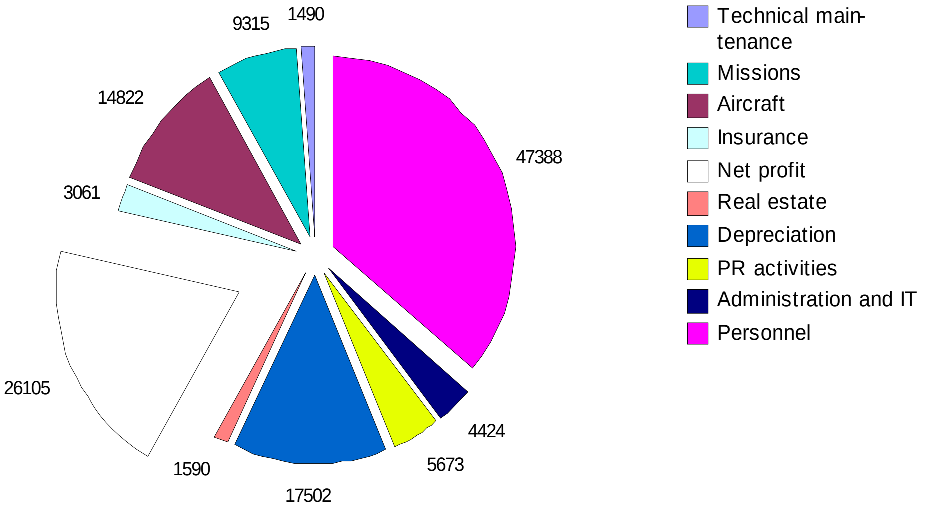

Figure 4: Expenditure for 2004.

Revenue for 2004 (in CHF 1,000)

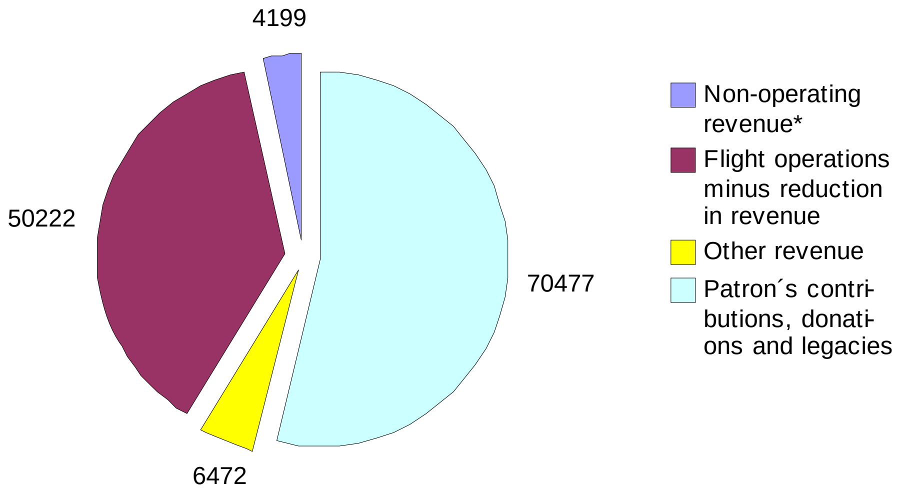

Figure 5: Revenue for 2004.
* Essentially earnings from financial investments and book profits from the disposal of fixed assets

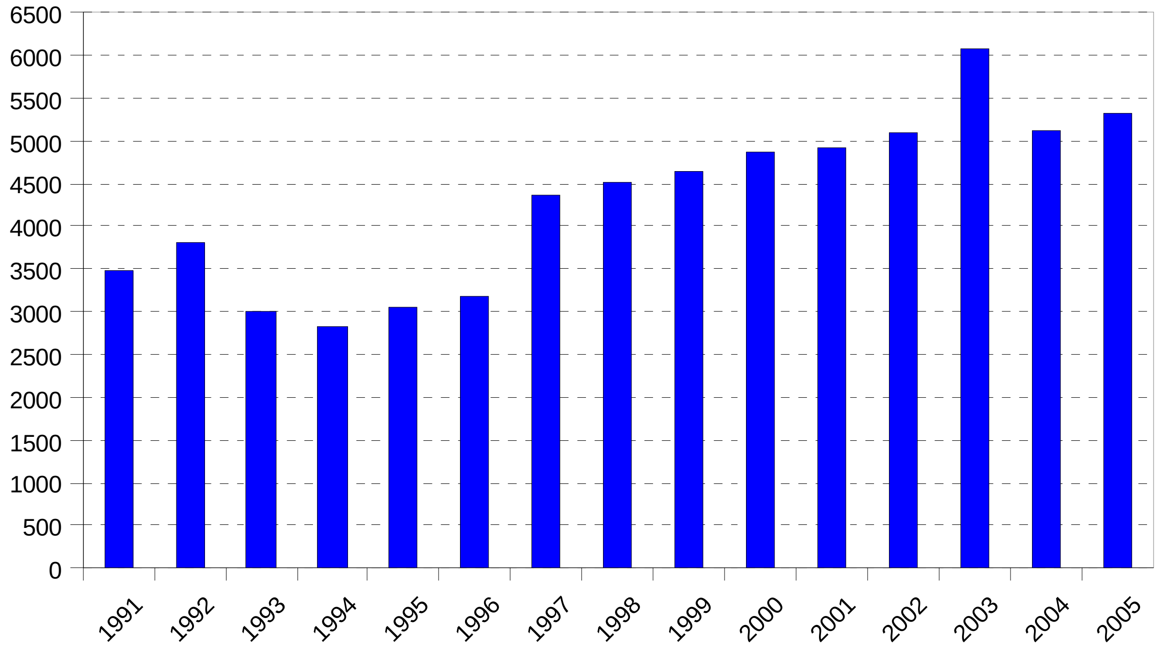

Figure 6: The evolution of annual numbers of REGA missions between January 1991 and December 2005

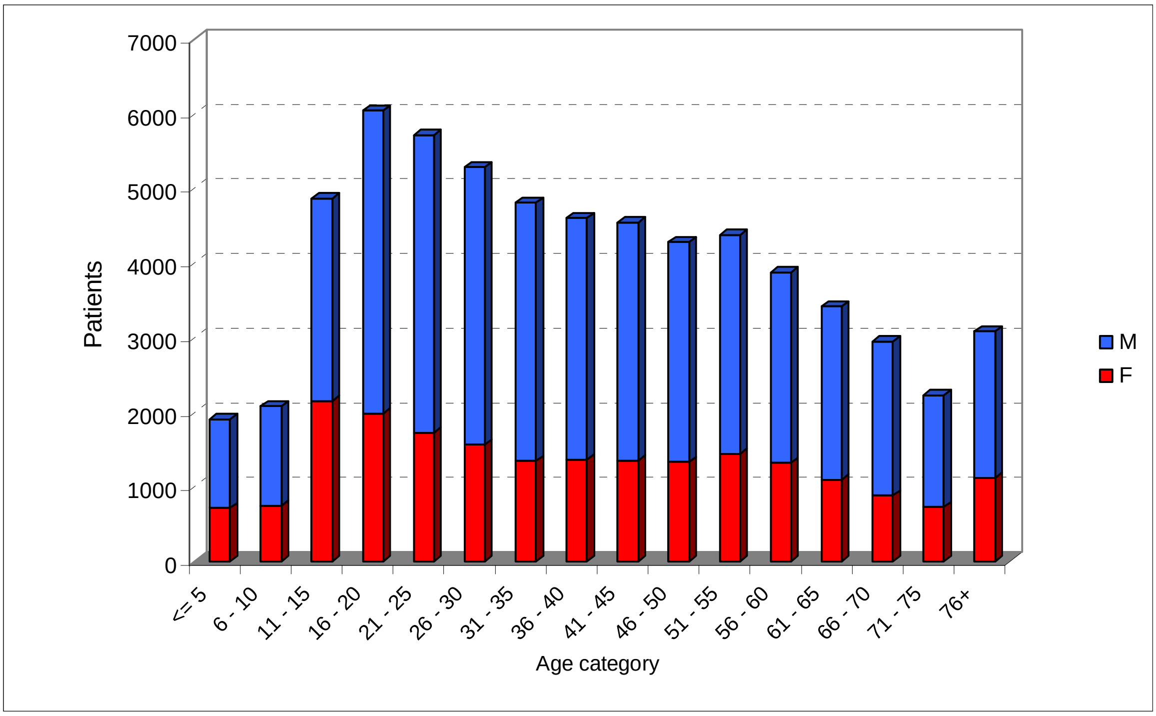

Figure 7: Age distribution

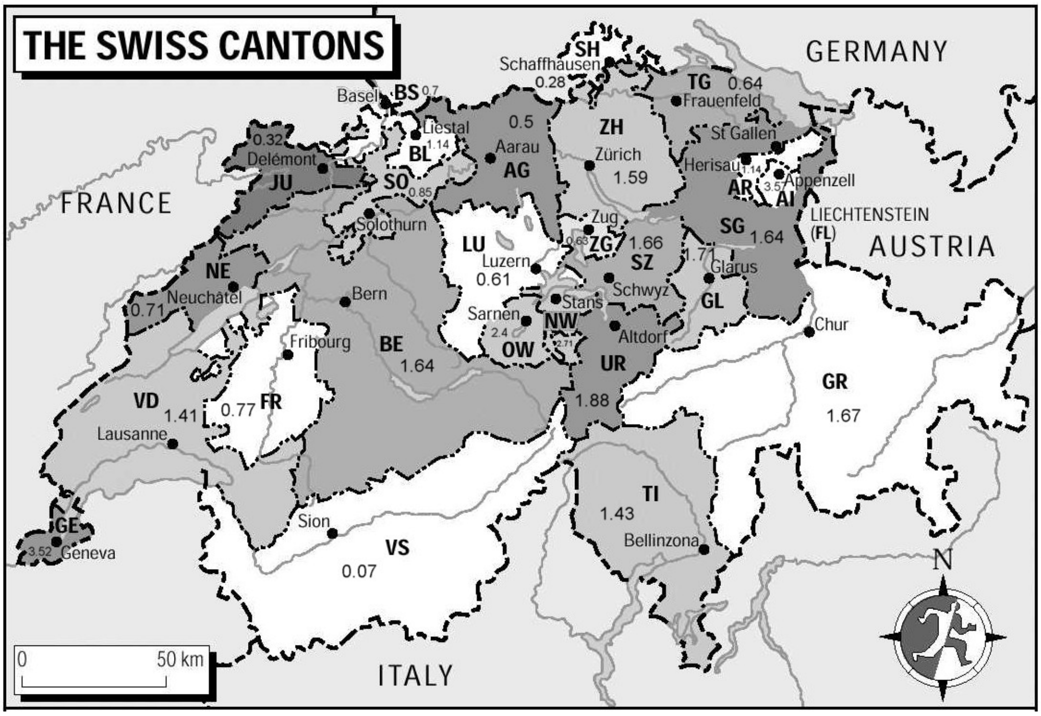

Figure 8: Regional differences in REGA helicopter use. Rescue missions per km^2 by canton (n=51,080).

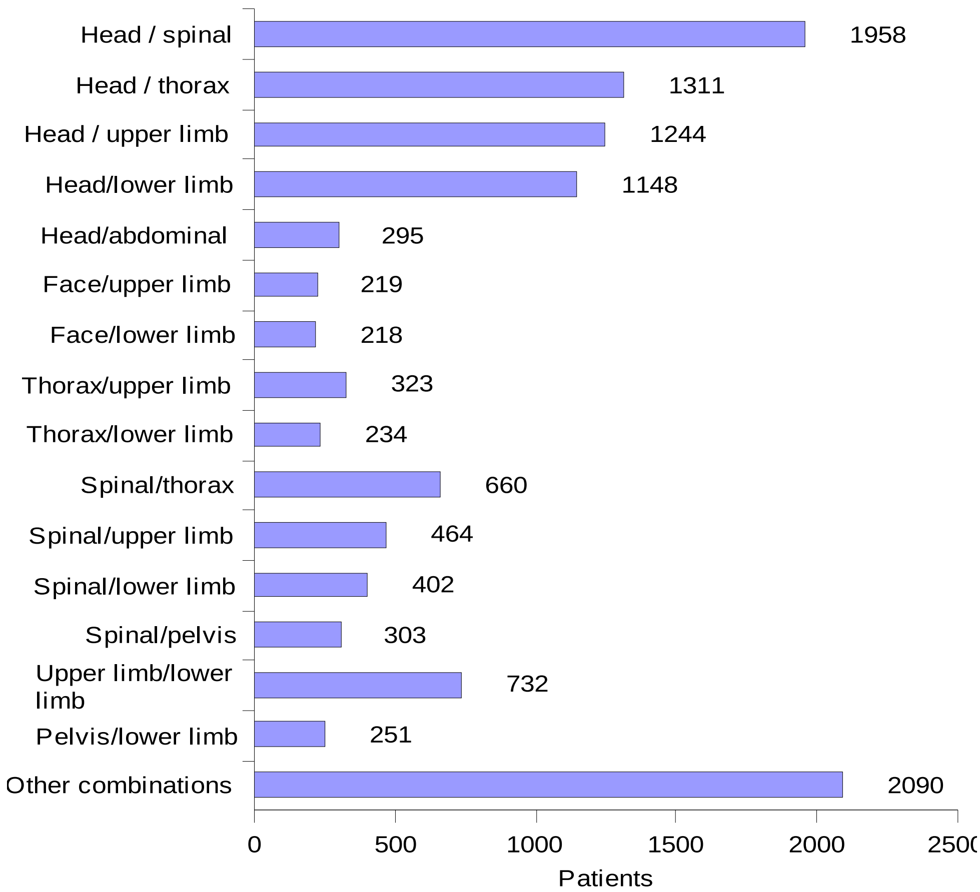

Figure 9: Double combination injuries (n=11,852)

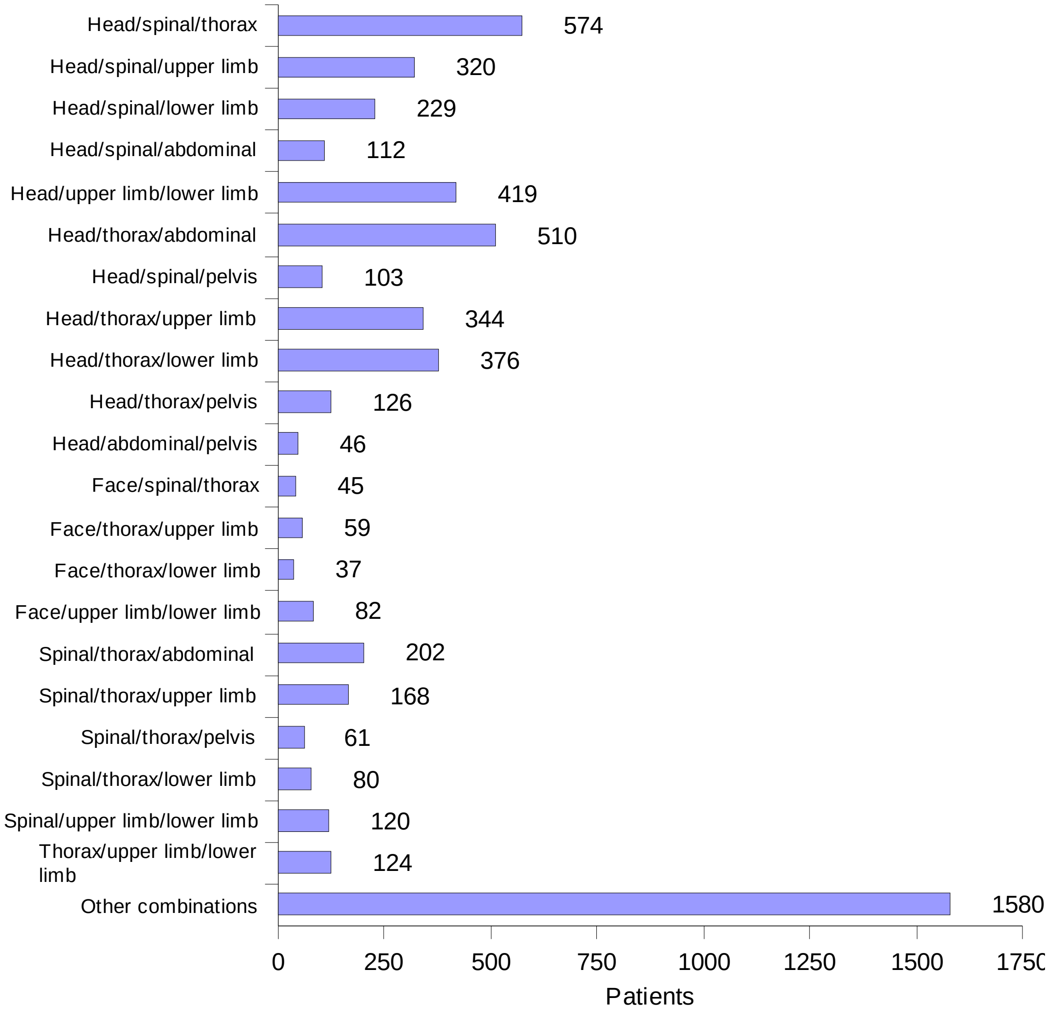

Figure 10: Triple combination injuries (n=5,717)

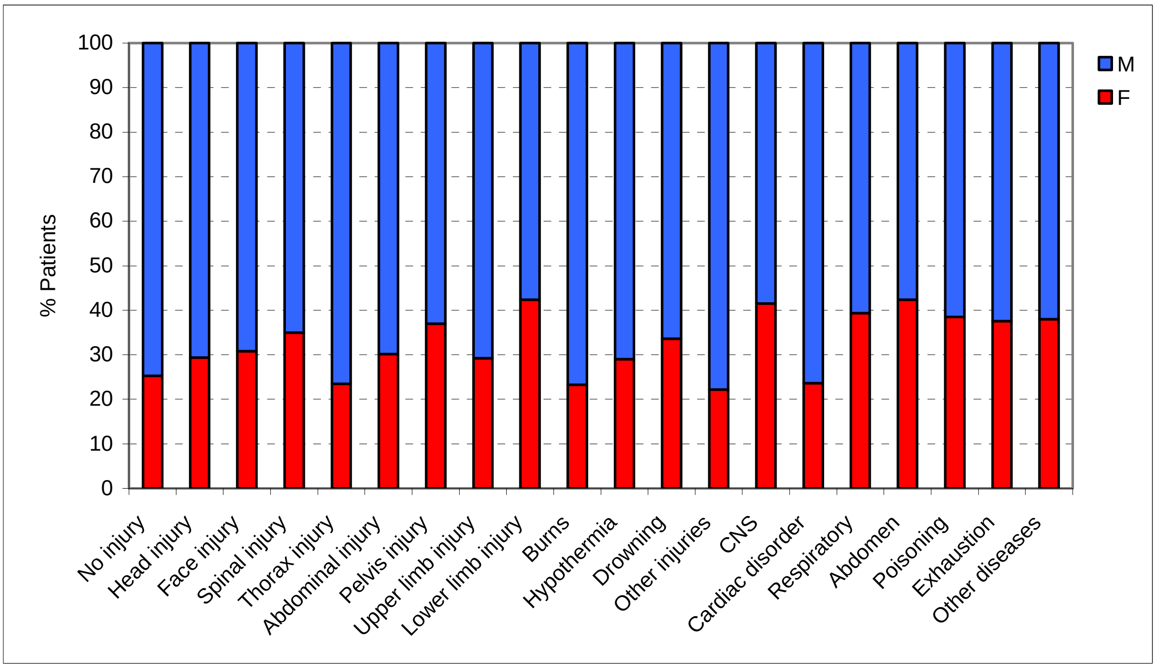

Figure 11: Gender distribution in relation to the injury/medical diagnosis

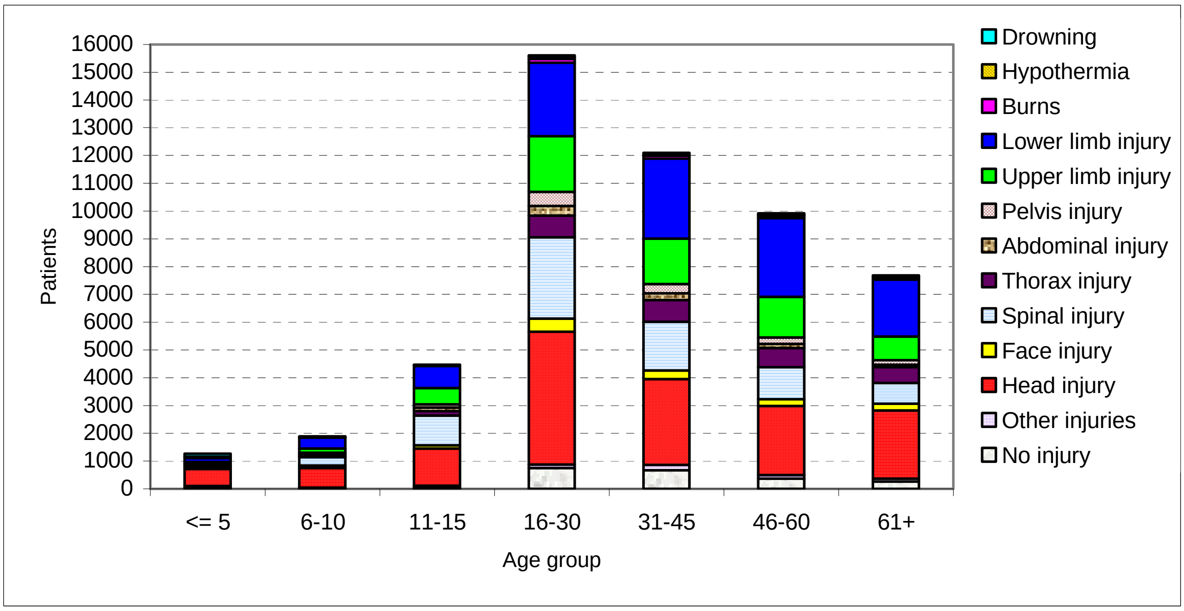

Figure 12: Distribution of injuries in relation to age categories.

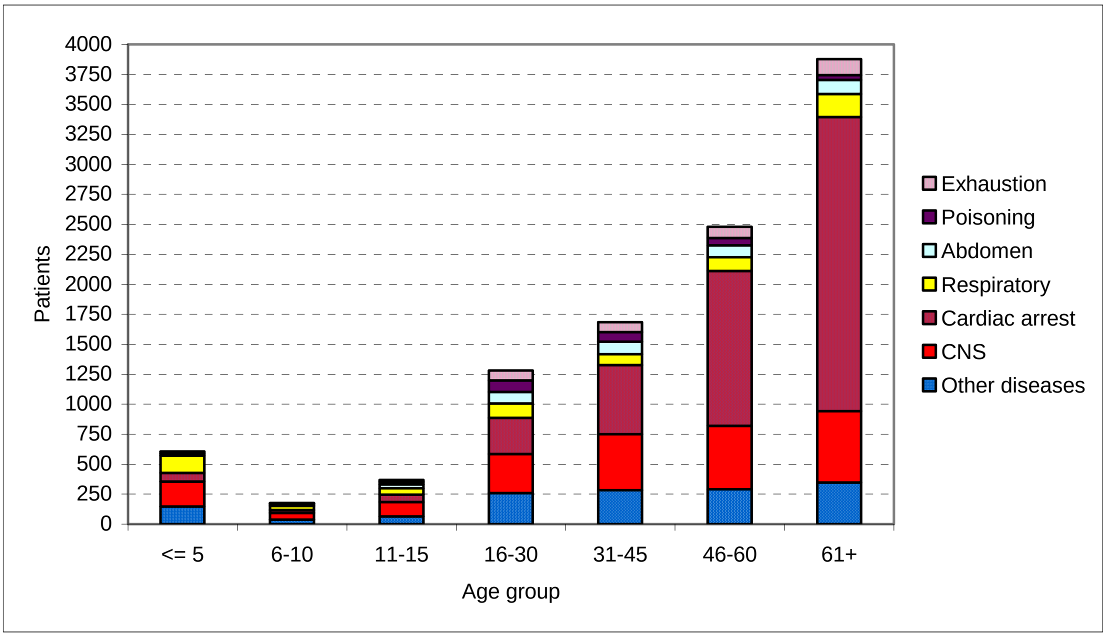

Figure 13: Distribution of medical indications to age categories.

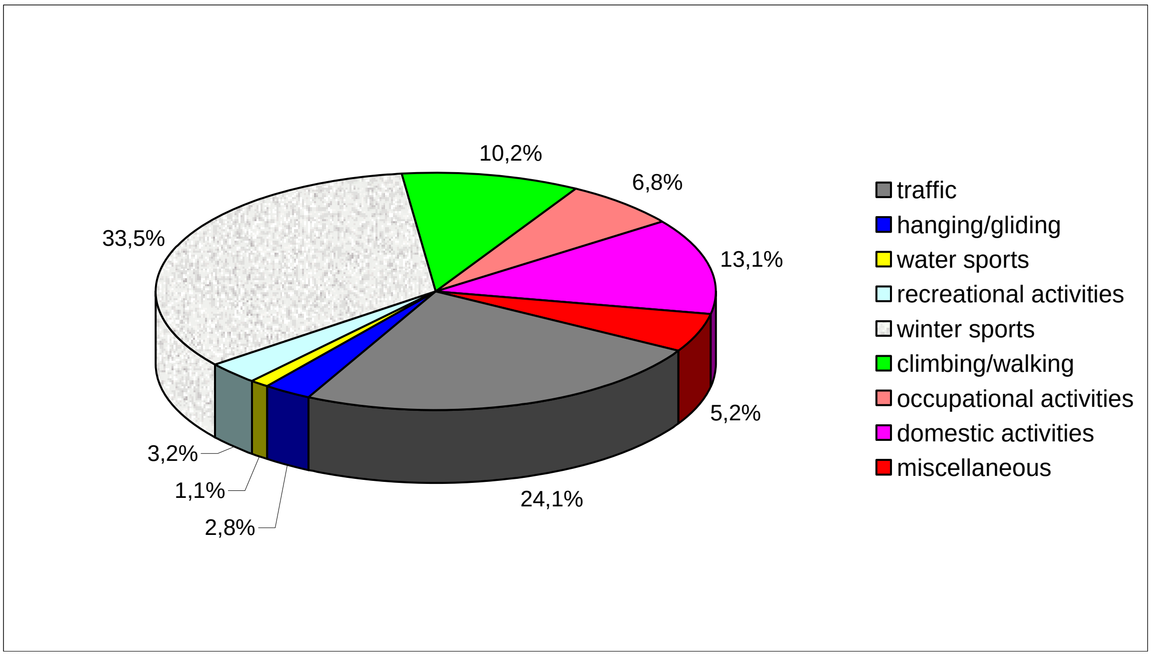

Figure 14: Categories of activities in which victims were injured.

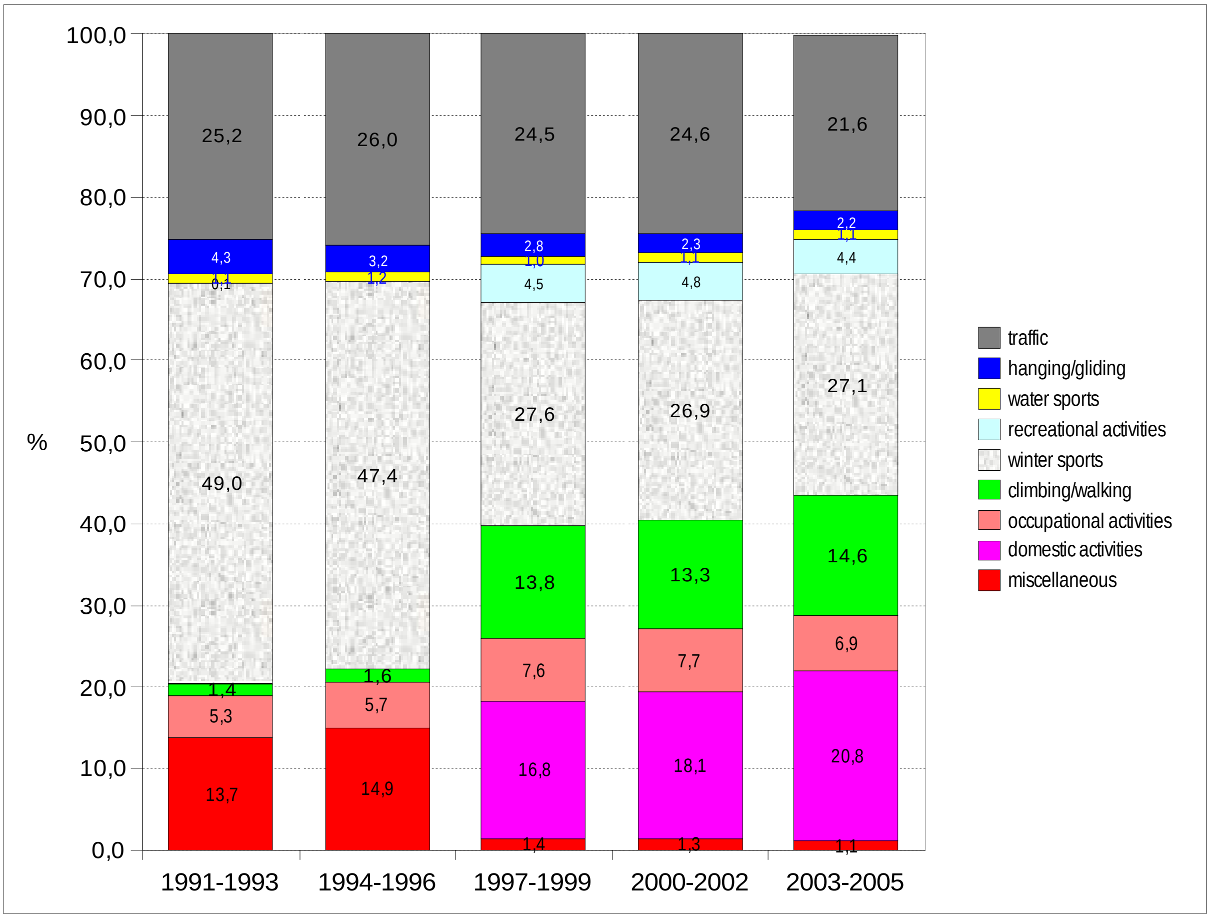

Figure 15: Circumstances of incident by study year

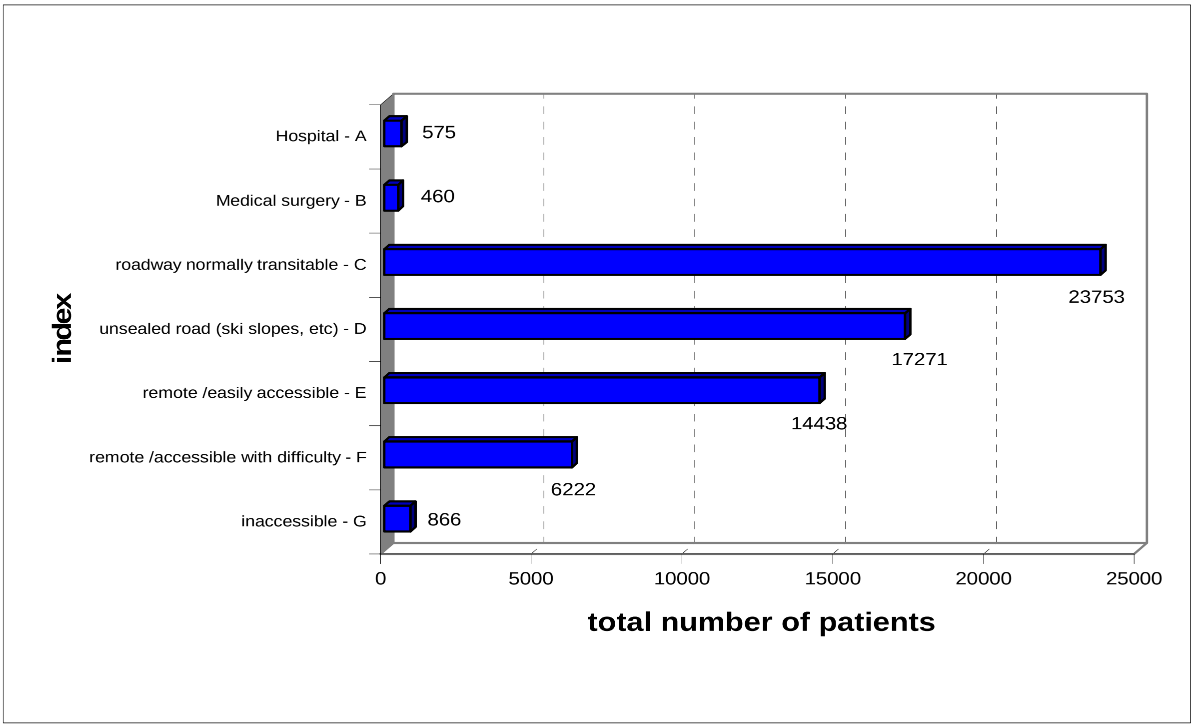

Figure 16: Distribution of all missions according to NACA Index (A-G) (63,585 rescue flights between January 1991 and December 2005).

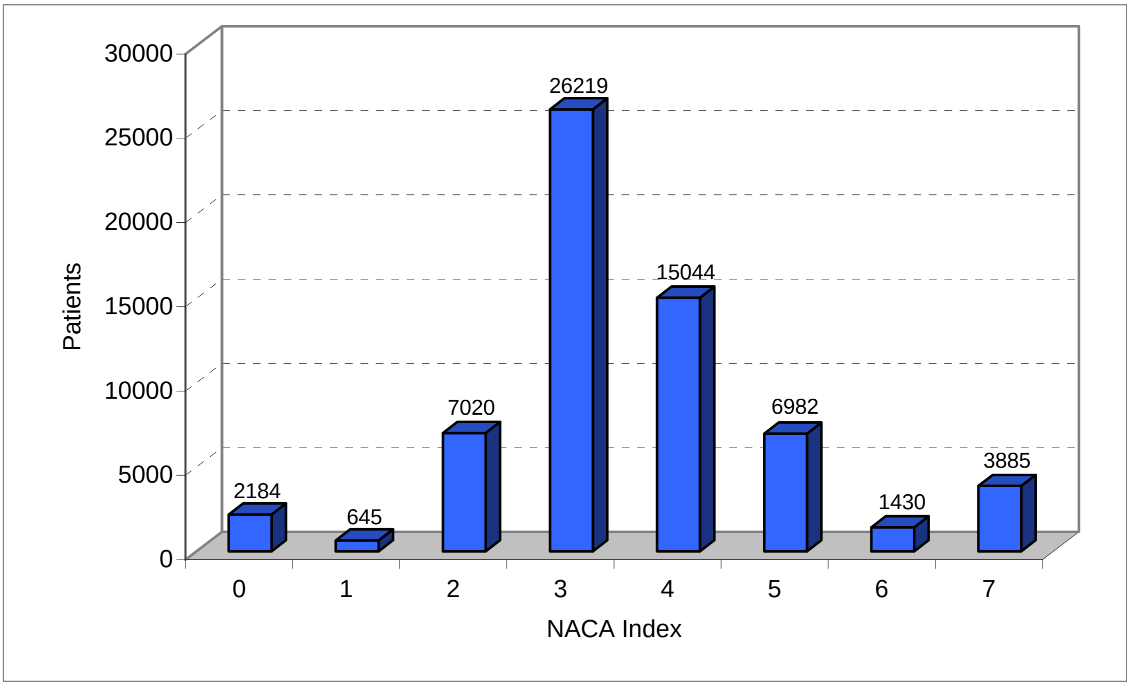

Figure 17: Distribution of patients by NACA (National Advisory Committee for Aeronautics) scale.

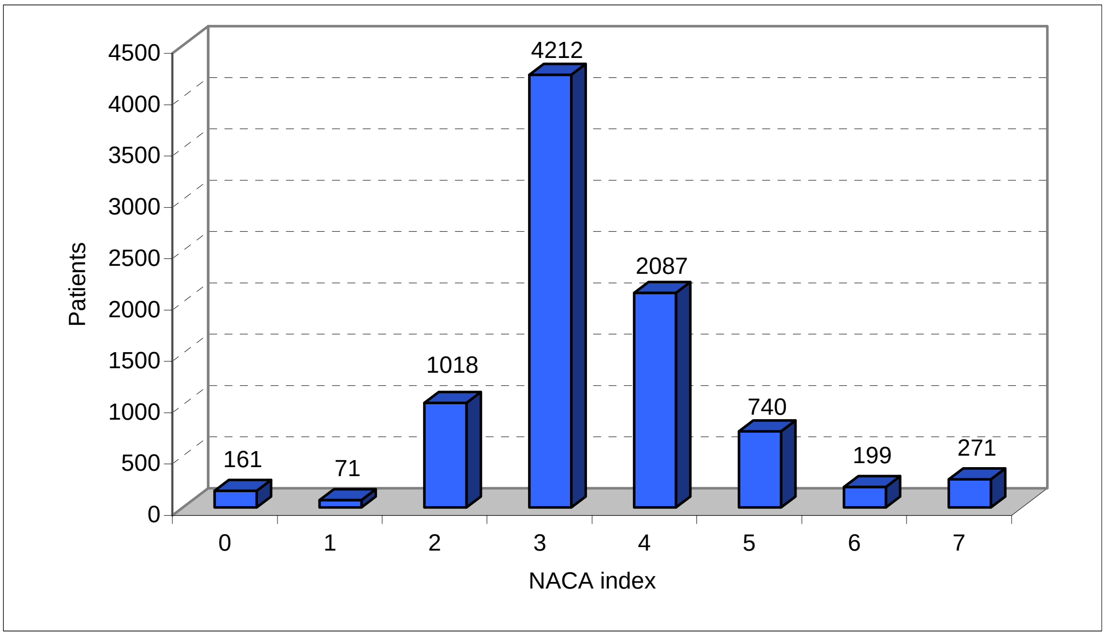

Figure 18: NACA severity index for children

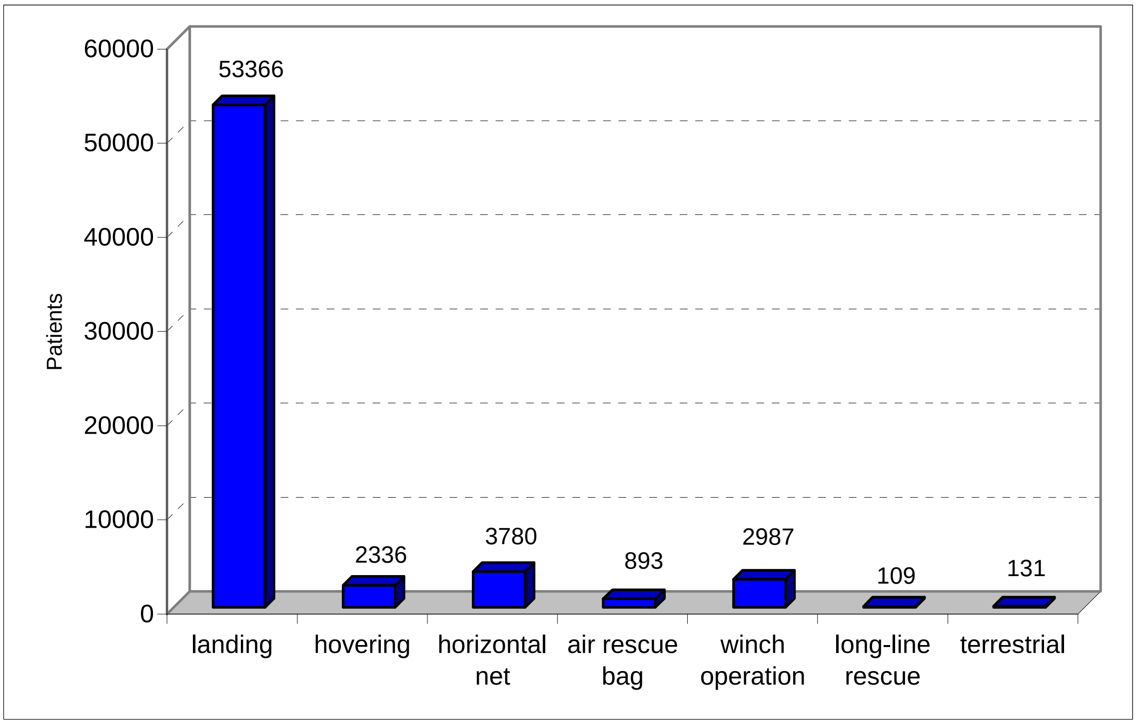

Figure 19: Flight operations to the accident sites (63,602 rescue flights between January 1991 and December 2005).

Tables

Table 1: NACA score (National Advisory Committee for Aeronautics)

SCORE LEVEL	PATIENT STATUS	INTERVENTION	EXAMPLES*)
1	Minor injuries or illnesses	No urgent medical treatment required	bruises, abrasions, sprains
2	Not life threatening injuries or illnesses	No hospitalization required, but a more thorough examination or treatment	worse abrasions, toe & finger fractures
3	Severe but not life threatening injuries or illnesses	Examination and treatment of prolonged nature with hospitalization necessary	open wounds, peripheral nerve or vessel injury, spinal insult with neuro findings, femur fx, lower extremity ligaments, mild hypothermia, appendicitis, high fever, etc.
4	Injuries or illnesses without immediate endanger life but with possible life threatening within a short time	Urgent treatment required	Open skull fx, head/ brain injury with >15 minute LOC, blunt belly trauma, simple closed upper leg fx, amputated lower extremity, hanging in rope system, etc.
5	Life-threatening injuries or illnesses, which, without urgent treatment, would be lethal	Transport and possible resuscitation	suspected neck fx with neuro symptoms, multiple rib fx with respiratory compromise, open chest wound/trauma, multiple fx of larger bones, femur fx with shock, open pelvic fx, cardiac problem with dysrhythmia, pulmonary edema, HAPE with severe respiratory insufficiency, severe hypothermia, etc.
6	Injuries or illness which, following the rehabilitation of the vital functions and successful resuscitation, necessitate hospitalization		
7	Fatal injuries or illnesses with or without an attempt at resuscitation, even if the resuscitation was carried out without success on-the-spot or during transport to hospital		

*) from Veldman et al. 2000

Table 2: Area Index

AREA INDEX	VALUE LABEL
A	Hospital or other treatment center (the majority with a heliport)
B	Medical surgery (mainly located in urban or semi-rural areas and adequately equipped)
C	Road normally trafficable (normal viability, but which can be in geographically inconvenient regions as a result of the protruding mountainous nature of the Swiss terrain)
D	Accessible with difficulty (skiing area, agricultural roads and lakes)
E	Remote but easily accessible (alpine refuges, mountain faces up to 2 degrees alpine difficulty)
F	Remote but accessible with difficulty (glaciers, mountain faces up to 3 degrees alpine difficulty)
G	Totally inaccessible (high north mountain faces, and those of 5 degrees)

Table 3: Flight operations to the incident sites - Rescue Index

RESCUE INDEX	FLIGHT OPERATION
1	Landing near the incident site is possible
2	Rescue flight in-and-out hover
3	Winch operation: horizontal net
4	Winch operation: air rescue bag
5	Winch operation: other
6	Long-line rescue system
7	Terrestrial run by a rescue guide

Table 4: Types of injury

INDEX	TYPE OF INCIDENT
01	injury resulting from being run over / pushed
02	injury by equipment / tools
03	lighting strike, electroshock
04	blocked
05	Hanging (e.g. over trees)
06	extensive burns
07	contused wound / crush trauma
08	critical illness
09	crevasse accident
10	motor vehicle crash
11	avalanche accident
12	gunshot wound
13	rock fall / icefall
14	falls
15	animal bite
16	lack of consciousness
99	other

Table 5: Distribution of REGA operation flights between January 1993 and December 2005

Region	**Patients**	**Percent**	**Valide Percent**
GR	11,856	20.8%	20.8%
BE	9,785	17.2%	17.2%
VD	4,545	8.0%	8.0%
TI	4,029	7.1%	7.1%
SG	3,326	5.8%	5.8%
ZH	2,748	4.8%	4.8%
UR	2,019	3.5%	3.5%
SZ	1,508	2.6%	2.6%
FR	1,292	2.4%	2.4%
OW	1,179	2.1%	2.1%
GL	1,173	2.1%	2.1%
GE	992	1.7%	1.7%
LU	915	1.6%	1.6%
NW	749	1.3%	1.3%
AG	699	1.2%	1.2%
SO	670	1.2%	1.2%
TG	632	1.1%	1.1%
AI	616	1.1%	1.1%
BL	592	1.0%	1.0%
NE	572	1.0%	1.0%
VS	374	0.7%	0.7%
AR	278	0.5%	0.5%
JU	271	0.5%	0.5%
ZG	150	0.3%	0.3%
SH	84	0.1%	0.1%
BS	26	0.0%	0.0%
Total operations in Switzerland	**51,080**	**89.7%**	**89.7%**
F	2,860	5.0%	5.0%
D	182	0.3%	0.3%
FL	91	0.2%	0.2%
I	58	0.1%	0.1%
A	42	0.1%	0.1%
Further operations abroad	2,647	4.6%	4.6%
Total operations abroad	**5,880**	**10.3%**	**10.3%**
Sum Total Operations	**56,960**	**100.0%**	**100.0%**

AG: Argovia, AI: Appenzell Inner Rhodes, AR: Appenzell Outher Rhodes, BE: Berne, BL: Basle-Country, BS: Basle-City, FR: Fribourg, GE: Geneva, GL: Glarus, GR: Grisons, JU: Jura, LU: Lucerne, NE: Neuchâtel, NW: Nidwald, OW: Obwald, SG: Saint Gall, SH: Schaffhausen, SO: Solothurn, SZ: Schwyz, TG: Thurgovia, TI: Ticino, UR: Uri, VD: Vaud, VS: Valais, ZG: Zug, ZH: Zurich, A: Austria, D: Germany, F: France, FL: Principality of Liechtenstein, I: Italy.

Table 6: Injuries and medical diagnosis of the transported patients

	Reasons for transport	**n**	**%**
	No injury	2,269	3.5
Trauma	Head injury	15,529	24.2
	Face injury	1,541	2.4
	Spinal injury	8,010	12.5
	Thorax injury	3,086	4.8
	Abdominal injury	1,074	1.7
	Pelvis injury	1, 376	2.1
	Upper limb injury	6, 778	10.6
	Lower limb injury	11,729	18.3
	Burns	490	0.8
	Hypothermia	314	0.5
	Drowning	268	0.4
	Other injuries	623	1.0
Subtotal		53,087	
Medical diagnosis	CNS	2,310	3.6
	Cardiac arrest	4,790	7.5
	Respiratory	748	1.2
	Abdomen	484	0.8
	Poisoning	317	0.5
	Exhaustion	418	0.7
	Other diseases	1,433	2.2
Subtotal		10,500	
Total		63,587	99
Missing cases		658	1.0
Sum total		64,245	100.0

Table 7: Body part injured by study year

	1991-1993		1994-1996		1997-1999		2000-2002		2003-2005	
	n	%	n	%	n	%	n	%	n	%
No injury	302	2,9	168	1,9	390	2,9	539	3,6	900	5,4
Head injury	2622	25,5	2335	25,8	3044	22,5	3316	22,3	3719	22,5
Face injury	279	2,7	258	2,9	300	2,2	343	2,3	361	2,2
Spinal injury	1235	12,0	1233	13,6	1789	13,2	1873	12,6	1879	11,4
Thorax injury	436	4,2	408	4,5	638	4,7	789	5,3	816	4,9
Abdominal injury	150	1,5	126	1,4	230	1,7	271	1,8	297	1,8
Pelvis injury	192	1,9	217	2,4	312	2,3	315	2,1	340	2,1
Upper limb injury	1129	11,0	1022	11,3	1403	10,4	1539	10,3	1684	10,2
Lower limb injury	1433	13,9	1978	21,9	2531	18,7	2506	16,8	2657	16,1
Burns	49	0,5	57	0,6	107	0,8	136	0,9	141	0,9
Hypothermia	71	0,7	33	0,4	50	0,4	83	0,6	77	0,5
Drowning	25	0,2	21	0,2	70	0,5	79	0,5	73	0,4
Other injuries	23	0,2	25	0,3	149	1,1	182	1,2	163	1,0

Table 8: Mechanisms of injury

Type of incident	**n**	**%**
by runover/pushed	1,631	2.5
by tools	587	0.9
Lighting strike/electrocution	126	0.2
blocked	893	1.4
Hanging	175	0.3
Burns	360	0.6
Crushing	1,010	1.6
Illness	6,755	10.5
Crevasse accident	55	0.1
Collision	7,998	12.4
Avalanche accident	2,571	4.0
Gunshot wound	376	0.6
Rock fall / Ice fall	270	0.4
Falls	21,889	34.1
Animal bite	202	0.3
Lack of consciousness	521	0.8
Other	18,207	28.3
Valid cases	*63,626*	*99.0*
Missing cases	*619*	*1.0*
Total	**64,245**	**100.0**

Table 9: Distribution of NACA index in relation to the location of the emergency

Location	**NACA Index**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
Hospital	3	5	6	118	234	174	16	14	570
	0.0%	0.0%	0.0%	0.2%	0.4%	0.3	0.0%	0.0%	0.9%
Medical practice	0	3	10	167	175	65	17	21	458
	0.0%	0.0%	0.0%	0.3%	0.3%	0.1%	0.0%	0.0%	0.7%
Normal street	62	55	466	5,697	9,021	5,472	1,047	1,881	23,701
	0.1%	0.1%	0.7%	9.0%	14.2%	8.6%	1.7%	3.0%	37.4%
Place difficult to reach	179	100	3,265	10,091	2,504	470	153	475	17,237
	0.3%	0.2%	5.1%	15.9%	3.9%	0.7%	0.2%	0.7%	27.2%
Place remote – easy to reach	616	269	2,379	7,398	2,217	557	149	789	14,374
	1.0%	0.4%	3.8%	11.7%	3.5%	0.9%	0.2%	1.2%	22.7%
Place remote – difficult to reach	996	157	816	2,540	791	198	44	599	6,141
	1.6%	0.2%	1.3%	4.0%	1.2%	0.3%	0.1%	0.9%	9.7%
Place impossible to reach	312	55	74	190	83	33	3	85	835
	0.5%	0.1%	0.1%	0.3%	0.1%	0.1%	0.0%	0.1%	1.3%
Total	2,184	645	7,020	26,219	15,044	6,982	1,430	3,885	63,409
	3.4%	1.0%	11.1%	41.3%	23.7%	11.0%	2.3%	6.1%	100.0%
Valid cases									63,409
Missing cases									836
Total									64,245

Table 10: Distribution of NACA index in relation to the Rescue index

Rescue Index	**NACA Index**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
landing	785	386	5,747	21,812	13,700	6,614	1,366	2,802	53,212
	1.2%	0.6%	9.1%	34.4%	21.6%	10.4%	2.2%	4.4%	84.0%
hovering	287	80	491	1023	231	43	21	128	2304
	0.5%	0.1%	0.8%	1.6%	0.4%	0.1%	0.0%	0.2%	3.6%
horizontal net	215	49	316	1,754	634	186	29	586	3,769
	0.3%	0.1%	0.5%	2.8%	1.0%	0.3%	0.0%	0.9%	6.0%
air rescue bag	33	0	34	418	252	76	7	70	890
	0.1%	0.0%	0.1%	0.7%	0.4%	0.1%	0.0%	0.1%	1.4%
winch operation	808	127	409	1139	179	39	6	227	2,934
	1.3%	0.2%	0.6%	1.8%	0.3%	0.1%	0.0%	0.4%	4.6%
long-line rescue	34	1	8	40	8	2	0	14	107
	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%
terrestrial	5	1	11	28	33	14	1	35	128
	0.0%	0.0%	0.0%	0.0%	0.1%	0.05	0.0%	0.1%	0.2%
Total	2,167	644	7,016	26,214	15,037	6,974	1,430	3,862	63,344
	3.4%	1.0%	11.1%	41.4%	23.7%	11.0%	2.3%	6.1%	100.0%
Valid cases									63,344
Missing cases									901
Total									64,245

Diagnosis	Event															Total	
	Collide with	Injury by tools	Lighting strike	blocked	Hanging	Burns	contused wound	Illness	Collision	Avalanche acci-dent	Gunshot wound	Rock fall /Icefall	Falls	Animal bite	Lack of consci-ousness	Other		
No injury	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2	5	0,1%
Head injury	92	9	-	-	3	1	28	13	395	1	-	-	417	1	-	466	1426	25,1%
Face injury	8	15	-	-	1	4	2	3	54	1	1	2	38	1	-	82	212	3,7%
Spinal injury	41	8	-	1	-	-	30	8	255	4	-	6	555	1	-	356	1265	22,2%
Thorax injury	12	2	-	1	-	3	10	4	121	1	1	-	89	1	-	86	331	5,8%
Abdominal injury	4	3	-	-	-	-	3	5	17	1	-	-	18	1	-	14	66	1,2%
Pelvis injury	7	1	-	-	-	-	8	-	40	-	-	-	56	1	-	25	138	2,4%
Upper limb injury	15	64	-	-	2	-	31	1	85	1	1	-	180	3	-	113	496	8,7%
Lower limb injury	56	29	-	1	-	-	35	-	226	1	3	2	266	1	-	186	806	14,2%
Burns	-	-	6	-	8	49	-	-	1	-	-	-	1	-	-	1	66	1,2%
Hypothermia	-	-	-	-	-	-	1	1	-	-	-	-	-	-	2	3	7	0,1%
Drowning	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	9	10	0,2%
Other injuries	-	1	2	-	1	-	-	5	11	-	-	-	7	4	-	41	72	1,3%
CNS	1	-	-	-	-	-	-	202	7	39	-	-	15	1	-	16	281	4,8%
Cardiac arrest	-	-	1	-	-	-	-	127	4	40	-	-	4	-	-	8	184	3,2%
Respiratory	-	-	-	-	-	1	-	30	1	16	-	-	-	1	-	14	63	1,1%
Abdomen	-	1	-	-	-	-	-	25	4	13	-	-	2	-	-	3	48	0,8%
Poisoning	-	-	-	-	1	-	-	17	-	5	-	-	3	-	-	19	45	0,8%
Exhaustion	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-	-	4	0,2%
Other diseases	1	-	1	-	-	-	-	90	5	26	-	-	4	5	-	35	167	2,9%
Total	238	133	10	3	16	58	148	533	1228	151	6	10	1656	21	2	1479	5692	
	4,2%	2,3%	0,2%	0,1%	0,3%	1,0%	2,6%	9,4%	21,6%	2,7%	0,1%	0,2%	29,1%	0,4%	0,0%	26,0%		100,0%
Missing cases																	5	
Sum Total																	5697	
Diagnosis	**Event**																	

Table 11: Diagnoses in patients rated NACA 3 rescued on normal trafficable roads

	Collide with	Injury by tools	Lighting strike	blocked	Hanging	Burns	contused wound	Illness	Collision	Avalanche ac-cident	Gunshot wound	Rock fall / Ice-fall	Falls	Animal bite	Other		
No injury	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	0,1%
Head injury	36	-	-	-	-	-	1	2	60	-	-	-	115	1	62	277	30.3%
Face injury	3	2	-	-	-	-	1	1	9	-	1	1	9	-	16	43	4.7%
Spinal injury	6	-	-	-	-	-	2	-	15	-	-	2	106	-	46	177	19.4%
Thorax injury	2	-	-	-	-	3	-	-	3	-	-	-	7	-	3	18	2.0%
Abdominal injury	2	1	-	-	-	-	-	-	5	-	-	-	7	1	2	18	2.0%
Pelvis injury	1	-	-	-	-	-	-	-	4	-	-	-	7	-	1	13	1.4%
Upper limb injury	2	2	-	-	-	-	2	-	4	-	-	-	30	-	13	53	5.8%
Lower limb injury	18	2	-	1	-	-	3	-	25	-	-	-	30	-	9	88	9.6%
Burns	-	-	2	-	3	22	-	-	-	-	-	-	-	-	-	27	3.0%
Other injuries	-	-	-	-	1	-	-	2	1	-	-	-	2	-	10	16	1.8%
CNS	-	-	-	-	-	-	-	77	-	8	-	-	7	-	3	95	10.4%
Respiratory	-	-	-	-	-	-	-	17	1	4	-	-	-	-	9	31	3.4%
Other diseases	-	-	-	-	-	-	-	34	1	7	-	-	1	1	11	55	6.0%
Valid cases	70	7	2	1	4	25	9	133	129	19	1	3	321	3	185	912	99.9%
	7.7%	0.8%	0.2%	0.1%	0.4%	2.7%	1.0%	14.6%	14.1%	2.1%	0.1%	0.3%	35.25	0.3%	20.3%		
Missing cases																1	0.1%
Total																913	100.0%

Table 12: Diagnoses in patients less than 15 years old with NACA index 3 who were rescued on normal roads

	PRIMARY MISSIONS	SECONDARY MISSIONS
Ground ambulance, w/o physician during the day	CHF 674	CHF 524
Ground ambulance with a physician and driver, during the day	CHF 1,019	CHF 869
REGA helicopter	CHF 1,493	CHF 1,364

Table 13: Comparison of costs for a 50km distance (Ummenhofer et al. 1996).