PRE-HOSPITAL EMERGENCY CARE IN SWEDEN

– with Special Emphasis on Care of Traffic Victims –

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Traffic injuries cause a heavy burden on society in most motorized countries. Pre-hospital and hospital trauma care may have a potential to reduce these losses. By tradition the pre-hospital ambulance care has not until the last decades been integrated in the medical sector organization in Sweden. Nowadays it is regarded as the extended arm of trauma care. Improved qualification level to Registered Nurse (R.N.) and structured education and training has improved the competence of the pre-hospital personnel. However, few objective studies of the effect are available.

The National Board of Health and Welfare publish national guidelines for pre-hospital care and disaster management and support economically training in mass casualty and disaster command and control.

Systemized training of rescue and ambulance teams in co-operation at a crash site may reduce the extrication time of entrapped car/truck crash victims by 40-50 per cent. This is a valuable time gain especially in a cold climate, which may add hypothermia problems to the injuries.

In Sweden (9 million inhabitants), a sparsely populated country with sometimes long transportation distances to the nearest trauma hospital, 800 ambulances, 7 ambulance helicopters and 3-5 fixed wing ambulance aircraft are the available transport resources. In case of a mass casualty or disaster situation, inside or outside the country, a governmental project (Swedish National Medevac) aims to convert a passenger aircraft from Scandinavian Airlines System (SAS) to a qualified medical resource for long distance transport, with capacity to nurse six intensive care patients and an additional 6-20 lieing or seated patients during transport.

Key Words: Pre-hospital, Ambulance, Traffic injuries, Ambulance helicopter, Fixed wing, Mass casualty, Disaster

1. BACKGROUND

In 1899, the Swedish Crown Prince, later King Gustav V, bought one of the first automobiles in Sweden and by this act, he exposed a positive attitude to this innovation. During the first decade of the 1900's the speed limit was 10 km/h in urban areas and 15 km/h in rural areas so the losses in injuries and dead were few[1]. The losses have since then increased tremendously and globally 1.2 million people are estimated to loose their lives every year in traffic incidents.

In Sweden, the number of traffic fatalities was highest, about 1300 per year, around 1970. Despite increasing traffic, the losses in dead have decreased to currently less than half that number. The decrease has been most pronounced for the "vulnerable" or "unprotected" road users. In fact the number of fatalities is now the same (530) as 1939, before World War 2. Contributing to this positive development is the traffic safety work done by authorities, organisations and devoted people, a work, which started in connection with the shift from left to right hand traffic in 1967.

In Sweden with today 9 million inhabitants, currently about 530 people are killed annually in traffic, i.e. 6 per 100,000 inhabitants or 7-8 per 10 billion motor vehicle kilometres. Four million passenger cars, 230,000 motorcycles, 200,000 mopeds, 75,000 trucks and 14,000 buses/coaches are in traffic. Additionally at least five million Swedes are bicycle owners.

According to statistics from the medical sector the number of traffic injured needing medical attention is about 80,000 per year, i.e. nearly 1 per 100 inhabitants. Bicyclists and passenger car occupants are the most frequently injured, but pedestrians and motorcyclists/mopedists have the highest proportion of serious injuries. During the last decades, the improvement of the pre-hospital and hospital medical care has been one post-crash factor aiming to reduce these losses.

1.1 Development of pre-hospital care

Before the 1980's the ambulance service was regarded as a pure transport service, with very limited capacity to treat the injured at the crash site and during the transport. Gradually the insight of the importance of early and correct medical treatment came to characterise the development. Data from especially the U.S. pointed out the importance of the correct and professional handling

of injuries during the first critical hour after an injury event (the Golden hour)[2]. "If the critical trauma patient is not given definitive surgical care within 60 minutes from the time of injury the odds of his successful recovery diminish dramatically"[2].

In a sparsely populated country as Sweden, with often-long transportation distances of traffic victims, this concept raises high expectations on the competence and organisation of the pre-hospital care of the injured. During the 1980's and 1990's a gradual increase of the basic competence, training and organisation of the pre-hospital care has been realised. The basic medical training for ambulance personnel was before the 1980's "rudimentary", roughly equivalent with basic first responder training. During the1980's and 1990's an increasing number of ambulance personal received 20 weeks training. During the 1990's the Swedish National Board of Health and Welfare increased the basic competence requirements to Registered Nurse (R.N.) in ambulances where the crew is expected to perform more advanced medical treatment. It has been a painful and somewhat costly process with this change, but currently most ambulance organisations have at least one R.N. in each emergency ambulance.

Luckily enough the medical sector in Sweden has had a limited experience of handling severe injuries. However, the down of this was that Sweden was not in the front line to introduce improvements of the trauma care. These improvements are, e.g., represented of programs and protocols as the Advanced Trauma Life Support (ATLS)[3], Trauma Nurse Core Course (TNCC)[4] and Prehospital Trauma Life Support (PHTLS)[2] programs (Figure 1). Since the middle of the 1990's these programs have gradually been introduced and they have given a common structure to, and improved the quality of, the trauma care. In this context, the PHTLS is of special interest. The PHTLS-course is a 3-day course focused on pre-hospital trauma care, with special emphasis on problems related to traffic crashes. Interestingly with this training course is the strong focus on the relation between injury mechanisms and injuries, as this citation indicates; "A complete, accurate history and proper interpretation of this information can allow the EMT (Emergency Medical Technician) to predict more than 90% of the patient's injuries before he ever lays a hand on the patient"[2].

In the pre-hospital setting, the relation between trauma energy, injury mechanisms, biomechanical factors and injury factors forms the basis for a professional judgement of the consequences of a crash and how to handle identified and expected injuries. Certain types of injuries,

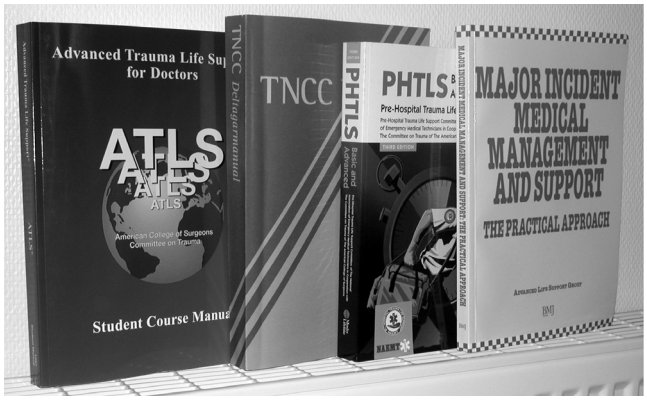

Fig. 1 Examples on different trauma and mass casualty training programs; ATLS for emergency physicians, TNCC for emergency nurses, PHTLS for pre-hospital personnel and MIMMS for command and control of mass casualty incidents in the pre-hospital setting

as fractures and superficial injuries, are often obvious and easy identifiable. Other, more hidden internal injuries to the thorax, abdomen, brain and spinal cord, causes much more trouble for pre-hospital personnel to identify and handle. It is obvious that these latter injuries are especially important to be handled correctly and quickly e.g. to compensate excessive internal blood loss, to treat a tension pneumothorax ("punctured lung"), or to handle a spin lesion with the risk for para- or quadriplegi (paralysis).

It has been estimated that a high quality trauma care can reduce fatalities by nearly 20% of those who are not killed immediately in the incident. The proportion of "immediate deaths" used to be between 55-65% for Swedish traffic victims.

2. ORGANIZATIONS INVOLVED

The three organisations involved in pre-hospital trauma care are the ambulance service, the rescue service (fire brigade) and the police. The personnel from these three organisations are working together at the crash site. In Sweden, a national organisation, (SOS Alarm), is responsible for handling the alarms and the dispatch of emergency resources.

2.1 The alarm centre

In Sweden (Figure 2) with 9 million inhabitants distributed over an area 500 × 1570 km or 450,000 km^2,

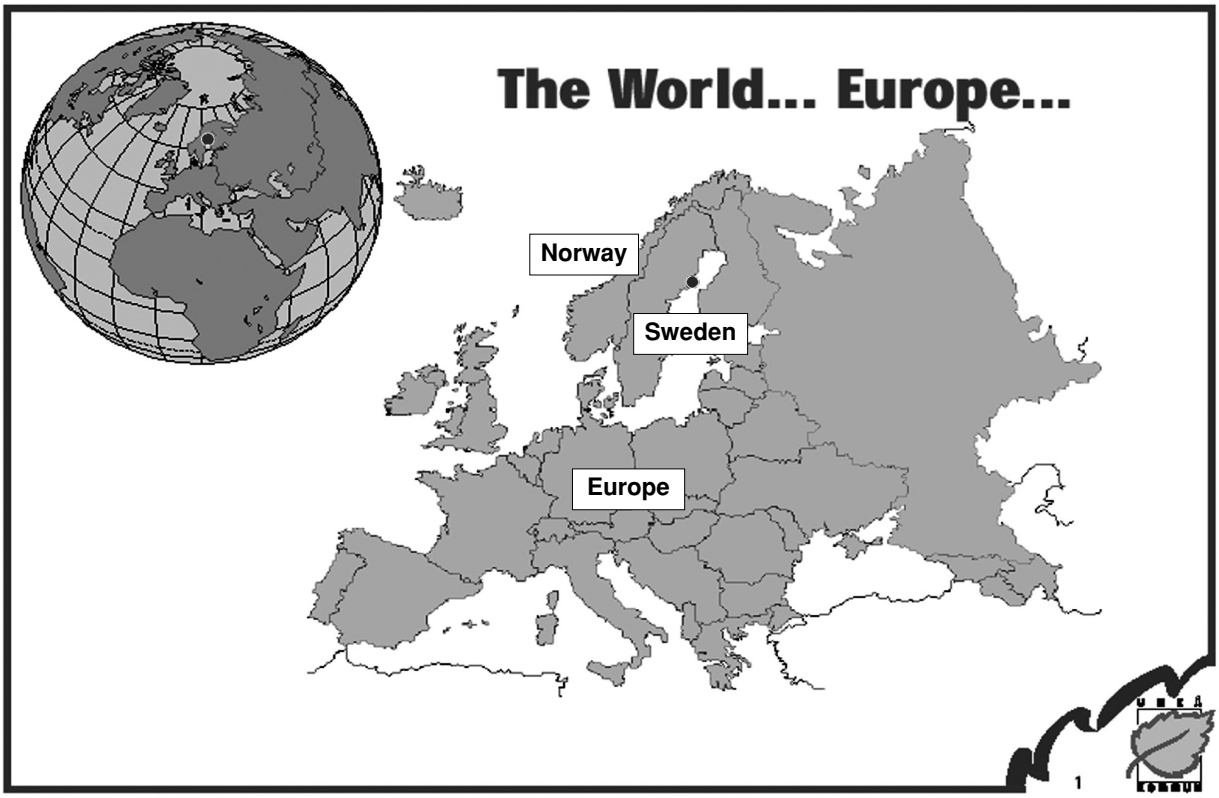

Fig. 2 Map over Europe and Sweden

(larger than e.g. Japan), 21 alarm centres are localised around the country, one in each county or region. It is possible to dial 112 and reach the nearest alarm centre in the whole of Sweden. The alarms in traffic crashes are raised by mobile phones in more than 95% of cases today, so the need for emergency phones along the roads has disappeared.

On receiving an emergency call, the alarm centre dispatches the necessary rescue-, ambulance-, and police resources. The staff at the alarm centre have a broad knowledge of medical emergencies, however not so deep. By support of different decision protocols they can in most cases follow standard procedures, and in this way reduce the risk for errors.

2.2 The Rescue service

The Rescue service has been developed from the former Fire brigade. The main duty of the Rescue service at a crash site is to secure the site against environmental hazards, to prevent further injuries to victims and rescuers, to uncover victims jammed in e.g. a car, and to clean up the site from spill of glass and oil.

By a recent governmental decision the Rescue service is also responsible for the injury preventive work in the local community in a broader sense. This is quite a new task for the organisation and working methods is under development. This is, however, an interesting and serious attempt from the government to localise the injury preventive work "near the people" in the local community.

The personnel of the Rescue service have special training to handle car crashes in which one important task is to uncover the injured. They have special cutting equipment to open up crashed cars. However, modern cars are built with so hard and strong steel, especially in their side protection structure, that the tools used may have problems to cut these parts. For the Rescue service located in smaller communities, often staffed with voluntary personnel, it is an obvious problem to buy updated expensive equipment and train the personnel. All rescue personnel also have 40 hours training in first aid so they may act as medical First Responders.

2.3 Police

The police are responsible for making the crash site safe from other traffic. By redirecting other traffic and sealing off the area from curious people, the safety increases. The police are also responsible for identifying the injured and dead and to investigate the circumstances

of the crash. The police also decide on the autopsy of the fatally injured. The autopsy rate in Sweden is nearly 100% for traffic victims and alcohol and drug analysis is routinely done. About 30% of the traffic fatalities are alcohol related.

2.4 Emergency and ambulance service

During the last 15 years, the ambulance service has moved closer to the medical sector institutions, from often being localized at fire stations or at private entrepreneurs. In rural areas, it is today quite common to have the ambulance connected to the local medical centre from which some, or all of the ambulance personnel, is recruited. This is convenient and economically beneficial, especially in areas where the ambulances make only a few missions per day.

The aim of the pre-hospital care is to give the injured or sick adequate care already at the incident site and "secure" him or her before the transport to hospital. Especially in modern trauma care, the "Golden hour" puts high demands on the pre-hospital care.

Ambulance vehicles and equipment

In Sweden, two types of ambulance vehicles are used (Figure 3):

- large ambulances based on van or minibus chassis
- small ambulances based on passenger car chassis

Fig. 3 Examples of common large and small ambulance vehicles in Sweden

The advantage of large ambulances is a spacious care-cabin, which creates the necessary conditions for advanced treatment of the injured. The disadvantage is bad comfort especially when driving on rough roads. The ambulances based on passenger-car chassis are most commonly used in rural areas with long driving distances, because of their better driving comfort and handling. Totally about 800 emergency ambulances are in use, i.e. nearly one per 1000 inhabitants, most of them with 24-hour service. Nationally, although not too accurate estimates, indicate that a ground ambulance can reach about 90 per cent of the population within 30 minutes. For some rural areas, the average driving distance per mission (to the injured - to the hospital - and back) is around 150-200 km. In densely built up areas of course these numbers are reduced; in the biggest cities to 5-10 minutes response time and 10 km.

The medical equipment in an ambulance must fulfil a basic standard specification, valid for all Swedish ambulances. The equipment permits advanced medical care with anti-shock treatment, assisted ventilation, defibrillation etc. Equipment for fixation and stabilisation of fractures and special devises as fixation mattresses and special stretchers, are necessary in tricky situations, e.g. during extrication of victims jammed in a car wreck.

Traffic congestion problems may interfere with the traffic ability for ground ambulances. This may happen in the two biggest cities in Sweden, Stockholm and Gothenburg, with 1 and 0.4 million inhabitants respectively. In e.g. Gothenburg, certain lanes have been marked with a sign indicating which lane should be cleared in case of emergency vehicles approaching. This is an attempt to facilitate the traffic ability for these vehicles.

Helicopters

Some areas, especially in the northern rural half of Sweden, ambulance helicopter service is available 24 hours a day. In most cases, an experienced anaesthesiologist or emergency doctor staffs the helicopter. In a few cases, the basic competence is only R.N. with special training, but with possibility for reinforcement on severe missions. The helicopters used are often midsize helicopters as e.g. Aerospatiale Dauphin AS 365 and Sikorsky S-76. The aim for the helicopter service is to bring the best medical competence to the injured as soon as possible, to stabilize the victim's vital functions, and to assure a safe and quick transport to hospital.

The ambulance helicopters are equipped with advanced medical equipment permitting a high degree of emergency and intensive care. They can bring one or two

injured. These helicopters are mostly used outside urban areas because ground ambulances are often quicker to the incident site in urban areas. Only in the two biggest cities may traffic congestion problems sometimes justify use of helicopters in the city.

A helicopter does between 400 and 1200 missions annually, depending on local circumstances. Nearly half the Swedish population have access to helicopter service provided by seven ambulance helicopters and these helicopters make a total of 6000-7000 missions annually i.e. about 1.5 per 1000 inhabitants and year. Additionally, at a few places around the long Swedish coast, heavy rescue helicopters (e.g. Super Puma and Vertol) are available for primarily sea rescue operations. They fly about 150 sea rescue missions annually. These helicopters usually do not have medical staff on call.

The helicopter in a big city as Gothenburg does about 1000 missions a year, with a total time in the air of 660 hours, i.e. the helicopter is airborne on average 40 minutes per mission. This is equivalent with a flying distance of 140 km. On average, the "total turn around" time (from alarm to "ready for next mission") is two hours per mission. The helicopter is on average airborne within 4 minutes after an alarm during daytime and after 7 minutes at nighttime. On average, the helicopter arrives to the injured 21 minutes after the alarm. In the northern, sparsely populated part of Sweden, a helicopter makes about 400 missions annually, but the length of each mission is at least double, sometimes much more, than for the helicopters in the two biggest cities. About 5-15% of the transported patients are traffic victims.

Fixed wing aircraft

In the northern part of Sweden, the flying distances may be so long that refuelling may be necessary for a helicopter. This makes transport with aircraft, or "fixed wing", an attractive alternative for inter-hospital transports (Figure 4). The advantage is higher speed (2-2.5 times higher than with a helicopter), all weather capacity, and no refuelling. The disadvantage is the necessary secondary transport with ground ambulances between hospitals and airports. The University Hospital for Northern Sweden (the only level 1 trauma hospital in the northern half of Sweden) is situated within three kilometres driving distance from Umeå airport, which is a great advantage when using fixed wing transport. These aircrafts fly between 6,000 – 8,000 missions per year, the majority planned secondary transport between hospitals.

Fig. 4 Fixed wing air ambulance transport is a convenient mode for long distance inter-hospital transports especially in the sparsely populated northern part of Sweden.

3. MASS CASUALTY AND DISASTER MANAGEMENT

3.1 Bus crashes

In a bus crash at high speed, as we have experienced a number during recent years, the consequences will often be disastrous. (Figure 5). The available rescue-resources will be insufficient at least in rural areas. In this situation, it is very important to have an accurate plan for mass casualty incidents worked out in advance. In Sweden the governmental body, The National Board of Health and Welfare (NBHW), has worked out recommendations on "Emergency and Rescue service in the event of a major incident". NBHW conduct and economically support training courses within different areas of Disaster Medicine. With these guidelines and this support, the medical personnel involved in the pre-hospital care will get a good basis and training in handling of mass casualty or disaster situations.

3.2 Disaster experiences

The NBHW have an organisation (KAMEDO) for collecting data from mass casualty or disaster incidents around the world. The aim is to learn from these incidents and disseminate this information. Those responsible for

Fig. 5 A bus crash with 34 injured in a remote area of northern Sweden. An example of a mass casualty or disaster for a sparsely populated area with limited resources. (Photo; Leif Danielsson)

disaster preparedness can, via these reports, gain experiences from "real incidents", wherever they happen.

In this context, it could be mentioned that just transport incidents, (ground, air or sea), as in most developed and motorized countries, are the cause of a majority of mass casualty incidents in Sweden. Mass casualty bus crashes have exposed many interesting rescue and emergency medical problems, which have not received much attention earlier. For example, where is the most convenient emergency entrance and escape routes in an overturned bus wreck? How to make triage (classification of injured) when many people are piled up unconscious in a bus? How to move in a bus/coach that has rolled 90 degrees, so it is impossible to use the aisle? How to handle the injured when common rescue equipment may be difficult or impossible to use etc.?

3.3 MIMMS-course

Recently the "Major Incident Medical Management and Support" (MIMMS)[5] course from the United Kingdom have been introduced in Sweden. This is a very well established course accepted in several European countries, which gives a common structure for the action in case of a major incident. This is a well thought out and pedagogic model gaining acceptance in more and more countries in Europe (Figure 1).

3.4 Swedish National Medevac

This is a governmental project headed by the Section for Emergency Planning and Security in the Swedish Civil Aviation Administration in cooperation with the National Board of Health and Welfare and the Scandinavian Airlines System (SAS). Within six hours, an SAS aircraft can be converted to an ICU equipped transport resource with capacity for six intensive care patients, plus 6-8 patients on stretchers and about 20 seated patients. The aircraft may be a Boeing 737-600, Airbus 321-100 or MD-80-90 (Figure 6). All equipment is certified for flying and is compatible with that particular airplane in which it will be used. The stretchers are small intensive care units and the patients are transported from hospital to hospital on the same stretcher. This aircraft may be used for long demanding transports inside or outside Sweden. Crews, trained also in aviation medicine, are ready to depart within 12 hours after an alarm.

Fig. 6 Swedish National Medevac. Within six hours, a regular SAS passenger aircraft can be converted to transport six intensive care patients and a further 20 more or less severely injured. (Photo published with courtesy of MICUS AB and SAS)

3.5 Hercules as carrier for an ambulance

In case of a mass casualty incident or in cases with special needs, victims may have a need for transportation to big referral centres with e.g. a burns unit, or to a unit with resources to perform ECMO-treatment of ARDS-cases; (ECMO=Extra Corporeal Membrane Oxygenation, i.e. oxygenation via heart-lung machine; ARDS=Acute Respiratory Distress Syndrome, a life threatening lung complication to trauma). A Swedish Air Force Hercules airplane has been converted for transport of an ambulance vehicle with a patient. The ambulance can drive into the fuselage and disconnection of the patient from the ICU-equipment in the ambulance is avoided. Three ambulances with intensive care equipment have been tested and modified so the ambulances and the equipment do not interfere with the aircrafts' electronics/ avionics. These three ambulances and the aircraft are located at different places in the middle of Sweden. One of the ambulances is developed for transport of patients with severe contagious diseases e.g. hemorrhagic fevers.

4. EXTRICATION OF ENTRAPPED VICTIMS

An entrapped car occupant indicates a high-energy crash with risk for severe injuries[2]. Uncontrolled internal bleeding and hypoxia are the main causes of early mortality. The extrication process may impose a risk of aggravation of spinal/neurological injuries[6]. Prolonged extrication in a cold climate exposes the victims to the risk of being hypothermic (body core temperature below 35 degrees), which is an aggravating factor in a trauma situation[7]. Hypothermia interferes with bleeding and coagulation factors in a negative way. It also affects many other functions e.g. causing cold diuresis[7], which means that the victims produce a lot of diluted urine that sometimes must be evacuated.

Consequently many factors point to the fact that quick and safe extrication is important. To facilitate the extrication process a high degree of bilateral exchange of "know how" between the medical and rescue service personnel is needed. Courses have been developed putting emphasis on a "team or crew concept" with the aim to reduce time spent at the site and time to treatment[6] (Figure 7). The basic factor is that the victims' condition is steering for the work and that the medical personnel are in charge of the extrication process.

A standard algorithm and flow pattern facilitates organization and cooperation. The concept means a mutual understanding between the medical and rescue personnel for their different tasks in the extrication process.

The algorithm includes the following main factors[6]:

- Safety/access; stabilize and secure the vehicle, establish necessary ABC-procedures on the trapped victims in the car;
- "Read the crash". Estimate the trauma energy and which "hidden" injuries that may be expected;
- Documentation by photo of the crash situation to present to receiving hospital's staff;
- Triage of the patients in case of several victims, i.e. classification of priority to treatment;
- Primary survey and resuscitation according to the PHTLS-principles[2]. Immobilization e.g. with cervical collar and ABC- control. Secondary survey, i.e. total body examination.

Evaluation has shown that by a 3-day "team training" course, the extrication and on scène-time may be reduced by as much as 40-50%[6].

Fig. 7 Extrication course with the aim to reduce the extrication and on scène time for entrapped victims. The medical and rescue team train structured cooperation, with the status of the injured as the steering factor for the work.

5. QUALITY OF CARE - ANY IMPROVEMENTS?

In the beginning of the 1990's, the National Board of Health and Welfare conducted a couple of quality as-

surance studies of pre-hospital care. The data indicated inadequate measures in some cases e.g. only 1/3 of patients with concussion got a cervical collar and half of those with thorax injuries were treated with oxygen. The proportion of people with femur fracture who got any type of pain relieving treatment or fracture stabilization was also inadequate. An all-pervading characteristic of the study was insufficient medical documentation, by crew members with a competence level below R.N. In Sweden, an ambulance crew has by law a responsibility to document vital parameters and treatment in the pre-hospital setting. This has been improved to a very high documentation rate today in those cases that are treated in some way during the pre-hospital phase. However, more quality assurance studies are needed to verify if the quality of the pre-hospital care has resulted in an improved outcome. A study of trauma care at hospital indicates a reduced number of "avoidable" deaths during recent decades, the majority related to better intensive care[8].

6. DISCUSSION

The understanding of the importance of the "Golden hour" has improved the competence and organization of the pre-hospital care in Sweden. However, any time limit within which an injured or sick person should be reached by pre-hospital care, is not established. This is peculiar in view of the strong regulation for the rescue/fire service. The rescue service has from a maximum of 5-10 minutes response time in densely built up areas to 30 minutes in rural areas. Consequently, Sweden has more rescue/fire stations than ambulance stations; in rural areas more than two times more. This has initiated a few attempts to use rescue personnel as medical First Responders, but old tradition and organisation boarders make these good attempts scarce. The extrication and team training courses is another way to cut down the pre-hospital time to a minimum. The "platinum quarter" is a concept introduced in this course i.e. the victim should be taken out from a crashed car within less than 15 minutes. This is especially important in a country with long transportation distances.

The ambulance helicopter and fixed wing service is more developed and structured in our neighbour country Norway, where the whole country is covered by this service. Contributing to this positive Norwegian development is the problem for quick ground transports in many areas, because the difficult terrain with high mountains and deep fjords/rivers. These facts, together with an offensive attitude to handle the transportation and pre-hospital care problems, have resulted in a national strategy to cover most of the country by ambulance helicopter service. Such a national strategy for air ambulance transport is lacking in Sweden. The extensive Norwegian offshore oil industry in the Nordic Sea uses many heavy helicopters usable also for sea rescue operations. This makes Norway a country with very good resources for sea rescue. The comparable Swedish, and Finnish, resources are scarce and may be insufficient in case of a major transport incident e.g. as when the passenger ship Estonia 1994 went down between Finland and Sweden and 860 persons died. By bilateral agreement, Norwegian ambulance helicopters cover some remote areas of Sweden, where the population has a bad coverage of ground ambulances. This is a good example of how the organization of pre-hospital trauma care can be optimized, independent of different administrative boarders.

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