European Agency for Safety and Health at Work

Emergency Services: A Literature Review on Occupational Safety and Health Risks

European Agency for Safety and Health at Work

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Table of Contents

List of figures and tables

Executive Summary

Emergency workers comprise large professional groups ranging from career and volunteer fire-fighters, police officers, emergency medical staff (paramedics, emergency medical technicians, doctors and nurses) to psychologists. In major disasters, rescue workers, technicians from large relief organisations, additional medical staff, military personnel, antiterrorist forces, body handlers, clean-up workers, construction workers, and numerous volunteers are involved. Depending on the emergency/disaster site, emergency workers need specialisation for instance in water rescue, mountain rescue or rescue from heights. Current environmental, economic, and political developments and trend data all suggest an increase in the severity and frequency of disasters in the future. Phenomena that support this assumption include increased energy use, progressive global warming, climate change and pollution, population growth, dispersal of industrialisation around the globe, expansion of transportation facilities, and the growing spread of terrorism. The growing issue of better protection for emergency workers against the occupational safety and health (OSH) risks has been emphasised as a priority by many experts.The demands made upon emergency workers, as well as OSH risks they are exposed to, will rise as they are confronted with events greater in both number and severity.

Although the exact number of emergency workers is difficult to estimate, the available figures and the large number of people affected by disasters and in need of immediate help are reliable indicators that emergency workers account for a significant proportion of the European workforce. Exact numbers can be given for some groups, such as fire-fighters. According to the report by the International Labour Organisation (ILO), in European countries there is on average one fire-fighter for every 1,000–1,200 inhabitants. There are also a considerable number of volunteer fire-fighters.

Emergency workers' priorities are to protect human life, property and the environment, and their most common fields of action include:

- everyday emergencies (road accidents, crime scenes, gas explosions, fires)
- natural disasters (floods, storms, fires, earthquakes, volcanic eruptions)
- industrial accidents (involving hazardous materials, such as in the nuclear and mining sectors)
- transport accidents (major car crashes, plane crashes, rail accidents)
- terrorist and criminal attacks (bomb attacks, gas attacks, shootings)
- massive public events (negative events during concerts, sport events, demonstrations)

The absolute numbers of emergency workers involved in specific events are often not easy to obtain. Some figures can be found in media reports. Around 4,000 emergency workers were involved during mud spills in Hungary (2010); 5,500 police and emergency workers were mobilised to organise evacuation during crowd panic in Duisburg, Germany (2010); 240,000 emergency workers and 2,000 members of the armed forces dealt with forest fires in Russia (2010); more than 500 emergency workers were sent to a mine explosion in Russia (2010); 2,500 rescue workers, including 1,500 firemen, were sent to the area affected by an earthquake in central Italy (2009); up to 70,000 emergency workers took part in the massive operation after the terrorist attack at the World Trade Centre in New York, including policemen, firemen, and construction workers (2001); 200,000 recovery workers were involved in clean-up activities in 1986–1987 after the disaster at Chernobyl (1986).

European emergency workers are often involved in dealing with major catastrophes that happen outside Europe. After the earthquake in Haiti (2010), a 64-member search and rescue team was sent from the UK; more than 500 personnel, particularly rescue workers, were sent by France; 450 troops, 50 doctors, technicians and specialists were sent from Spain; more than 20 emergency workers went from Portugal; a plane with a search and rescue team went from the Netherlands; and three medical teams were sent from Hungary.

All types of emergency workers can be involved in any kind of intervention, and the spectrum of possible demands and risks those workers may encounter is very wide. They may especially be high when the management and preparedness are poor, and there is lack of or insufficient coordination, information and communication, lack of training, inappropriate or insufficient safety and personal protective equipment.

There are some **general OSH hazards** and risks likely to occur in any kind of emergency intervention.

- Demanding work environment: working in remote, difficult to access areas, unstable and extremely difficult weather conditions, and unpredictable hazards at the disaster scene such as the danger of collapse of damaged structures. High risk of violence.
- Emotional and psychological overstrain: dealing with many fatalities and injured people, high responsibility for people's lives, time pressure, long, unpredictable working hours.
- Physical overstrain: physically demanding work, insufficient breaks, manual handling (wearing heavy protective equipment, transportation of patients, carrying dead bodies, removal of debris).

Additionally, particular types of emergency events are related to the greater possibility of other, more **specific OSH hazards**.

Natural disasters may put emergency workers at risk of:

- water-borne diseases where there is contact with contaminated water (diarrhoea, cholera, typhoid fever, hepatitis A, hepatitis E, parasitic diseases, rotavirus, and shigellosis);
- infectious (tuberculosis) and blood-borne diseases (HIV, hepatitis B, and hepatitis C) as a consequence of contact with survivors and dead bodies, and the possibility of infection transmitted by needle-stick injuries;
- vector-borne diseases (malaria, dengue, St. Louis encephalitis, and West Nile fever) transmitted by mosquitoes;
- respiratory and asthmatic problems, including asphyxiation, heat stress, and the carcinogenic effects of volcanic eruptions, landslides and earthquakes, and fires leading to significant release of ash and gases, and dust;
- being trapped or seriously injured by debris, working in confined spaces, drowning, confrontation with wild, aggressive or infected, domestic animals.

Industrial accidents may lead to:

- fatalities, serious injuries and short- and long-term health problems stemming from accidents caused by explosions, followed by fires and the release of toxic substances; the health consequences may include headache, confusion, fainting, agitation, delirium or convulsions, respiratory complaints, cardiovascular complaints, renal failure, eye and skin problems and gastrointestinal problems;
- severe health consequences such as burns, skin diseases, and incurable diseases including different kinds of cancer, Acute Radiation Syndrome (ARS) and death as a result of nuclear radiation.

Transport accidents may involve:

- the risk of being struck by a passing vehicle;
- specific risks associated with accidents involving the transport of dangerous substances, hazardous materials, or stemming from burning fuel or chemicals used in vehicles which have ignited or exploded.

Terrorist and criminal attacks may involve:

- unfamiliar, unpredictable, confused, and complex scenarios;
- the risk of death or serious injury, injury from weapons and the prospect of being taken as a hostage;
- the risk of being exposed to chemical and radiological hazards;
- a possibility of bioterrorism using biological agents such as smallpox, anthrax, botulism, tularaemia, and viral haemorrhagic fevers which can be easily disseminated or transmitted from person to person and cause high mortality.

Negative events during massive public events may lead to:

- specific risks, varying from scenario to scenario, including fire, collapsing buildings, violence, terrorist attacks;
- specific hazards stemming from violent behaviours and the unpredictable acts of a panicking crowd, such as people trying to escape from a confined space.

Emergency workers are exposed to a combination of many different risks and there may be many possible consequences for their safety and health. Possible OSH outcomes have been explored by the analysis of relevant statistics and studies.

Although the risk of **fatalities** caused by burn injuries is considered to be relatively small, these kinds of accidents continue to happen. Data from the UK shows that in the period 2003–2008, 22 fire-fighters died on duty, significantly more than in the previous five years. From February 1996 to October 2002, there were no recorded fire deaths in the UK among fire-fighters who actually attended fires, whereas in the years 2002–2005 13 fire-fighters were killed at fires. These statistics do not include fatal heart attacks which happened during the emergency intervention, nor road traffic accidents in transit to or from the accident. Statistics on fatal accidents indicate that in the US, 43% of fire fighters' deaths in 2009 were caused by sudden cardiac death, 34% by internal trauma, 6% by asphyxiation, 6% by stroke, 6% by 'other' causes, 4% by burns, and 1% by gunshots. The high prevalence of fatalities due to cardiovascular overexertion among fire-fighters (triggered, for instance, by the emergency alarm that abruptly terminates sedentary activity and begins intense exertion, the very high heart rates recorded during fire fighting, exposure to extreme heat, and wearing of heavy protective equipment) has been confirmed by many studies. Also at high risk are emergency medical staff and ambulance personnel. Fatal accidents can occur as an immediate consequence of vehicle-related accidents, homicides (a higher prevalence of this among emergency medical workers compared to other medical staff has been reported), and terrorist attacks (such as the hundreds of emergency workers who died in the aftermath of the 2001 attack at the World Trade Centre). In Sweden in 2002, 80% of emergency paramedics reported being threatened or experiencing physical violence. Fatalities are also related to radiological exposure caused by industrial accidents. Out of 237 emergency workers involved in the 1986 disaster at Chernobyl and later diagnosed with acute radiation syndrome (ARS), 28 died from ARS in the following months, and a further 19 in the years afterwards.

Available statistics indicate the significant prevalence of **non-fatal accidents and injuries** among emergency workers. For instance, the number of non-fatal accidents suffered by fire-fighters in Finland ranged between 500 and 600 per year during the period 2005–2007 out of a total population of about 19,000 fire-fighters. German data shows that accidents while moving, such as being struck or hit by objects, are the most prevalent, following those involving manual handling and dealing with dangerous, sharp, pointed, stiff, or rough-textured objects. In 2004–2005, the most frequent non-fatal accidents among workers in the fire service in the United Kingdom were injuries while handling, lifting or carrying (41.3%), followed by slips, trips or falls on the same level (27.6%) and being hit by a moving, flying or falling object (8.9%). Many other studies confirm that back injuries and upper and lower extremity injuries related to transportation of patients and manual handling are the most common types of injuries experienced by emergency workers, leading to many types of musculoskeletal disorders.

In the last 25 years, the **psychological trauma** suffered by emergency and rescue workers has gained the attention of scientists. Although studies show that the majority of rescue workers may experience stress that does not necessarily lead to diagnosable mental disorders, a variety of symptoms such as strong emotional reactions (shock, anger, guilt, helplessness), cognitive reactions (disorientation, lack of concentration), physical reactions (tension, fatigue, pain, racing heartbeat) and social effects (isolation from family and friends) may for some time after an incident have a negative impact on workers' wellbeing. More serious problems such as acute stress disorder, depression, anxiety, and post-traumatic stress disorders have also been diagnosed. A Swedish study indicates a prevalence of between 3% and 25% of PTSD among rescue workers there. In the USA the national prevalence of PTSD for the general population was recorded at 4%, whereas the highest reported prevalence for a particular group was 25% among rescue workers and 21% among fire-fighters. Higher rates of 'burnout' and problems with substance abuse have also been recorded in these groups, compared to the general population.

Occupational diseases described in the literature are related to the development of different types of cancer as a consequence of radiological exposure, such as the increase in cases of thyroid cancer revealed in a study of Russian emergency workers involved in the Chernobyl disaster. There are also several epidemiological studies which refer to respiratory disorders experienced by emergency workers, including fire-fighters, rescue workers, clean-up workers, and police officers who were exposed for several months to dust and hazardous toxic pollutants at the WTC disaster scene, showing that WTC-related lower respiratory symptoms were experienced by 60% and upper respiratory symptoms by 74% of the studied sample. Respiratory symptoms include the ‘World Trade Centre cough’, a persistent cough that some workers developed after exposure to conditions at the site, and which was accompanied by respiratory symptoms severe enough to require medical leave for at least four weeks. Other serious health problems caused by exposure to hazardous materials and dangerous combustion products include various types of cancer, asbestosis, skin disorders, changes in biochemical and blood parameters, reproductive problems, and even general shorter life expectancy. Many studies however show ambiguous results and further research in this area is needed.

The nature of emergency work makes it impossible to eliminate, or often even significantly reduce, the amount of risk personnel are exposed to. However, there are many primary and secondary preventive measures which may provide better protection. Some examples of **preventive measures** at international and national levels include the development of common cooperation and communication procedures, and the introduction of specific laws or policies to protect emergency workers.

Preventive measures at the company level include:

- better management (communication and coordination);
- comprehensive risks assessment;
- appropriate preparedness and training (for instance, workers should obtain knowledge about what hazards can be encountered at the disaster scene, the possible physical and mental reactions to them, and how to protect themselves against the negative outcomes);
- vaccination;
- providing appropriate personal protective equipment, protective clothes, safety equipment (for instance, gas detectors, radiation alarm systems, mosquito nets), and ergonomic equipment (fire-fighter robots, syringe needles that incorporate safety features);
- providing primary and secondary prevention of mental health problems (psychological preparedness, post-intervention psychological support and help, and long-term psychological care when needed);
- long-term-care and health surveillance alongside mandatory medical examinations, including workplace health promotion projects that provide workers with appropriate and safe keep-fit facilities.

Although major disasters and accidents are always to be expected, past disasters and more recent events demonstrate that communities are still often not fully prepared for dealing with major disasters; it is also clear that the protection of emergency workers against OSH risks exhibits shortcomings. This literature review indicates some areas in which additional research and actions are necessary. General preventive measures begin with reducing the vulnerability of people to disasters, and reducing the severity of the damage that might be caused by a disaster, resulting in a smaller number of emergency workers needed to take part in disaster control. The OSH of emergency workers should be also taken into consideration in the earliest stages of building design, such as by making it possible for lifts to be used during an emergency, and in the formation of emergency response plans at international, national, and organisational level. Rehearsing different terrorist attack scenarios can serve as way to predict possible hazards for emergency workers. Also essential is the further development of personal protective and other safety equipment, especially against multiple hazards and bioterrorism, and taking into consideration the possibility of physical overstrain and the difficult working environment of emergency workers. Further longitudinal research on the negative health effects of dangerous substances is needed, including studies on the toxicological properties of the combustion of new products which are constantly being developed and introduced to the market.

1. Introduction

Emergencies and disasters which demand a high involvement of emergency workers are likely to occur more frequently and heavily in the future. Just a few examples of the most recent major natural disasters include the Haiti earthquake in January 2010, the Deepwater Horizon oil spill in the Gulf of Mexico in April 2010, the flood in Pakistan and the Russian forest fires in Moscow in the summer of 2010, and the earthquake and ensuing tsunami in Japan in 2011.

Global warming and pollution constantly destabilise existing ecosystems. The figures for recorded natural disasters have doubled in the past two decades alone. Continuous climate change will cause more intense natural disasters such as droughts, floods and storms, and will have devastating effects on communities. At present, rising sea levels threaten the lives and homes of almost 634 million people (UNISDR, 2008). The incidence of man-made disasters, the consequences of which are often difficult to predict, is also likely to rise. Global development increases the density of transport routes and their utilisation, new technologies and biochemical substances are being tested and employed in industry, and around the world the risk of terrorism is on the increase.

Emergency workers comprise large professional groups ranging from fire-fighters, police officers, emergency medical staff (paramedics, emergency medical technicians, doctors and nurses) to psychologists. Depending on the emergency/disaster site, emergency workers need narrow specialisation – for instance, in water rescue, mountain rescue or rescue from heights. Depending on the scale of the event, additional rescue workers, body handlers, medical staff, different technicians from large relief organisations and military personnel can be also needed at the scene. Clean-up workers, construction workers, civil engineering specialists and numerous volunteers can also be involved.

Emergency forces are established in all European countries. Although the exact number of emergency workers is difficult to establish, the available statistics and the increasing number of people affected by small scale emergencies and major disasters indicate that a significant proportion of the European workforce is involved in emergency activities and disaster control both within its own region and around the world.

Various hazards leading to occupational health and safety risks for emergency workers range from more general issues related to managerial aspects, to more specific ones related to the character of a given event. As a consequence, excessive physical and emotional strain may result in serious health problems. The specificity and complexity of tasks facing emergency forces make it impossible to control their working conditions. These professional groups are exempted from the requirements of the EU Framework Directive 391 on Safety and Health at Work. Nevertheless, OSH risks for emergency workers should be – and certainly can be – assessed and reduced, and followed by the implementation of appropriate protective measures.

This report aims to present the current state of knowledge about the occupational health and safety risks faced by emergency workers. The following chapter describes the main groups of emergency workers and the main areas of their activities. Chapter 3 provides an overview of OSH risks for emergency workers – the more general risks, as well as those related to specific events such as natural disasters, industrial accidents, transport accidents, terrorist attacks, and accidents during public events. Chapter 4 summarises the statistics and results of research related to accidents and adverse health effects in the emergency worker population. In Chapter 5, some possible preventive measures are proposed at international, national, and organisational levels. Chapter 6 includes conclusions and identifies research proposals and areas needing further action.

2. Emergency forces

2.1. Population of emergency workers

Presenting exact figures on the number of emergency workers in Europe is difficult. There are professions subsumed under the term ‘emergency workers’, such as fire-fighters, emergency physicians, other medical staff (emergency medical technicians and paramedics), emergency psychologists, emergency chaplains, social workers, and police officers, members of relief organisations, military workers and body handlers. However, most of these professions also regularly deal with routine non-emergency work and, equally, not all members of these professional groups are involved in the handling of emergencies. It is also true that representatives of other professions not immediately associated with emergency scenarios serve according to need at the scenes of accidents and emergencies, as do military personnel and volunteers. After the terrorist attack on the Federal Building in Oklahoma City in 1995, the regular emergency services were joined by anthropologists, radiologists, dentists, students and residents from the University of Oklahoma Health Sciences Centre, and radiology technicians who had volunteered to help victims (Tucker et al, 2002).

Emergency workers protect human life, property and the environment during daily interventions in accidents, mishaps and large-scale disasters. Interventions usually demand the cooperation of several different groups. Some figures on the involvement of emergency workers in emergency events are given in official and media reports. Around 4,000 emergency workers were involved during mud spills in Hungary (2010) (Irish Times, 2010); 240,000 emergency workers and 2,000 members of the armed forces were combating forest fires in Russia in 2010 (France 24, 2010); 2,500 rescue workers, including 1,500 firemen, were sent to the vicinity of an earthquake in central Italy (London Evening Standard, 2009). Rescue activities after the earthquake in Kobe (1995) were performed by 29,000 peronnel from Self Defence Forces, 83 rescue teams, 110 birgades and 65 other teams sent by Fire Defence Agency, and by 27,000 policemen (Swedish Disaster Medicine Study oerganisation, 1996). More than 500 emergency workers were sent to a mine explosion in Russia (Fox News, 2010); 200,000 recovery workers were involved in clean-up activities in 1986-1987 after the Chernobyl disaster (USNRC 2009); up to 70,000 emergency and rescue workers took part in the massive operation after the terrorist attack on the World Trade Centre in New York in 2001, including policemen, firemen, and construction workers (The Guardian 2009); 5,500 police and emergency workers were mobilised to organise an evacuation during crowd panic in Duisburg, Germany in 2010 (Livemint.com, 2010)

European emergency workers are also involved in dealing with major catastrophes around the world. After the earthquake in Haiti in 2010, a 64-member search and rescue team was sent from the UK; more than 500 personnel, particularly rescue workers, were sent by France; 450 troops, 50 doctors, technicians and specialists were sent from Spain; more than 20 emergency workers were sent from Portugal; a plane with search and rescue team went from the Netherlands; and three medical teams were sent from Hungary (Buenos Aires Herald, 2010).

2.1.1. Fire-fighters

The range of emergency tasks covered by fire-fighters obviously includes preventing and combating fire, but also includes tasks such as assisting in major transport accidents (aviation and maritime accidents, car crashes involving trapped people), industrial accidents, natural disasters, terrorist attacks or civil riots, or when special technical help is needed. They are often in charge of environmental protection, for example when a hazardous material jeopardises the environment (Deutscher Feuerwehr Verband, 2009), and they provide help in situations where animals present a danger to human life or are trapped (Ungerer, Hesel & Morgenroth, 1993). Fire-fighters often also have supplementary training as emergency medical technicians or paramedics.

According to an ILO report (ILO 2003), **in European countries there is on average one fire-fighter for every 1,000-1,200 inhabitants**. In 2003, there was one fire-fighter for every 26 inhabitants in Austria (in total 294,340 workers), for every 32 inhabitants in Switzerland (in total 210 500), and for every 69 in Germany (in total 1,162,819). However, in Italy, there was one fire-fighter for every 2,036 inhabitants (in total 28,000), in Greece one for 1,563 inhabitants (6,400), and in Bulgaria one for

1,438 inhabitants (5,910). The situation is significantly different in, for instance, African countries such as Mali, where the ratio is one fire-fighter to every 33,435 inhabitants.

In many countries, professional fire services coexist with volunteer fire brigades. Volunteer fire brigades are needed in order to ensure rapid help in regions in which a professional fire brigade is not maintained, or where the manpower of the professional fire services is not sufficient. In Germany, legislation generally makes provision for professional fire brigades in big and medium-sized cities (obligatory in cities with 80,000 – 100,000 inhabitants). However, career fire-fighters often need the assistance of volunteer fire-fighters, and these generally outnumber the professionals. There are 100 professional fire services employing 27,600 career fire-fighters, against 23,000 volunteer fire brigades which can call on 1.3 million volunteer fire-fighters. In 2005, requests for technical assistance was the most common reason for call-outs of German fire-fighters (51%); this was followed by fire/explosion (18%), false alarms (16%), animal rescue (4%) and other interventions (11%) (Deutscher Feuerwehr Verband, 2009).

In France, 237,940 people were working as fire-fighters in 2007: 80% as volunteers, 15% as professionals, and in Paris (departments 92, 93 and 94) and Marseille, 5% who were also military staff (Direction de la Sécurité Civile, DDSC, 2007). Belgium has 251 fire services for 589 local authorities. These services consist of 5,000 professional fire-fighters and 11,000 volunteer fire-fighters (Portaal Belgium.be, 2008). 42,324 full-time fire-fighters were working in the United Kingdom (excluding Northern Ireland) in 2008 (Department for Communities and Local Government, 2008). The Republic of Ireland has 222 fire stations, run by 1,206 full-time and 1,952 retained part-time fire-fighters. Whereas full-time fire-fighters tend to be employed in conurbations such as Dublin, Cork, Limerick or Galway, retained fire-fighters are mainly deployed in rural areas. The Dublin Fire Brigade runs 15 of the above-mentioned fire stations with 850 fire-fighters. They responded to 22,391 fire calls in Dublin in 2003 (Irish Fire Services, 2009). In Greece, 8,740 full-time fire-fighters and 5,500 seasonal fire-fighters were active in 2007 (Greek Fire Service, 2007).

In Finland, the number of full-time employees in the rescue service system (including fire-fighters and paramedics/ambulance drivers) is approximately 5,000. In addition to this number, 14,300 part-time employees and voluntary fire brigade members are available for emergency situations (Ministry of the Interior, Rescue department, Finland, 2006). The emergency operations of Finnish fire-fighters in 2006 were distributed as follows: fires 18%, rescue operations 25%, medical first aid (first response) 15%, checking and verification 35%, assistance-type operations 7%. At present, some 100,000 emergency operations are carried out by fire-fighters each year in Finland, a figure which has doubled over the last ten years (Ministry of the Interior, Rescue department, Finland, 2006).

In 2008, in Romania, approximately 41,407 (97%) full-time fire-fighters were registered within operative units, and approximately 1,237 (3%) members of the auxiliary staff were assigned to educational institutions, research units, study centres, bases, workshops, technical stores, and logistics and maintenance units. At the same time, 613 persons from the public community voluntary services for emergency situations acted under the command of the military fire-fighting structures of The General Inspectorate for Emergency Situations (IGSU). This is the state-run specialised service for emergency situations and was set up in 2004 through the fusion of the Civil Protection Command and the General Inspectorate of Military Fire-fighters Corps into a single entity. It is subordinated to the Ministry of Administration and Internal Affairs. In 2008, IGSU, through its fire-fighting structures, carried out 88,820 interventions, out of which 15,530 (17%) were fires, 9,131 uncontrolled burnings (10%), 5,000 'other' emergency situations (6%), 2,859 providing assistance to individuals (3%), and 4,193 local community protection operations (5%). A number of emergency cases – 52,107 (59%) – were assisted by SMURD - Serviciul Mobil de Urgenta, Reanimare si Descarcerare (General Inspectorate for Emergency Situations in Romania, IGSU, 2008).

2.1.2. Emergency medical service

Emergency medical staff (emergency medical technicians, paramedics and nurses) and emergency physicians respond to all kinds of emergency call-outs where people are injured or in need of medical help. In the case of emergency call-outs, they must be at the scene within few minutes, fulfilling highly time-critical tasks (Behrendt, 2008).

Two different systems of emergency care delivery exist in Europe, the Anglo-American system and the Franco-German system. The difference lies within the role of medical physicians and the place where they provide medical care. Within the Anglo-American model, emergency medical staff comprises emergency medical technicians and paramedics. They are responsible for providing a patient with first aid and medical care at the scene. The patient is then transported to the emergency department in a hospital where emergency physicians provide definitive emergency care. In the Anglo-American system, emergency medicine is recognised as a speciality within hospitals. (Fleischmann & Fulde, 2007)

In the Franco-German system, the emergency medical staff includes the emergency physician who goes to the scene and provides the patient with pre-hospital emergency care. However, emergency medical technicians and paramedics often arrive first at the scene and perform first aid until the emergency physician arrives. Pre-hospital medical care in the Franco-German system is characterised by life-saving measures, as well as ensuring that people are transportable and taking care of the actual transport to hospitals of the injured (Bengel, Bordel & Carl, 1999; Bohnen et al., 2010). The patient is triaged in the field and then transported directly to the in-patient speciality service in the hospital that is appropriate to their specific needs and where they receive further medical care.

EU-OSHA Photo Competition - Alexandru Obregia

In **Germany**, the laws of most federal states concerning emergency medical services make provision for an executive emergency physician to be responsible for coordinating and managing emergency medical aid in disaster situations (Behrendt, 2008).

In 2000, Germany had more than 17,000 specialist emergency physicians and some 32,000 full-time paramedics (Behrendt, 2008). The tasks of Germany’s paramedics include the moving of sick or injured people and the provision of emergency aid (Behrendt, 2008). Almost 10 million rescue service call-outs occur each year. (Joó, 2000, cited by zur Mühlen, Heese & Haupt, 2005). Most of these involve transportation of patients that are not in a life-threatening situation. Only 17% of all rescue service call-outs in Germany concern patients whose lives are at risk (Hering & Beerlage, 2007). Paramedics in Germany worked around 44.6 million hours in 2000 (Behrendt, 2008). In 2003, 22.5% of the rescue service call-outs were performed by paramedics of the fire services (Behrendt, 2008).

In **Belgium**, emergency phone numbers include 100 (the national number for medical care), 101 (the national number for the police) or 112 (the internationally recognised emergency number) and any of them can be called for urgent medical care. The responding ambulance is staffed by two paramedics. Depending upon the severity of the emergency, a Mobile Urgency Group (MUG) can be sent out together with the ambulance. The MUG is staffed by a nurse with special intensive care and emergency care qualifications, and an emergency physician, sometimes accompanied by a driver-paramedic. The MUG has advanced life support material on board in order to stabilise the patient. After stabilisation, the patient is brought to a hospital for further medical care. An ambulance may belong to one of four different institutions: fire services, private institutions, hospitals and the Red Cross (First Response.be, 2005). In 2007, the 100 Belgian dispatching centres for emergency calls received approximately two million calls. One third of these calls (29%) were from the international emergency number, 112.

The Emergency Medical Service (EMS) system in **France** is organised centrally. It has two levels: the first level consists of a Basic Life Support (BLS) fire department ambulance and, at the second level, ambulances staffed by an Advanced Life Support (ALS) physician. The French EMS has a specific out-of-hospital structure and an inside-hospital structure. Those emergencies that are ‘out-of-hospital’ fall under the responsibility and service of the SAMU (*Service d’Aide Médicale d’Urgence*). France is divided into 105 regions: each region has its own SAMU and dispatching centre. This dispatching centre is normally located in a major hospital in the region and is staffed by switchboard operators and dispatching physicians. Both the national emergency number 15 and international number 112 are redirected to the dispatching centre in the area from which the call originated. The dispatching physician decides what level of response is appropriate. Four levels of emergency medical response are possible:

1. EMT (Emergency Medical Technicians): ambulances staffed by EMTs;
2. fire-fighters with basic life support skills;
3. general practice physician by private vehicle; and
4. MICU (Mobile Intensive Care Unit). The MICUs are located in regional bases (320 throughout France), referred to as SMURs (*Service Mobile d'Urgence et de Réanimation*). The MICU ambulances are staffed by a senior physician (generally an emergency physician), a nurse and in some cases a medical student. A specially trained driver drives the MICU ambulance.

The Emergency Departments within French hospitals (ED) also have two levels. The first level provides around-the-clock coverage by surgeons, and departments are equipped with an intensive care unit (ICU), a laboratory, and radiology facilities. Some 200 hospitals have a first level Emergency Department. Level 2 Emergency Departments (in around 350 hospitals) also provides specialists, but they are only available on-call (Adnet & Lapostolle, 2004). The hospital switchboard physicians (referred to as regulator doctors) are emergency physicians with broad experience in emergency units, for example the Hospital Mobile Intensive Care Unit (H-MICU). The H-MICU doctors often combine their work in the MICU with other hospital activities such as cardiology and anaesthesiology. (SAMU de France, 2006). The staff structure may differ from ED to ED. In university hospitals and teaching hospitals, residents from different specialties are employed. One attending emergency physician is available 24 hours a day, and they must supervise the resident doctors. The medical director, who is usually an emergency physician or anaesthesiologist, has overall responsibility for the ED. A fully equipped resuscitation room for patients in life-threatening situations is available in each ED. Initial resuscitation is usually performed by the attending emergency physician. Following initial resuscitation, the patient is evaluated to determine further care (Adnet & Lapostolle, 2004).

On average, 10 million calls are received each year in France by the SAMU call centres (one call per six inhabitants). Of these 10 million calls, 4.5 million are medical cases. 30% of responses involve the providing of information and advice, 30% the dispatch of a GP on duty, 30% the dispatch of an ambulance, and 10% the dispatch of an H-MICU (Hospital Medical Intensive Care Unit) (SAMU de France, 2006). The origin of the medical calls is as follows:

- 57% from individuals (witnesses or victims of an accident or illness);
- 27% from fire-fighters (in France, fire-fighters are in charge of emergency ambulances, as certified first responders)
- 5% from hospitals (usually life-threatening emergencies in a department)
- 5% from a general practitioner (usually visiting a patient at home)
- 5% from others (police, ambulance for transportation of sick people) (Ministère de la santé et des sports, 2008).

In **Greece**, the service in charge of out-of-hospital emergencies is the National Instant Aid Centre (EKAB). Altogether, Greece has 12 independent EKAB centres. The main activity of an EKAB is to provide prompt medical care to all civilians. EKAB services are structured around a coordinating centre, mobile medical services, motorcycles, airport services and baby-care services. There are also two specialised services: air transportation of civilians (mainly from the islands), and the special department for disasters (natural or technological disasters, pandemics and terrorist attacks). The number 166 can be dialled for urgent medical care (National Instant Aid Centre, EKAB, 2009). In addition, a special administrative service, the National Center of Health Operations (E.K.E.P.Y.), is responsible for taking health decisions in national crisis situations, such as natural disasters, pandemics, etc. (Greek Ministry of Health, 2009).

In the Republic of **Ireland**, the National Ambulance Service provides the ambulance service except in greater Dublin where it is provided by the Dublin Fire Brigade, and in Tramore, where the Order of Malta Ambulance Corps does this in tandem with the National Ambulance Service. Volunteer and private ambulance services support the National Ambulance Service. Volunteer ambulance services include, for example, the Order of Malta Ambulance Corps, the St. John's Ambulance Brigade of Ireland and the Irish Red Cross. Their main tasks are pre-hospital services, assistance at public events, community services, ambulance transport and first aid training (Pre-Hospital Emergency Care Council, 2009).

In **Romania**, approximately 11,200 people were working in pre-hospital emergency medical services in 2008, including about 580 emergency physicians and 4,600 nurses (Romanian Physicians College, 2008). The Emergency Departments of hospitals, the Emergency Receiving Units (UPUs), receive patients from three sources: SMURD (Mobile Emergency Service for Resuscitation and Extrication), the public County Ambulance Service, and private emergency services such as PULS Medical Emergency Service or S.O.S. Ambulance Service. These ambulance services all provide emergency assistance and pre-hospital medical aid. In an emergency, SMURD and the County Ambulance Service can be called on the same phone number, 112. Private services can only be called directly on their own phone numbers, or they may be reached via the private hospitals or clinics for which they are subcontractors. The private ambulance services are paid-for services. About 50% of the critical cases requesting the support of intensive care ambulances are transported to the emergency hospital services by SMURD mobile intensive care units. For the remainder of medical emergency calls, the public County Ambulance Service or private ambulance services provide the transport and emergency medical aid, prior to hospital medical assistance (SMURD, 2009). However, private ambulance services are called only where SMURD or the County Ambulance services are not available quickly or where patients hold private medical insurance for these private service providers.

For 2007/08, figures from the National Health Service in the **United Kingdom** show that 7.2 million urgent and emergency calls were received. 81% of the cases (5.9 million calls) were followed with an emergency response at the scene. 1.8 million calls were about life-threatening situations (National Health Service, 2008).

In **Finland**, around 1 million emergency calls are received for ambulance and primary care services each year. These account for 25% of all emergency calls received each year (Ministry of the Interior, Rescue department, Finland, 2006).

2.1.3. Police

The main task of police officers is to ensure the internal security of a country and to protect the public. This includes ensuring civil order and law enforcement (ILO, 2009). The police mainly provide protection against danger and criminality, and ensure road safety. In addition, they are generally charged with border defence on land, air and water, and monitor train, air and sea safety. Cooperation with politicians, relevant groups or institutions within society is crucial. Whereas police control centres and police officers on patrol or in police stations respond to the needs of individuals, special police units also exist which can be called upon by governments to ensure safety under special circumstances. In major incidents involving the injury or traumatisation of persons, the police are also in charge of providing help for victims. Police officers are also charged with notifying families of deaths and admissions to hospital, and with giving testimony in courts. In case of major incidents or disasters, they also safeguard the disaster site, regulate traffic and enforce mandatory measures (Ministry of the Interior, Lower Saxony, Germany, 2009).

266,000 police officers were employed in Germany in 2009 (Bundesministerium des Innern, 2009). In England and Wales there are (in 2010) 143,734 police, including 33,376 officers working for the Metropolitan Police – the largest employer in London (Association of Police Authorities, 2010). The number of police officers on operational duty in Finland was 7,591 in 2007. This is equivalent to one officer per 675 citizens (Ministry of the Interior, Police department, Finland, 2007). The Finnish police receive around 1.1 million emergency calls a year which equates to 45% of all incoming calls for emergency response units in Finland (Ministry of the Interior, Police department, Finland, 2007). In Belgium, approximately 39,000 men and women are employed as police officers. This number also includes administrative employees of the integrated police force in Belgium (local and federal police) (Lokale Politie in België, 2009). The police '101 centres' received 2.7 million calls in 2007 (First Response.be, 2008). In France, a total of 145,820 police officers are on active service (15.3% women and 84.7% men) (Ministère de l'intérieur de France, 2006). 55,000 police officers (11.6% of them women) are employed in Greek police forces (Greek Police, 2009). Activities of Swiss police forces in the Canton of Geneva in 2000 covered 54,691 'emergency and other' calls and 9,874 other activities, such as arrests, transporting injured persons or evacuations, security for visiting dignitaries, and patrolling demonstrations (ILO 2003).

2.1.4. Body handlers

The main tasks of body handlers are search, recovery, identification, death certification and transportation. Body-handling activities in mass disasters are often not confined to professionals normally working in service organisations that deal with body handling. Numbers of volunteers, often affiliated to different medical organisations, and community safety organisations and other professionals are often drafted in (Blashan, 1977). Military personnel are also often called in in such situations.

2.1.5. Providers of psychological first aid

Psychological first aid refers to the psychological support of victims, family members, members of the action force or witnesses to an extreme event or a disaster, in an attempt to prevent the development of long-term psychological problems or disorders such as post-traumatic stress disorders (Manz, 2007). Psychological first aid is limited to the initial hours or days after the event. Emergency psychologists provide secondary prevention until four weeks after the event. Should disorders or trauma symptoms persist, the affected person must be referred to other professional specialists (psychotherapists). Emergency psychologists also support action forces in emergency calls and provide supervision for crisis intervention teams. Whereas psychologists active in the field of emergencies and providing support for victims and their families are mostly specially trained emergency psychologists, emergency chaplains or social workers often lack solid preparation for psychological first aid. They may therefore be at greater risk of psychological harm due to secondary traumatisation.

2.1.6. Special Forces for disaster control

In addition to the specialised professional groups, members of relief organisations and military forces are often called out for disaster control in cases of events on a devastating scale. Abolghasemi et al. (2005) emphasise that the service of military forces is of particular importance in developing countries where relief organisations are not well-equipped. An advantage of the deployment of military forces is that they can be rapidly available, and that they are trained for team work and for working in poor conditions. Their main tasks may be to evacuate disaster victims, to construct field hospitals where necessary, transport injured people to hospitals and medical and health care personnel to the disaster scene, and safeguard clean water, energy, and telecommunications services.

2.1.7. Gender aspects

Emergency occupations as fire-fighters, emergency medical staff and police are generally male-dominated professions. The UK Department for Communities and Local Government (2009) reported that 3.6% of fire-fighters in England in 2009 were female. In Finland, 15% of the police officers on operational duty are women (Ministry of the Interior, Police department, Finland, 2007). In France, 23.8% women and 76.2% men work for the police force (Ministère de l'intérieur de France, 2006), and 10% of the volunteer fire-fighters in France are women (Direction de la Sécurité Civile, DDSC, 2007). In Belgium, only 2% of the fire-fighters in 2005 were women (DeMorgen.be, 2008). 11.6% of the Belgian local police are women. Within the federal police, the proportion of operational staff to administrative staff betrays a gender divide, since 10.3% of operational staff and 60.9% of administrative staff are women (Rol en Samenleving vzw, 2005). In Romania, 10.7% of police officers were women and 89.3% were men in 2009 (General Police Inspectorate of Romania, 2009). There were also 414 female fire-fighters in Romania in 2008, and the first full-time woman fire-fighter joined the fire service in 2007 (General Inspectorate for Emergency Situations in Romania, IGSU, 2008). In

Ireland, less than 1% of fire-fighters were women (1999). The first two full-time female fire-fighters joined the Irish fire service in 1997 (Department of the Environment and Local Government, 2002).

2.2. Emergencies and disasters

Occupational health and safety risks for the emergency workers presented in this report are mainly related to major negative events, which can be described as ‘disasters’ and ‘emergencies’.

‘**Emergencies**’ occur more frequently than disasters, although they also require appropriate and immediate action and might – in the event of a failure of emergency services to respond – lead to a disaster. World Health Organisation (WHO, 2011a) defines an emergency as a ‘…state[s] in which normal procedures are suspended and extra-ordinary measures are taken in order to avert the impact of a hazard on the community. Authorities should be prepared to effectively respond to an emergency. If not properly managed, some emergencies will become disasters.’

According to the World Health Organisation a ‘**disaster**’ is defined as: ‘…an occurrence where normal conditions of existence are disrupted and the level of suffering exceeds the capacity of the hazard-affected community to respond to it.’ Disasters can be of natural origin (floods, seismic events, hurricanes, forest fires), caused by industrial accidents (nuclear accidents, release of chemicals, mining accidents), caused by transport accidents (major car crashes, airplane crashes, rail accidents), be a consequence of criminal or terrorist attacks, or undesired events which may happen during massive public events (fire, crowd panic). The summary of Norris et al. (2002) is that all types of disaster ‘…share in common (…) [a] potential to affect many persons simultaneously and to engender an array of stressors, including threat to one’s own life and physical integrity, exposure to dead and dying, bereavement, profound loss, social and community disruption, and ongoing hardship.’

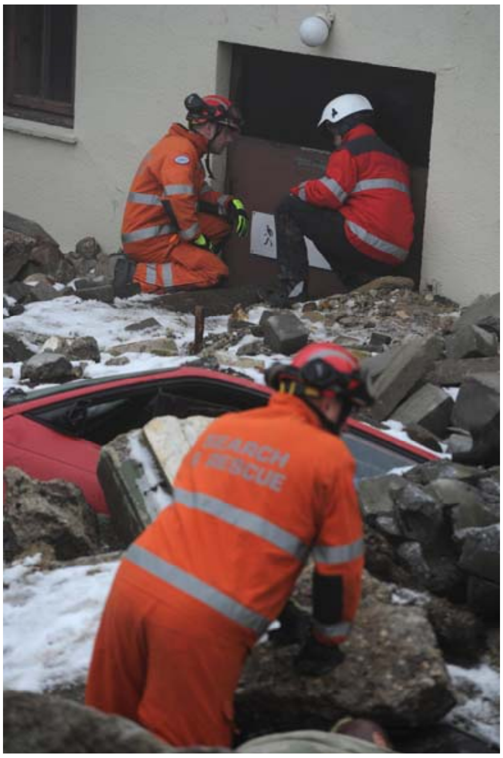
2.2.1. Natural disasters

According to the global report published in 2004 by the United Nations Development Programme (UNDP, 2004), ‘some 75 percent of the world’s population live in areas affected at least once by earthquake, tropical cyclone, flood or drought between 1980 and 2000.’

The number of natural disasters has increased steadily since 1900. Since the 1960s, a considerable increase has been observed. Whereas 588 natural disasters were counted worldwide in the 1960s, 2,720 natural disasters were recorded between 1990-1999, and to 2,788 for the five-year period from 2000 to 2005 (UNISDR, 2009). In the future, not only will natural disasters strike even more frequently and with more severity, but the number of people vulnerable to natural disasters will also increase (UNISDR, 2008) because the world’s population is growing, and urbanisation and deforestation are increasing (Schulte & Chun, 2009). During the last five decades, the Earth’s surface temperature has risen by 0.65 °C, and a further dramatic rise is expected unless new and environmentally friendly energy sources are used (WHO, 2010a). Global warming and environmental pollution constantly destabilise ecosystems and impact heavily upon climate and weather. To date, the lives and homes of almost 634 million people are jeopardised by potential floods should sea levels rise further, because more than half of the world’s population now lives within 60 km of the sea (WHO, 2010a). In particular, populations in Asia live in flood-prone areas and are therefore increasingly vulnerable to natural disasters (UNISDR, 2008). Global warming also appears to be creating a generation of more violent windstorms. Increasing incidences of water-borne and vector-borne diseases are another consequence of climate change, since their transmission seasons will be prolonged and they may therefore be able to spread to new regions (WHO, 2010a).

In 2005, 157,511,938 people worldwide were affected by natural disasters and 91,963 lost their lives (UNISDR, 2009). In 2007, 960 natural disasters killed 16,000 people. Most occurred in Asia (34%), followed by North America (including Central America and the Caribbean, 23%), Europe (19%), Africa (10%), Australia (9%), and South America (5%) (Munich Re Group, 2008).

Abolghasemi et al. (2005) emphasise that the service of military forces is of particular importance in developing countries where relief organisations are not well-equipped. An advantage of the deployment of military forces is that they can be rapidly available, and that they are trained for team work and for working (UNISDR, 2009b). UNDP (2004) emphasises the strong interaction between risks of natural disasters and the progress of human development. Human development processes such as urbanisation in hazard-prone areas or rapid construction of unsafe buildings often enhance the risk of natural disasters. Human development also often goes hand-in-hand with environmental degradation such as deforestation, increasing the vulnerability of nearby areas to natural hazards. Equally, natural disasters destroy human developmental progress. UNDP's annual report in 2004 stressed the importance of ensuring that human development is consciously planned with the need to reduce the risk of natural disasters in mind.



The Natural Disasters Risk index 2010 (Global Risk Portfolio, 2010), covering the possibility of events such as earthquakes, volcanic eruptions, tsunamis, storms, flooding, drought, landslides, extreme temperatures and epidemics, ranked 229 countries by their vulnerability to natural disasters. The top five non-European countries with an 'extreme risk' of natural disaster include Bangladesh, Indonesia, Iran, Pakistan, and Ethiopia; some European countries also face a 'high risk', with France in 17th place, and Italy in 18th; some a 'medium risk', including Germany and Russia in 50th and 54th place respectively; and some a 'low risk', including the UK in 111th place.

Comprehensive information about natural disasters in Europe and world-wide may be also found at the PreventionWeb1, with the specific situation in particular country provided by National Platforms. This includes a country's risk profile, disaster statistics, and additional sources of information, such as educational materials or relevant publications. Another possible source of information, also offering country profiles, is EM-DAT (Centre for Reaserch on the Epidemiology of Disasters: the International Disaster Database)2.

Natural events likely to create emergency situations or disasters can be sub-divided into hydro-meteorological events (floods, windstorms, extreme temperatures, drought, vegetative fires, landslides and avalanches), geological events (earthquake, tsunami, and volcanic eruptions), and biological events (epidemics and insect infestation) (UNISDR, 2009). Floods are the most frequent disasters world-wide (32% of the total), followed by windstorms (25%), epidemics (13%), earthquakes and tsunamis (8%), droughts (6%), landslides (5%), extreme temperature (4%), wildfire (4%), volcanic eruptions (2%), and insect infestation (1%) (Figures for 1991 to 2005, UNISDR, 2009). The same source shows that in 2005, geological disasters accounted for 82.9% of fatalities in natural disasters. 13.7% of fatalities resulted from hydro-meteorological disasters, and 3.4% from biological disasters.

2.2.2. Industrial accidents

Major industrial accidents may lead to fires and explosions in installations where flammable and/or explosive substances are used or being stored, and where flammable liquids are transmitted through pipelines. Particularly serious consequences of industrial accidents can stem from the release of toxic substances in accidents at nuclear or chemical plants. If large quantities of hazardous materials are present, a disaster usually affects a significant number of workers and people living nearby, leading to long-term environmental damage. Industrial accidents may happen as a direct consequence of human error, or as a side-effect of natural disaster such as the recent explosion at the nuclear plant in Fukushima, Japan, in 2011 after the earthquake and tsunami in the region. The most frequent causes of underground coal mining disasters are fire, malfunctions in haulage systems or procedures (i.e.

[1] http://www.preventionweb.net/english/
[2] http://www.emdat.be/

transportation of personnel, material or equipment), falling roof rock or the outward bursting of walls in an underground work area, inundation (inrush of toxic gases or water) CDC, 2009).

Within the European Union Member States, the so-called Seveso II directive (Council Directive 96/82/EC), applies to industrial establishments where dangerous substances are present in quantities exceeding specified thresholds. According to this directive, 'a major accident shall mean an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive, and leading to serious danger to human health and/or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances' (European Commission, 1997). The Seveso II directive was further extended by *Directive 2003/105/EC of the European Parliament and the Council of 16 December 2003,* '… to cover risks arising from storage and processing activities in mining, from pyrotechnic and explosive substances and from the storage of ammonium nitrate and ammonium nitrate based fertilizers' (European Commission, 2010).

Many countries conduct initiatives to provide industry, governments and research institutions with statistical information on industrial accidents. Available databases include the European Commission's Major Accident Reporting System (MARS) and national databases in some European countries such as ZEMA in Germany, ARIA in France, AEA Technology's MHIDAS database in the UK and TNO's FACTS database in the Netherlands. The International Atomic Energy Agency (IAEA) is the main source of data on nuclear incidents and accidents (Kirchsteiger, 1999).

Deriving significant quantitative trend estimates regarding industrial accidents is often not possible, since underlying notification criteria vary, making the resulting sample of events inhomogeneous. Moreover, there are different levels of data completeness. However, more than 700 major industrial accidents were reported by the Competent Authorities of the EU Member States to the MARS database from 1982 to April 2010 (eMARS, 2010). During this period, an overall slight increase in numbers of accidents per year could be observed. This is not necessarily an actual increase in accident occurrences in the EU Member States and may be the consequence of an increased acceptance and use of the MARS reporting system. However, regardless of whether the trend during the past decade is constant or slightly increasing, it is certainly not decreasing (Kirchsteiger, 1999). Analyses based on the European MARS reporting system regarding Seveso II installations showed that half of all industrial accidents occurred in the chemical sector and one in five accidents occurred in the petrochemical industry (eMARS, 2010).

2.2.3. Transport accidents

In 2005, the European transport network consisted of 4.5 million kms of road, railways, inland waterways and oil pipelines (Eurostat, 2009). In EU-27 in 2005 the density of the railway network was 49 km/1000 km², motorway density was 14 km/1000 km², inland waterway density 9 km/1000 km² and oil pipeline density 8 km/1000 km² (Eurostat, 2008a).

From 2000 to 2005 motorway density increased by 12% in the EU-27, alongside a 5% increase between 2002 and 2006 in passenger cars in EU-27 (Eurostat, 2008a), reflecting the fact that road is the predominant transport route for passengers and goods.

Since the mid-1990s, due to increasing numbers of low-cost air carriers, also passenger air travel has become more popular throughout the EU-27. From 1995 to 2006, air passenger transport grew annually by 4.6% on average in the EU-27, showing the highest growth rate of all transport types in this period. Passenger transport via air accounts for 8.6% of total passenger transport, but only 0.1% of goods are transported via air. Rail transport accounted for 6.1% of passenger transport and 10.5% of goods transport.

Only 0.6% of passenger transport goes by sea, but the sea is a vital path for the transportation of goods, particularly to destinations outside the EU. However, sea plays an important role in the transport of goods within the EU, accounting for 37.3% of all goods transport in 2006 and making it the second most important way of transporting goods between EU countries (Eurostat, 2009). More than one million tonnes of goods were conveyed by ship and more than 200,000 passenger movements were recorded at the ports of the EU-27 in 2006 (Eurostat, 2008a).

From 1995 to 2006, there was growth in all means of passenger transport except for by sea, which dropped by 1%. The transport of goods by all means, including by sea, grew annually by between 1% and 4% (Eurostat, 2009).

The WHO (2004) estimates the worldwide number of fatalities in **road accidents** to be between 750,000 and 1,183,492 casualties annually, with over 50 million injuries. This means that over 3,000 lives are lost each day in road transport, making it the most dangerous means of transportation. Underreporting, the limitations of some data collection and analysis, and differences in interpretation might hamper the establishment of precise figures.

The number of fatalities in road transport in Europe decreased slightly betwee 2001 and 2006, but road fatalities still accounted for 97% of all transport fatalities in 2006 (Eurostat, 2008a, 2009). In 2006 in the EU-27 1.3 million road accidents occurred, with 42,950 people losing their lives. This translates into 87 fatalities per one million inhabitants in the EU-27. Most often killed in road accidents are pedestrians, pedal cyclists and motorcyclists. In 2006, cars and taxis accounted for 61% of road casualties. Motorcycle accidents caused 16% of all fatalities, and buses, coaches and agricultural tractors both caused 1% of all fatalities. Pedal cycles caused 8%, mopeds 5%, lorries under 3.5 tons caused 3%, and heavy goods vehicles caused a further 3% of all fatalities (Eurostat, 2009).

- ***Air accidents***

In 2008 there were more than 10.2 million flights in European airspace, and the average daily number of flights was approximately 27,818 - a growth of 14.8% compared to the year 2004 (Eurocontrol, 2008; 2009). Although air-transport is statistically the safest way of travelling, **plane accidents** continue to happen and the fatality rates among those involved in each incident are high. In 2008, 62 air accidents causing 808 fatalities occurred worldwide. The most recent examples from Europe are the crash of a Polish plane in Smolensk, Russia, on 11 April 2011, with 96 fatalities, and the plane crash at the airport in Madrid- Barajas, Spain, on 20 August 2008, with 154 fatalities and 18 people severely injured.

- ***Railway accidents***

In 2006 transport via rail caused 1,360 fatalities in Europe (EU-27), excluding suicides (Eurostat, 2009). This means fewer than three deaths for every million inhabitants, and when compared to 87 deaths for every million in road accidents, railway transport in Europe seems to be relatively safe. Out of the total number of railway accident fatalities in Europe, 69% of the fatalities were caused by rolling stock in motion (involving individuals trespassing and crossing the tracks or employees carrying out maintenance work), 26% were caused by level-crossing incidents, 2% by collisions and 1% by derailment. An additional 1,239 persons were injured in railway accidents: 47% by rolling stock in motion, 33% by level-crossing and 8% by collisions.

- ***Maritime accidents***

In 2008, 22,752 merchant vessels berthed in European ports and 694,000 port movements were recorded. In the same year, 754 vessels moving in and around EU waters were involved in 670 accidents. Causes of maritime accidents were mainly collisions (40%), groundings (29%), fires or explosions (12%), and sinking (8%) (EMSA, 2009). There is a significant difference in accident rates between passenger transport and goods transport by sea, and the majority of accidents occur in goods transport. When the accident numbers are broken down according to vessel types, the EMSA (2009) shows that 41% of the accidents at sea occurred in 2008 in general cargo ships, 18% in passenger ships, 11% in tankers, 11% in fishing vessels, 9% in other vessel types and 8% in container ships.

In recent years, accidental pollution has significantly declined in and around EU-waters. The last major oil tanker disaster occurred on 13 November 2002, caused by the oil tanker 'PRESTIGE' carrying 77,000 tonnes of oil. A large crack in the starboard side of the hull made the tanker break in two, spilling more than 50,000 tonnes of oil which polluted more than 1,000 km of coasts from South West France to the North of Portugal (EIONET, 2007; European Commission, 2002).

- ***Transportation of hazardous material***

The transport of dangerous goods by any means may lead to a major accident (fire, explosion, toxic release or a combination of any or all of these). Major accidents can also occur where hazardous materials are transported by pipelines. Approximately 4.1% of all road goods transport is of dangerous materials. Flammable liquids and gases are the two dangerous goods most frequently transported by road, 58% and 12% of total road goods transport respectively. Other dangerous goods transported via road include corrosives (10%), miscellaneous dangerous goods (7%), substances liable to spontaneous combustion (3%), oxidising substances (3%) and toxic substances (3%), and 'others' (4%). Distribution of dangerous goods via rail is comparable to the figures above for distribution via road, with 'flammable liquids' and 'gases' again the two main categories (59% and 12% respectively). Transport of goods via sea is distributed as follows: 27% crude and manufactured minerals, 16.9% petroleum products, 9.2% solid minerals fuels, 9.1% miscellaneous products, and 20.9% are ores, metals and chemicals (Eurostat, 2009). In the EU-27 in 2006 51 rail transport accidents involving dangerous goods occurred. About half of them (24) resulted in the release of dangerous substances (Eurostat, 2009).

2.2.4. Terrorist and criminal attacks

The EU framework decision issued on 13 June 2002 on combating terrorism defines terrorist offences as 'intentionally committed serious offences (attacks upon a person's life or physical integrity, kidnapping or hostage taking, seizure of aircrafts, release of dangerous substances, etc.) which may seriously damage a country or an international organisation'. Terrorist offences pursue a specific aim, such as 'seriously intimidating a population, or unduly compelling a government or international organisation to perform or abstain from performing any act, or seriously destabilising or destroying the fundamental political, constitutional, economic or social structures of a country or an international organisation' (EUR-LEX, 2002).

The main types of possible terrorist or criminal attacks are:

- Bomb attacks (suicide attacks, car bombs, assassinations)
- Gun rampages (including school shootings)
- Aircraft hijackings
- Biological terrorism ('the deliberate release of viruses, bacteria, or other germs (agents) used to cause illness or death in people, animals, or plants' (CDC, 2007))
- Chemical attacks (when chemical substances are used in the attacks or chemical plants are targets of terrorist's acts)
- Radiological attacks (the most likely radiological material will be an agent which is both poorly protected and easily accessed i.e. Cobalt-60, which is used in food radiation)

According to Europol (2008) trends show that the number of terrorist attacks is increasing throughout the EU, including those mounted with home-made explosive materials.

Many studies were carried out after the terrorist attack in New York on 11 September 2001 where around 3 000 people lost their lives (Long, Meyer, & Jacobs, 2007). Recent terrorist or criminal attacks in Europe include the train bombings in Madrid on 11 March 2004 (190 people were killed); a series of bomb attacks in London's public transport system during the morning rush hour on 7 July 2005 (52 fatalities), and school shooting in Kauhajoki (Finland) on 23 September 2008 (11 people killed).

2.2.5. Massive public events

Intervention of emergency workers is also demanded during serious accidents that may happen during occasions which gather a significant number of people in one place, including entertainment events (music concerts, festivals, and picnics), sports tournaments or demonstrations. Among the possible negative scenarios are building collapse, fire, car or plane crashes during certain types of car or air show, physical aggression with or without weapons, crowd panic, and any kind of terrorist attack. In Duisburg, Germany (2010), 18 young people were killed during a Love Parade event when a panicking crowd became stuck in a confined space. A plan of action for possible terrorist attack has been included in the plans of every large-scale sporting event since the killing of 11 athletes taken hostage by terrorists at the Olympic Games in Munich in 1972.

The main groups of emergency workers and the areas of their activities are summarised in Table 1.

Table 1: Emergency workers – main groups and areas of activities

<table>
<tr><th>Emergency workers - occupations</th><th>Areas of activities</th></tr>
<tr><td rowspan="6">Fire-fighters
Rescue workers (pilots, divers, construction workers, drivers, life-savers, life-guards, mountain-rescuers, cave-rescuers)
Body handlers
Police force
Antiterrorist force (bomb disposal)
Military forces
Doctors, nurses, paramedics, ambulance personnel
Municipal workers
Psychologists and psychiatrists
Volunteers
Other professions, according to need</td><td>Daily interventions
road accidents, crime scenes, gas explosions, fires</td></tr>
<tr><td>Natural disasters
floods, storms, fires, earthquakes, volcanic eruptions</td></tr>
<tr><td>Industrial accidents
involving hazardous materials, nuclear and mining</td></tr>
<tr><td>Transport accidents
major car crashes, plane crashes, rail and maritime accidents</td></tr>
<tr><td>Terrorist and criminal attacks
bomb attacks, gas attacks, shootings</td></tr>
<tr><td>Accidents during massive public events
fire, collapsing of a building, car crash, violence, crowd panic, terrorist attacks</td></tr>
</table>

3. Occupational health and safety risks for emergency workers

The nature of the work of emergency workers puts them at the top of those professions who have to deal with a considerable number of occupational health and safety hazards which are often unavoidable. Frequently they do not face one single safety risk, but a complex combination of risk factors, including the unpredictability of the situations they are required to work in. There are some general OSH issues likely to occur in any type of emergency intervention, such as physical and psychological overstrain. Other hazards are more typical for natural or man-made disasters. Additionally, the existing risks may be considerably increased by poor management.

Workplace scenes demanding the intervention of emergency workers may be located in remote, difficult to access areas (mountains, sea, caves), with changing and sometimes extremely difficult weather conditions. Emergency workers must arrive very rapidly at the disaster scene at any time of the day or night, and there is always the possibility of car crashes or other transportation accidents on the journey to the disaster scene or to hospitals. The collapse of buildings and other structures is likely during and after most natural disasters, and as a result of fires and explosions.

In operational situations at the scene of the emergency, surfaces are frequently unstable, narrow, inclined, slippery or dark, of all which pose slip and trip risks, the risk of falling or overexertion of different body parts (Cham & Redfern, 2002, Gershon et al., 1995). Walkway impediments, such as icy steps, wet leaves, broken and uneven pathways, may also cause slips, and trips and falls (Gershon et al., 1995).

Emergency workers provide pre-hospital health care at the scene which often means provision of health care under uncontrolled and adverse circumstances, such as in a moving ambulance, at an accident scene, or in locations with confined space or limited visibility (Boal, Hales & Ross, 2005). The taking of reasonable precautions, such as regularly changing gloves and washing hands or the appropriate disposal of sharp devices in containers, is more difficult than in a controlled situation. Exposures to blood or body fluids are also more likely, since victims may be seriously injured by broken glass or debris and suffer from uncontrolled bleeding. They may even behave aggressively and hurt the emergency worker (Boal et al., 2005).

Dealing with criminal and terrorist attacks, as well as working with people who are suffering, in need, frustrated, desperate, confused, angry, traumatised and generally under the influence of strong negative emotions put emergency workers at increased risk of violence and homicide. Potential hazards during public events include the unpredictable behaviour of large crowds panicking while trying to escape from confined spaces.

3.1. Physical overstrain

The work of emergency workers is usually physically demanding, with long shifts, a lot of overtime work, and insufficient breaks. Emergency workers are a professional group at particular risk of MSDs resulting from physically and psychologically highly demanding work tasks (Wiitavaara et al., 2007; Hignett et al., 2007). The following risks for musculoskeletal injuries and disorders among emergency workers can be identified (ILO, 2009a, 2009b):

- overexertion of the musculoskeletal system owing to frequent lifting and moving of patients, dead bodies and objects (specialised rescue equipment or stretchers, extrication of patients) and the prolonged maintenance of incorrect postures;
- wearing of heavy protective equipment;
- working under extreme time pressure;
- high psychological stress as a consequence of exposure to disasters (post-traumatic stress) and organisational factors (shift work, irregularity and unpredictability of working hours, prolonged interventions);
- exposure to whole-body vibration during driving over bumpy roads;
- prolonged time spent in a sedentary activity (such as driving an ambulance).

Studies show that a significant number of emergency medical workers regard lifting and carrying as the main strain they face in their jobs (zur Mühlen et al., 2005). In a study of São Paulo ambulance drivers, Takeda and Robazzi (2007) showed that they often perform more tasks than 'merely' driving an ambulance, since they also exercise the functions of EMS workers. They often work alone and have to move sick people. In addition to this they have to sit during a high proportion of their working time, and are exposed to the vibration of the engine. Sedentary activity, a high physical workload and whole-body vibrations are risk factors for musculoskeletal disorders.

3.2. Emotional overstrain

The possibily of avoiding negative stressors in the work environment are significantly reduced for emergency workers who often find themselves attending a 'critical incident', which can be defined as an 'incident that is sufficiently disturbing to overwhelm or threaten to overwhelm the individual's usual method of coping' (Alexander and Klein, 2001). Dealing with many fatalities, injured people and their families, high responsibility for people's lives, violence at work, irregular and unpredictable working hours, and severe time pressure are all prevalent hazards which may lead to serious emotional overstrain in emergency workers. Additionally, major accidents and incidents such as school violence usually draw intense media coverage and this may add to stress for the rescue workers. According to the study of Strömberg et al. (2005), public attention and media interest evoked uncomfortable feelings in the rescue workers in the wake of the terrorist bomb attack in Myyrmanni, Finland. Emergency workers had no experience of how the general public would react in this kind of disaster situation or how the rescuers should handle such intense scrutiny. Rescue workers were annoyed by journalists and photographers, who kept taking pictures of them working. Furthermore, the negative feedback given by the media on the day following the explosion caused stress and tension in the rescue workers (Strömberg et al., 2005). Psychological burdens may be also related to moral dilemmas when decisions have to be made about balancing the need to help other people with risks to an emergency worker's safety. Sometimes emergency workers may face unrealistic public expectations, even in situations where OSH risks outweigh the potential benefits of intervention (HSE, 2010a).

Among emergency workers, symptoms of mental ill health or even diagnosed mental ill health may result from the strong impressions and feelings they have to bear when confronted with death and destruction as well as injuries, pain, suffering, and the despair of survivors of disasters (Brauchle et al., 2000). Emergency workers face enormous psychological demands, burdened with responsibility for the lives of others, and the sense that any errors or failures could lead to someone's death (Bengel, 2004) and cause feelings of guilt that would be difficult to cope with. There is a correlation between the duration of an emergency worker's time at a disaster scene and the severity of the psychological consequences that may become apparent later (North et al., 2002, Perrin et al., 2007).

The Diagnostic and Statistical Manual of Mental Disorders (DSM) defines in detail the criteria a traumatic event, when identified as a trigger of post-traumatic stress disorder, should meet (American Psychiatric Association, 2000).

A traumatic event can be:

- a personal experience of a life-threatening situation or a situation that leads to serious injury or another threat to one's physical integrity
- a situation where one witnesses death, injury, or threat to the physical integrity of another person
- a situation in which one receives the news of unexpected death or serious injury of a family member or close associate
- an event where intense fear, helplessness or shock are present in the person's reaction following the event.

Natural and man-made disasters, and terrorist and criminal attacks are highly likely to include potentially traumatic events with workers experiencing profound feelings such as grief, despair, helplessness, horror and revulsion (Bierens De Haan, 2005; Tomczyk et al., 2008). Excessive stress may lead to development of post traumatic stress disorder (PTSD), severe symptoms of depression and burnout. A low level of personal and professional preparedness also increases the level of stress in emergency workers (Young et al., 1998).

According to the DSM (American Psychiatric Association, 2000) a post-traumatic stress disorder (PTSD) can be diagnosed if a number of diagnostic criteria are met for the duration of at least one month. The symptoms must disturb the person in their functioning in occupational or private life, with constant recollections of the traumatic event, recurring distressing dreams, and dissociative states during time spans ranging from seconds to days in which the person behaves as if they are experiencing the trauma again. The person may also suffer from intense psychological distress when confronting elements that symbolise or are reminiscent of the event, and may try to avoid anything they associate with the trauma. These difficulties are often combined with emotional numbness such as reduced interest and participation in everyday life or feelings of detachment. Persistent increased arousal leading to difficulty in falling asleep, nightmares, irritability, and concentration problems, is also symptomatic of PTSD.

The depression which may accompany mental health problems may result in feeling 'low' most of the day and bring a loss of interest or pleasure in most daily activities, and may be accompanied by other symptoms such as weight loss, insomnia or hypersomnia, psychomotor agitation (restlessness), fatigue, feelings of worthlessness, concentration problems, recurrent thoughts of death and suicide.

Emergency work is characterised by high workload and severe time pressures, confrontation with death and dying, the requirement to suppress emotions while working and yet, at the same time, being emotionally empathic, features which may be risk factors for burnout. Burnout is defined as a 'long-term reaction to occupational stress' (Mitani et al., 2006), and may be characterised by three main factors (Maslach and Jackson, 1981):

- emotional exhaustion: emotional fatigue, feeling 'empty' because of contacts with others;
- reduced personal accomplishment: having the idea that one's competencies have diminished;
- depersonalisation: loss of concern and compassion towards the environment.

Someone suffering from burnout may complain of exhaustion combined with heightened tension, reduced efficiency, reduced motivation (loss of interest, demoralisation), leading to poor job performance and recurrent short-term sickness absences.

3.3. OSH risks specific to natural disasters

Among the primary tasks of emergency workers during natural disasters is the rescue of survivors and provision of medical help, the evacuation of people from the affected area, the recovery of dead bodies, prevention of further damage, clean-up work, the provision of food and potable water, the maintenance of a good level of hygiene to prevent spread of epidemics, and supporting the vaccination of the population. Specific risks for emergency workers may be related to significant devastation of the area, collapsing buildings and other structures, devastation of electrical installations, and general devastation of infrastructure and communication lines. The situation may require working in confined spaces, with the attendant risks of being seriously injured by debris, trapped, or injured by aggressive animals.

Natural disasters may involve flooding (caused by floods, windstorms and tsunamis), and related risks such as drowning and the spread of water- and vector-borne diseases. Water-borne diseases are spread when the affected population or emergency workers come into direct contact with contaminated water, with high concentrations of bacteria, viruses, and other microorganisms, such as when sewage enters the drinking water supply, or when emergency workers have to work in contaminated surface water. Typical water-borne diseases are diarrhoea, cholera, typhoid fever, hepatitis A, hepatitis E, parasitic diseases, rotavirus, and shigellosis (WHO, 2011b; Ligon, 2006).

Vector-borne diseases are also likely to occur after flooding or following disasters in which field camps must be erected for the care of disaster victims and an intact functioning of waste management is disturbed. Standing water serves as a breeding-site for mosquitoes, and rodents are attracted by nutrients in the waste. Diseases that are typically transmitted by mosquitoes are malaria, dengue, St. Louis encephalitis, and West Nile fever. The faeces of rodents may contain large quantities of leptospires, permitting the spread of leptospirosis (Ligon, 2006).

Infectious diseases that might affect emergency workers through their contact with survivors are wound infections, diseases that are transmitted by droplet infection such as tuberculosis, diseases such as gastrointestinal diseases transmitted by smear infections, and blood-borne diseases such as HIV, hepatitis B, and hepatitis C. The possibility of infections associated with contact with dead bodies is highest for blood-borne diseases, gastrointestinal diseases and tuberculosis (Morgan, 2004; WHO, (2011b). Morgan (2004) indicates that other infections from dead bodies are possible, although no more likely than through contact with survivors, such as group A streptococcal infection (meningitis), sepsis or some rare diseases such as Creutzfeld-Jakob disease. Shih et al. (2009) concluded that ‘the biggest perceived danger in epidemics like severe acute respiratory syndrome (SARS) may be the possible invasion of health professionals’ internal and external work environments and their loss of control’.

Fire-fighters and other rescue and relief workers deployed in natural disasters may be particularly at risk of respiratory and asthmatic problems. Volcanic eruptions lead to a significant release of ash and gas. Smoke is also generated in vegetation fires or fires occurring as secondary effects to natural disasters. Landslides and earthquakes lead to dust production. All these factors (ash, gas, smoke, and dust) cause eye and pulmonary irritation, and in the most severe cases asphyxiation. Some of the by-products of combustion are often carcinogenic.

Volcanic eruptions, vegetative fires or fires generated as secondary effects of natural disasters cause high heat stress, presenting the possibility of skin injuries and burns. Air pollution caused by dust from collapsed buildings, gas and ash released as a consequence of volcanic eruptions, or smoke resulting from fires also make transportation accidents more likely.

In pre-hospital health care and in the provision of assistance to disaster victims, emergency workers face an increased risk of exposure to blood and bodily fluids and to needle-stick injuries. Three diseases are of primary concern here: HIV, hepatitis B and hepatitis C (Sulsky et al., 2006; Takagi et al., 1998).

Where disasters occur in regions in which tuberculosis is prevalent among the population, emergency workers should consider the possible transmission of infection when in contact with survivors or dead bodies. Tuberculosis is most prevalent in developing countries in Asia and particularly in Africa (Morgan, 2004; WHO, 2010c). Transmission of tuberculosis may occur when either residual air passes from the chest cavity of an infected dead body and is inhaled by the body handler, or when an emergency worker is in contact with an infected person who coughs, sneezes, talks or spits, with the result that the tuberculosis bacillus is emitted into the air (Morgan, 2004; WHO, 2010c).

3.4. OSH risks specific to man-made disasters

Emergency workers are involved in the early stages of an emergency response at industrial sites and at post-accident scenes. Their duties depend on the type of the accident and the specific danger they have to deal with. They may be involved in quenching fires, evacuating people, controlling traffic around the site, providing first-aid and medical care to survivors, recovery of dead bodies, and the clean-up of contaminated areas. The most severe consequences to the safety and health of emergency workers results from accidents involving hazardous materials and caused by explosions, followed by fires, and finally the release of toxic substances (Carol et al., (2002). Possible OSH risks related to transport accidents may be associated with fires, explosions, and hazardous materials (stemming from transporting goods but also burning fuel and other chemicals used in vehicles). Rescuing victims of car, train, or airplane crashes may require working in confined spaces which increases risk. Additionally, emergency workers responding to a traffic accident are particularly at risk of being struck by a passing vehicle.

Fires

Fires and explosions produce high levels of thermal radiation and overpressure. The shock wave of an explosion can lead to the injury or death of people in the vicinity and significant damage to buildings. Shock waves are so strong that even heavy objects are moved into the air, windows break and missiles are ejected even over long distances, possibly hitting people (ILO, 1988). Likewise people can be flung off their feet by the shock wave so fiercely that it may lead to serious injury or death (Delgado & González, 1998). In the human body, shock waves first affect those organs that contain most air, meaning that injuries in such situations can range from a rupture of the tympanic membrane to haemorrhage of the lungs (Delgado & González, 1998; Ide, 2007). Fires may lead to skin burns, depletion of oxygen, and exposure to toxic fumes produced by combustion processes. Emergency workers may be in particular danger when a domino effect occurs, leading to secondary explosions.

Chemical hazards

The main paths through which chemicals enter the body are the skin, the respiratory system and the digestive tract. Once a chemical has entered the body, the severity of health impairment depends on whether the toxicity of the substance and the dose received are sufficiently high to cause damage. Sufficient toxicity to cause damage can either be reached by short but significant (acute) exposure or due to prolonged (chronic) exposure leading to accumulative effects. Negative health outcomes can either be local (at the point of contact, blistering or burning of the skin) or systemic (distant from the body's initial point of contact). Effects can occur immediately (irritations in eyes or respiratory tract) or be delayed (such as cancers) (Wisner & Adams, 2002).

At industrial sites emergency workers may be exposed to variety of chemical substances such as carbon monoxide, ammonia, cyanide, isocyanides, hydrogen fluoride, hydrogen chloride, acetaldehyde, formaldehyde, phosgene, methane, sulphur dioxide, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, polychlorinated dibenzofurans and dibenzodioxins including 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), asbestos, free radicals and particulate matter etc. Additionally, when dealing with fires in new buildings, fire-fighters might be exposed to novel building materials, such as synthetic polymers, and the by-products of their combustion which might have changed qualitatively and quantitatively during the last few decades (Guidotti, 1995) and thus their effects on human health may not yet have been fully investigated.

Exposure to chemical substances is not limited to major incidents but may also be due to exposure to substances used to combat the disaster, for example chemicals from fire extinguishers used by fire-fighters or gases used by policemen dealing with aggressive people or animals. Smoke created as a result of a combustion process may result in a mixture of gases, and liquid or solid particles. The chemical composition of smoke depends on the type of material burned and consists of products caused by oxidation and thermal decomposition processes.

The risks for healthcare workers may arise from secondary exposure to the toxicity of the substances accumulated on a victim's hair, skin and clothing. Potential negative effects depend on the concentration of the toxic substances and the duration of contact with the victim (Horton, Berkowitz & Kaye, 2003). Chemicals which may be related to emergency health care are, for example, nerve agents (sarin), blood agents (hydrogen cyanide), blister agents (nitrogen and sulphur mustards), heavy metals (arsenic), volatile toxins (benzene), pulmonary agents (phosgene), poisonous gases (cyanides), and corrosive acids (Koenig et al., 2008).

Short-term and long-term negative effects due to acute exposure to toxic substances may occur. The consequences from toxic exposure can either be instant fatality, latent fatality (as in the case of cancer development) and many other types of disorders. Contact with some toxic substances leads to problems with the central nervous system (restricted functioning of the central nervous system, headache, confusion, faintness, agitation, delirium or convulsions), respiratory complaints (cough, breathlessness), cardiovascular complaints (arrhythmia, hypertension), renal failure, eye and skin problems and gastrointestinal problems (Delgado & González, 1998).

Radiation exposure

Radioactivity is ionising radiation that is emitted from radioactive materials and can have severe adverse effects on health in human beings. This can occur via DNA changes and protein alterations leading to cell damage or even cell death. The severity of the damage depends on radiation type, its intensity, the distance from the source and the time of exposure.

Radioactive contamination (when radioactive material is in an unwanted location) and radioactive exposure (exposure to an external source of radiation) can occur in a variety of situations such as when emergency workers respond to nuclear reactor accidents, accidental exposure from industrial radioactive sources, and contact with contaminated people needing help (Bushberg et al., 2007). In some cases radioactive material might also be deployed by terrorists concealing radioactive sources in public locations, using radiological dispersal devices, sabotaging a nuclear plant or using nuclear weapons (Bushberg et al., 2007).

Negative effects in human health related to nuclear accidents range from nausea and skin problems to severe consequences such as burns, incurable diseases (different kinds of cancer) and death. Effects that are fatal, life-threatening or result in permanent injury, reducing quality of life, are usually called 'deterministic' because the injury and damage (skin burns, radiation sickness or death) are an inevitable consequence of the exposure, and occur immediately when the dose exceeds the threshold level. Radiation sickness caused by exposure to a high dose of radiation over a short period of time is known as Acute Radiation Syndrome (ARS). The symptoms related to ARS may be loss of appetite, fatigue, fever, nausea, vomiting, diarrhoea, skin damage, hair loss, seizures and coma. Stochastic or random effects such as cancers and inheritable defects due to modified DNA are latent and unpredictable (IAEA, 2006).

Terrorist and criminal attacks

Emergency workers are confronted with particularly unfamiliar, unpredictable, confused, complex and unsafe scenes when attending a rescue operation in the wake of a terrorist or criminal attack. The emergency caused by a terrorist or criminal attack is often a combination of a mass casualty incident, a hazardous material exposure site, and a crime scene scenario. Gunfire, incendiaries, explosives, and secondary devices magnify the risks to responders. There is a greatly increased risk of mass casualties and of hostage-taking (Department of Homeland Security, 1999). Additionally, in terrorist acts, emergency workers can be involved in two ways, either as rescue workers or as victims themselves, whether directly or indirectly targeted by the terrorists (Bierens De Haan, 2005; McElroy, 2000).

When emergency workers are targeted in politically motivated terrorist acts, they '... are usually deliberately targeted by the kamikazes and bombers and those who are behind the attacks, who choose – or even prefer – them because of the media impact. They are *soft targets,* i.e. ill-defended, as opposed to hard targets, such as the military or politicians', who are far more difficult to reach (Bierens de Haan, 2005.)

Terrorist and criminal attacks can involve physical, chemical, biological, and radiological hazards. Different secondary consequences such as explosions or collapsing structures may occur when emergency workers are already at the scene. The partial or complete collapse of a building due to a terrorist or criminal attack creates an array of hazards, including those posed by electrical equipment, vehicles and heavy equipment, noise, falling objects, sharp objects, confined spaces, structural instability, and uneven or unsteady working surfaces. Chemical hazards are created by fires, toxic fumes, and the pulverisation of building materials and contents. In the aftermath of the 2001 WTC attack, ongoing risks throughout the rescue and recovery period included lingering airborne particulate matter and combustion products from initial and persistent fires beneath the rubble pile (Feldman et al., 2004; Landrigan et al., 2004; Lioy et al., 2002).

Biological agents possibly used in bioterrorism

Emergency workers may become victims of bioterrorism through either direct or indirect contact. Direct contact occurs when the emergency worker enters an area that has been intentionally contaminated with a biological agent. Indirect contact may occur through the provision of health care to a person infected with a disease that has been initiated by bioterrorism (Deitchman, 2002).

The Centre for Disease Control and Prevention (CDC, USA) provides a list of biological agents that pose the greatest threat to civilians. Category A (the most dangerous agents) includes *variola major* (smallpox), *bacillus anthracis* (anthrax), *yersinia pestis* (plague), clostridium botulinum toxin (botulism), *francisella tularensis* (tularaemia), and *filoviruses* and *arenaviruses* (viral hemorrhagic fevers) (Khardori, 2006; Deitchman, 2002). They head the list because they '…1. can be easily disseminated or transmitted from person to person; 2. cause high mortality with potential for major public health impact; 3. might cause public panic and social disruption; and 4. require special action for public health preparedness.' (Khardori, 2006). Category B and Category C include biological agents that are less threatening to people.

Risks posed by biological terrorism are those against which emergency workers are usually ill-prepared and poorly protected (Abatemarco et al., 2007; Vinson, 2007). The rescuers do not always dispose of adequate respiratory or skin protective equipment (Abatemarco et al., 2007; Okumura, 2005).

3.5. Poor management of resources

In all types of emergencies, depending on their scale, cooperation at organisational, local, national or international level is essential. A lack of immediate information about the real situation at a disaster scene, and the unpredictability of events as they unfold, are inherent aspects of emergency work. However, poor cooperation or a lack of it between the authorities and the various groups of workers involved will increase the level of risk for workers' health and safety.

Poor management results in lack of, insufficient or inappropriate:

- preparedness plan

- coordination of all groups of emergency workers involved in a particular event, given specificity of their tasks, different communication system they may use or language they may be able to understand
- information and communication before, during, and after the event
- personal protective equipment and protective clothes
- training
- post-event support

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Different groups of emergency workers may use incompatible radio systems, causing communication breakdowns that can have severe consequences, making it difficult for managers to maintain disaster scene control, utilise forces most effectively and to share all necessary safety information (LaTourrette et al., 2003). Poor management and lack of a common communication system between on-scene professionals may create serious confusion and can cause major safety issues among responders (Virginia Tech Review Panel, 2007). The lack of a common language and incompatible information channels may particularly affect cross-border collaboration.

Lack of information or training, and the uncertainties related to risk evaluation, led to a situation in which emergency responders arriving at the scene of an accident, and health professionals receiving victims in hospital, did not know the characteristics of the hazardous substances released during the accident and were not able to protect themselves from them (Kirchsteiger et al., 1998; Angle, 2005; Fabbri & Contini, 2009; Bonvicini, Leonelli & Spadoni, 1998).

4. Health and safety outcomes

Emergency workers are exposed to many different risks at the same time and the possible consequences for their safety and health may be manifold. Many emergency workers suffer from accidents and injuries in the course of their jobs, as well as other negative health effects that lead to severe deterioration of their physical and psychological well-being. High levels of sick leave, absenteeism and premature retirement are also recorded.

4.1. Fatalities

In UK during the years 1978 – 2007, 121 fire-fighters died while carrying their duty, which is one on-duty death every three months during this 30-year period (Fire Brigades Union, 2008). Around 80% of all cases were related to operational activities, following by road traffic accidents (during a way to or from a disaster scene). After the decreasing trend in the number of fatalities in UK observed in the late 1980, there was a grown up during last years. Data shows that in the period 2003-2008 22 fire-fighters died on duty, and this was significantly more than in the previous five years. “Fire deaths” such as burns and asphyxiation were related to the largest number of fatalities (36%). Around 30% of deaths were caused by heart attacks, either at the place of accident or shortly afterwards, or on fire services premises while on duty (Fire Brigades Union, 2008).

Deaths while fighting fires often result from a series of explosions which can occur during emergency response procedures (Björnhagen, Messner & Brändström, 2006). In 1997, in West Helena (US), a severe explosion and fire occurred which resulted in the death of three fire-fighters and the serious injury of another (Mannan, 2005). Another 16 fire-fighters required medical attention. A fire-fighting team came to the plant after smoke was detected in a pesticides warehouse. The explosion occurred in the warehouse while fire-fighters were outside the building during emergency operations. When an explosion ripped through a fireworks warehouse in Enschede, the Netherlands, in 2000, four of the 22 victims killed were fire-fighters.

Longitudinal data on on-duty fire-fighter fatalities in the US show that the number of fire-fighter deaths decreased between 1977 (157 deaths) and 2009 (82 deaths), and that the number of fatalities among volunteer fire-fighters was consistently higher than for career fire-fighters. In 2009, most of fire-fighters’ deaths occurred while operating at the site of the fire ground (33%). 24% of deaths occurred while responding to or returning from alarms, 17% during other activities on duty, 13% during training, and 12% during non-fire emergencies. 54% of the deaths were due to overexertion/stress/medical problems, 27% due to being struck by or contact with objects, 11% due to falls or jumps, 7% due to being caught or trapped, and 1% due to assaults.

When clustered by the nature of injury, 43% of the US fire-fighters’ deaths in 2009 were caused by sudden cardiac death, 34% by internal trauma, 6% by asphyxiation, 6% by stroke, 6% by ‘other’ causes, 4% by burns, and 1% by gunshots (Fahy, LeBlanc & Molis, 2010). Asphyxiation is the third leading cause of death for career-fire-fighters (20%), with 76% of the asphyxiation deaths attributable to being caught by collapsing buildings or trapped. Asphyxiation accounted for 7% of on-duty accidents among volunteer fire-fighters, 69% of these incidents due to being caught or trapped (CDC, 2006a). The number of on-duty deaths of fire-fighters in the US was slightly higher among workers in the 50–59 age group, and significantly higher among older fire-fighters above 60 years of age when compared to younger workers (Fahy et al., 2010).

Emergency workers, in particular fire-fighters and emergency medical staff, are exposed to physically strenuous work that affects the activity of the heart. The emergency alarm abruptly terminates sedentary activity and signals the start of intense exertion. The almost maximal heart rates recorded during fire fighting, exposure to extreme heat, wearing of heavy protective equipment and dehydration all place heavy strains on the heart and these can trigger fatalities due to cardiac overexertion (Kales et al., 2003).

Kales et al. (2003) stated that coronary heart diseases were responsible for most of the on-duty deaths of fire-fighters (45%) in the US. This has also been confirmed by other studies (CDC, 2006a). Kales et al. (2003) additionally found that most of the on-duty deaths due to coronary heart disease (CHD) among fire-fighters occurred between noon and midnight, and three quarters of those fire-fighters who died on-duty as a result of CHD had not undergone a recent routine fire department medical examination.

Geibe et al. (2008) investigated possible risk factors for on-duty death due to coronary events by comparing a group of fire-fighters who died within one day of a coronary event with a group of fire-fighters who experienced a non-fatal coronary event while on-duty. They identified previous diagnosis of CHD, carotid stenosis, or peripheral arterial disease, current smoking and hypertension as significant risk factors for fatality.

Fahy et al. (2010) showed that the age of the fire-fighters played a role in sudden cardiac death. In 2009 in the US, fire-fighters aged 41 years or over died significantly more frequently from sudden cardiac death than fire-fighters up to the age of 40.

Kales et al. (2003) found increased risks of death due to coronary heart disease in personnel engaged in fire suppression, training, and alarm response. Cardiovascular problems, as a possible cause of on-duty fatalities among emergency medical staff and ambulance personnel, was also confirmed (Maguire et al., 2002, Sterud et al., 2006).

In the US, the annual fatality rate in 1992-1997 was 5 per 100,000 employees on average, whereas among emergency medical workers increases to 12,7, among police service to 14,2, and among fire-fighters reached 16,5 (Maguire et al. 2002). As far as transportation-related fatal accidents are concerned, the highest rate was recorded among emergency medical workers (9,6), following by police (6,3), and fire-fighters (4,5), with national average being 2 (Maguire et al. 2002). CDC (2006a) found that 26% of deaths among volunteer fire-fighters, and 12% among career fire-fighters in US were caused by vehicle-related accidents. These accidents were most often vehicle crashes (around 70%) followed by being struck by a passing vehicle. National Traffic Incident Management Coalition stated that between 1995 and 2006, an average of one US law enforcement officer was struck and killed each month by a passing vehicle (NTIMC, 2006).

4.2. Violence at work

The New York Sate Health Department recorded 817 deaths of emergency workers in 2001, the majority of whom were involved in the intervention after the terrorist attack at the WTC on 9 September 2001 (The Guardian, 2009). In terrorist attacks, rescuers are sometimes deliberately targeted as ‘soft targets’ (Bierens De Haan, 2005; McElroy, 2000; Department of Homeland Security, 1999). For example, in January 1997 a bomb exploded at the rear of a family planning clinic in the USA, and about an hour later, as the emergency workers were attempting to secure the scene and evacuate the area, a second bomb was detonated (McElroy, 2000). In the Kauhajoki and Jokela school shooting incidents shots were directed at emergency workers (Aho, 2008; Mäkinen, 2008). According to the US Fire Administration technical report on the Columbine High School mass shooting, ‘fire service and EMS providers were subjected to hostile behaviours and gunfire while retrieving seriously injured victims in this accident’ (Department of Homeland Security, 1999). Maguire et al. show US emergency medical workers’ assault fatality rate to be 7 times higher than for other health care workers, and non-fatal injury rate 22 times higher than the national average (Maguire et al. 2002).

Höök and Huttunen (2007) reported similar results about the prevalence of violence among Finnish emergency workers where 73.3 % of fire-fighters and emergency workers reported having been threatened or being targets of violence. A high prevalence of violence among paramedics has been also shown in the Swedish study by Suserund, Blomquist and Johansson (2002). Another Finnish study shows that 17% of police officers' accidents were attributed to violence and aggression (FAII, 2009). Among ambulance drivers in São Paulo, Brazil, various types of assault accounted for 26% of all occupational accidents (Takeda and Robazzi, 2007).

A French study by Duchateau et al. (2002) found that one or more assaults had been experienced by 23% of ambulance personnel during their careers, and 4% of these incidents resulted in sick leave and 4% led to a need for PTSD therapy. Of the Australian paramedics surveyed by Boyle et al. (2007), 87.5% had been exposed to workplace violence during the previous 12 months, and the most common form of workplace violence was verbal abuse (82%), following by intimidation (55%), physical abuse (38%), sexual harassment (17%), and sexual assault (4%). Grange and Corbett (2002) also found in their study of EMS workers in California that they were at substantial risk of violence in the pre-hospital setting while performing their routine duties. That study found that verbal or physical violence occurred in 8.5% of patient encounters. About half (53%) of the reported violence was directed against pre-hospital care providers, while the reminder was directed against others. In most cases, the violent behaviour was expressed by the patients. In the official injury reports submitted by the US fire department-based EMS system, out of 1,100 injuries, 44 were related to assaults of paramedics or firefighters (Mechem et al., 2002).

4.3. Accidents and injuries

Finnish statistics (FAII, 2009) show that the number of non-fatal accidents suffered by fire-fighters (including full-time, compensated part-time and volunteer fire-fighters) varied between 500 and 600 per year (within a population of about 19,000 fire-fighters). The number of accidents experienced by police officers has increased by about 100 every year between 2005 and 2007, rising to more than 800 in 2007. For Finnish emergency workers, sick leave after accidents has been less than three days in most cases. However, about 20% of accidents required sick leave of more than 15 days. Longer periods of sick leave are more prevalent among fire-fighters aged 35–55 years. Over half (55%) of all work related accidents suffered by Finnish rescue workers occur while the individual is moving, and 15% while the manual carrying of victims and objects is underway (FAII, 2009). In 2004/2005, the most frequent non-fatal accidents for fire service workers in the United Kingdom were injuries incurred while handling, lifting or carrying (41.3%), followed by slips, trips or falls on the same level (27.6%), and being hit by a moving, flying or falling object (8.9%) (HSE, 2010). According to Walton et al., (2003) one in three injuries to fire-fighters is caused by overexertion. Overexertion, strenuous or repetitive movements were responsible for 42% of all occupational accidents which befell 22 emergency drivers of a Sao Paolo ambulance centre (Takeda & Robazzi, 2007).

Complex tasks that divide a worker's full attention can reduce his or her ability to control body movements and balance while moving and therefore predispose him/her to injury (Hsiao & Simeonov, 2001). In hospitals, the most common causes (24%) of slip, trip and fall (STF) accidents for EMS workers and other hospital employees are liquid contamination of floor surfaces (Bell et al., 2008). According to Bell et al. (2008) the transport/emergency medical service is one of the occupations with the highest risk of an STF-related injury claim in the hospital environment in the USA. Accidents requiring three or more days of sick leave as a result of loss of balance because of STF accidents on level surfaces or falls and jumps from upper to lower levels are reported to account for a considerable proportion of work-related accidents among emergency workers in Finland; 33% of fire-fighters, 20–30% of paramedics/ambulance drivers, 21% of police officers, and 27% of workers in the health and social services (Statistics Finland, 2009; FAII, 2009). Among emergency drivers in one Brazilian ambulance centre where 22 subjects were interviewed, 11% of occupational accidents had been caused by falls on the same level or from slipping, tripping or stumbling (Takeda & Robazzi, 2007).

A survey conducted in US revealed a high risk of injury among emergency medical service providers - they experienced 34.6 injuries per 100 full-time employees per year and had a seven times higher risk of suffering injuries requiring time off work than the general working population (Maguire et al., 2005). At work, emergency medical workers have six times higher the overall rate of injuries and illnesses, 21 times higher rate of lifting injuries, 30 times higher risk of transportation injury, and 22 higher violence-related injury, when compared to national rate in the US. The same study showed higher than average (which was 5,6) occupational injury rate among fire-fighters (18,6), and police workers (13,9) (Maguire et al., 2005).

In Finland, the proportions of accidents occurring during body movement under physical stress are 29% in fire-fighters, 26% in police officers and 28% in paramedics/ambulance drivers (FAII, 2009). Hospital employees in US (EMS workers included) above 45 years of age suffered higher rates of STF accidents than younger workers (Bell et al. 2008). In addition, fire-fighters aged 40–44 years experienced a higher proportion of accidents involving STF incidents while walking, running, climbing up or down stairs and ladders and other types of movement than either younger or older fire-fighters (Cloutier & Champoux, 2000). The additional weight burden of PPE has been reported to be a contributory factor to some accidents. PPE requirements have significantly impaired both postural and functional balance among fire-fighters aged 33–38 and 43–56 years (Cloutier & Champoux, 2000). Postural balance when using PPE with eyes closed has also been found to be more closely related to accidents for older subjects than their younger colleagues (Punakallio, Lusa & Luukkonen, 2003).

In the US hospital employees (EMS workers included), the lower extremities were the body part most commonly injured (45%) due to STF accidents, most often by sprains, strains, dislocations, and tears (48%) (Bell et al., 2008, Gershon et al., 1995). In addition, STF accidents were more likely to cause fractures and multiple injuries compared with other types of accidents. STF resulted most commonly in sprains and pulls in Canadian fire-fighters and the lower extremities were the body part most commonly injured (33-42%) (Cloutier and Champoux, 2000). Furthermore, in Canadian EMS workers, the back was often (42%) injured due to the excessive exertion required while transporting and handling personal protective respiratory equipment (PPRE) (Cloutier & Champoux, 2000). Most accidents among EMS workers are caused by stretcher mishaps, especially during transportation of heavy patients (Gershon et al., 1995; Conrad et al., 2008).

Although accidents mostly occur at the scene of the emergency, a considerable number of injuries happen during training at work. There are several studies revealing that on-duty fitness training has been responsible for injuries to fire-fighters and police officers in Sweden, Poland, Finland, and Germany (de Loes & Jansson, 2002; Szubert & Sobala, 2002; FAII, 2009; Deutscher Feuerwehr Verband, 2008) In Sweden, around 50% of injuries occurred in team and contact sports (Loes & Janson, 2002). An analysis of work-related causes and the circumstances of injuries among fire-fighters in Poland (Szubert & Sobala, 2002) revealed that the majority (40%) occurred during compulsory physical training, and these injuries accounted for 41% of post-injury absence from work. Injuries during emergency operations were responsible for 25% of all injuries, accounting for 24% of post-injury absence. Workers who had been employed for less than one year were at the highest risk of injury. The analysis of the data showed that the frequency of injuries was not significantly age-dependent. However, the duration of work disability was found to increase by 20% with the increasing age of the workers. Finnish statistics reveal that in recent years at least one in five of all accidents among fire-fighters and police officers occur during physical training (FAII, 2009). Among German volunteer fire-fighters, the reported accidents requiring sick-leave of more than 3 days occurred during training during work (24.5%), fire-fighting (21.2%) and fire-fighter group meetings (13.5%) (Deutscher Feuerwehr Verband, 2008).

Back injuries and upper and lower extremity injuries seem to be the most common type of injury experienced by emergency workers (Maguire et al., 2005). In all, 10.3% of the emergency medical technicians investigated in the study of Schwartz, Benson and Jacobs (1993) reported back injuries with a prevalence rate of 25.4 injuries per 100 full-time employees per year. More than 50% of back injuries required an average of 30 days off work. Moreover, 9.8% of the emergency medical technicians in the study of Schwartz et al. (1993) experienced injuries in the upper and lower extremities. The prevalence rate was 23.7 injuries per 100 full-time employees per year with about one in every three of these injuries requiring sick leave. Gershon et al. (1995) also stated that in EMS workers, the back is the most commonly injured part of the body (20%). According to FAII (2009), the most often injured body parts in Finnish fire-fighters and paramedics were the lower extremities and the back (about half of all accidents). Most of the injuries suffered by police officers were in the lower extremities (about a quarter of all accidents) and the fingers (about 17%). Back injuries were often linked to overexertion (Walton et al., 2003).

Maguire et al. (2005) reported that the most frequent types of injuries were sprains, strains, and tears. Finnish statistics confirm 'dislocations, sprains and strains' as the largest accident category. In 2007, these kinds of injuries accounted for about half of the accidents experienced by paramedics and fire-fighters and 41% of police officers' accidents (FAII, 2009). The New Orleans Police and Fire Departments reported that 7–13 weeks after Hurricane Katrina, lacerations and sprains were the most common injuries (CDC, 2006). The next largest categories were 'wounds and superficial injuries' and 'concussions/internal injuries'.

Table 2 depicts the percentages of different injuries (and their causes) recorded for fire and emergency workers in Queensland, Australia (Queensland Government, 2009). The most prevalent injuries are those affecting the back, those involved with the carrying or moving of equipment, people or vehicles, and knee injuries caused by slips or trips on poor or uneven surfaces and equipment.

Table 2: Injury statistics for fire and emergency workers

% of total injuries	Body part	Description of most prevalent injuries and causes
20%	Back	Muscle & tendon strains & sprains from lifting, carrying or moving equipment, people or vehicles
16%	Knee	Muscle & tendon strains & sprains from tripping or slipping on poor or uneven surfaces and equipment
8%	Shoulder	Muscle and tendon sprains and strains from lifting, carrying or moving equipment or vehicles
7%	Ankle	Muscle & tendon sprains & strains from tripping or slipping on poor or uneven surfaces
6%	Hand, fingers and thumbs	Wounds/lacerations from hitting or being trapped between objects and equipment
5%	Leg	Muscle & tendon strains & sprains from lifting, carrying or moving equipment, people or vehicles
4%	Psychological system	Post-traumatic stress, anxiety, depression, work-related stress from exposure to a traumatic events and work related pressures

Source: Queensland Employee Injury Database (Queensland Government 2009)

4.4. Musculoskeletal disorders

Fire-fighters have to lift around 30 kg of full personal equipment in fires in addition to the extra tools they need for call-outs (Bethge, 1999). Additional burdens of this kind are related to psychological overstrain. Morren et al. (2005) stated that cases of musculoskeletal disorders (MSDs) increased among rescue workers (fire-fighters, police officers and medical emergency service personnel) who had been deployed during the explosion of a fireworks depot in Enschede, the Netherlands, in May 2000. The increased occurrence of MSDs in terms of prevalence and incidence is reflected in a higher frequency of absence, an increased number of days of sick leave and an increased length of absence up to 30 months post-disaster. When the rescue workers who had been deployed in Enschede were compared to rescue workers not involved in the disaster, increases were found in the prevalence, incidence and frequency of absence, but not in the number of sick days and duration of absences.

MSDs have been found to be the leading reason for early retirement due to ill health among employees of the United Kingdom's National Health Service, and this was especially true for the ambulance workers (Pattani, Constantinovici, and Williams, cited by Wagner et al.,2006). The predominant problem leading to early retirement was cervical spine injury. Also Sterud et al. (2008) reported that male ambulance workers suffer more frequently than male workers in the general population from neck pain (14.7% vs. 11.2%), upper back (9.4% vs. 6.0%), and lower back (22.1% vs. 14.0%). Ambulance workers seek the help of chiropractors more frequently than do people in the general population (11.7% vs. 4.5%). Back problems are a frequently reported health complaint among emergency medical technicians. Studnek & Mac Crawford (2007) reported that an increased risk of back problems among emergency medical technicians was associated with lower general levels of physical fitness, low satisfaction with the current assignment, and job tasks including transport of patients. Berríos-Torres et al. (2003) reported that 19.3% of 5,222 rescue workers who had requested medical assistance at the Manhattan Hospital emergency services in New York after 11 September 2001 were suffering from musculoskeletal problems. This was the most frequently reported health complaint among rescue workers, followed by respiratory problems (15.6%) and eye problems (12.8%) (Berríos-Torres et al, 2003).

4.5. Negative health outcomes for mental health

The psychological traumatisation of emergency and rescue workers has been gaining the attention of scientists for about 25 years (Brauchle et al., 2000). Some studies show that psychosomatic disorders are one of the main causes of sick-leave among fire-fighters (Bethge, 1999). The majority of rescue workers may experience stress that does not necessarily lead to diagnosable mental disorders, but instead to a variety of symptoms such as emotional reactions (shock, anger, guilt, helplessness, emotional numbness), cognitive reactions (disorientation, lack of concentration, memory loss, guilt), physical reactions (tension, fatigue, pain, racing heartbeat) and psychosocial reactions (avoidance of socialising, isolation, distrust, being distant) (Rhoads et al., 2008). Emergency workers involved in the rescue response to the Myyrmanni bomb detonation in Finland stated that they experienced several stress symptoms in the days following the incident, such as insomnia, over-anxiety, tension, feelings of inadequacy, edginess, and vivid, even disturbing, images of the victims. The rescue workers also reported changes in perceptions of security. According to Strömberg et al. (2005), the working ability of these emergency workers may have been transiently reduced. Another study shows that 15% of the rescue workers involved in operations after an air crash sought medical care for emotional problems during following 13 months, compared with 4% of the overall population of rescue workers seeking similar help, and excluding all those involved in this particular operation (Fullerton, Ursano & Leming Wang, 2004). Su et al. (2007) showed that depression and insomnia were greater among nurses who were involved in the SARS outbreak compared to colleagues not involved.

Having experienced other traumas in the past, having an existing psychological disorder, and other major life stressors, high self-expectations, lack of training, lack of belief in the operation, and seeing death or serious injuries for the first time are all factors that increase the probability that a rescue worker's stress reaction will be more severe. Social factors such as poor leadership, lack of solidarity or bonding within the group, low level of social support and lack of information on the situation, also raise the stress level in emergency workers (Maanpuolustuskorkeakoulu, 2007; Young et al., 1998). However, some researchers indicate that emergency workers may be often characterised as having high level of hardiness, a psychological trait that moderates the negative effect of traumatic events on mental health (Duckworth, 1986 cited by Alexander & Klein, 2001).

Normally, stress reactions should fade away within a month after the trauma. Emergency workers develop differing coping mechanisms in order to handle stressful events (Jonsson & Segesten, 2004). For example, by distancing themselves from the scene and acting as if the stressful event was 'unreal' emergency workers protect themselves from emerging negative feelings because identification with the victim can have a negative impact in the development of traumatic stress reactions (Jonsson & Segesten, 2004). However, where the symptoms last beyond one month after the stressful event, it is possible that the individual develops an acute stress reaction or a post-traumatic stress disorder or other serious mental health problem such as burnout, depression, anxiety (Koopman et al., 1995).

Rivard et al. (2002), examining the prevalence of acute traumatic dissociative responses in law enforcement officers involved in critical incidents, concluded that 90% of these officers experienced a dissociative response during the critical incident, 30% met the criterion of acute stress disorder, and 19% reported memory impairment for details of the incident (Rivard et al., 2002). Gallagher and McGilloway (2007), who studied the impact of critical incidents on ambulance personnel found that exposure to these kinds of incidents has a significant impact on the health and well-being of the workers. Study participants reported a wide range of mental health problems such as sleeping difficulties, outbursts of anger, irrationality and feelings of alienation. An Australian study that examined police officers who had been involved in traumatic or critical shooting incidents found that these events can cause acute stress reactions that are frequently overwhelming and may well overcome an individual's normal ability to cope. Stress symptoms can continue over a significant period of time and may include guilt, anxiety, depression, sleep disturbances, intrusive thoughts and excessive anger (Leonard & Alison, 1999).

Specialists indicate that emergency workers are at higher risk of developing post-traumatic stress disorder (PTSD) even if they are not exposed to major disasters. Jonsson, Segesten and Mattsson (2003) report between 3% and 25% prevalence rates of PTSD among rescue workers in Sweden. In the USA the national prevalence of PTSD for the general population was recorded at 4%, whereas for rescue workers it was 25% and for fire-fighters 21% (Perrin et al., 2007). Günthner and Strang (2004) estimate that the probability of PTSD is two to three times higher for career fire-fighters than for the general population. According to Fullerton et al. (2004) 11% to 32% of fire-fighters and volunteer mortuary workers have high levels of PTSD symptoms. Teegen (2001) found post-traumatic stress disorders in 32% of emergency medical staff surveyed and a further 32% suffering from sub-syndromatic post-traumatic stress disorders. The emergency medical staff which suffered from post-traumatic stress disorders were more likely than their unaffected colleagues to have personal experience of the sudden death of loved ones, severe accidents, and physical/sexual violence in their childhood. A study by Giosan et al. (2008) also showed that there was a correlation between the ability to recall personal experience of a perceived threat to life or of having seen human remains, and the incidence of PTSD symptoms among disaster restoration workers. According to a study by North et al. (2002) of fire-fighters after the Oklahoma City bombing, PTSD was associated with reduced job satisfaction as well as functional impairment. According to Perrin et al. (2007), the prevalence of PTSD was highest for those who had to perform tasks that were uncommon for their occupation, suggesting that workers who had the least disaster training or experience were at greatest risk of PSTD.

According to the CDC (2004a), the majority of emergency workers exposed to circumstances at the WTC site met the criteria for a clinical mental health evaluation during July to December of 2002. Symptoms of depression, panic, or generalised anxiety were reported by approximately 6% of participants. Also reported were emotionally related disabilities such as problems with social life (15%), work (14%), and home life (13%). Several studies on the WTC attack (2001) have concentrated on PTSDs (Bills at al., 2008; Fullerton et al., 2004; Giosan et al., 2008; Katz et al., 2006; Levin et al., 2002; Perrin et al., 2007). In addition to PTSD symptoms, there is evidence that the rescue and recovery workers, some of whom did not seek treatment until years after the attack, also experienced symptoms of survivor guilt, shame associated with intense feelings, substance abuse relapse, distressing memories, psychosis, problems in family relationships (Katz et al., 2006), flashbacks, and panic attacks so severe as to prevent many sufferers from working (Levin et al., 2002).

According to White (2001) and Adams et al. (2008), healthcare and social workers involved in the WTC recovery efforts were at risk of experiencing secondary traumatic stress. According to the CDC (2004a), approximately 20% of emergency workers exposed to the WTC site reported symptoms meeting the thresholds for PTSDs. Long et al. (2007), surveying the American Red Cross disaster workers involved in the response to the 9/11 attacks, concluded that 'workers directly exposed to disaster stimuli reported no more symptoms of distress than those who were not directly exposed'.

There is also a study carried out after the terrorist attack in Oklahoma City that showed relatively low level of posttraumatic stress and depressive symptoms among body handlers. However, PTSD symptoms were related to the occurrence of new physical problems, increased alcohol use, and seeking mental health treatment. The authors of the study suggest that problems with alcohol could correlate with the avoidance of difficult feelings characteristic to PTSD (Tucker et al, 2002).

In the high-speed train accident near Eschede, Germany, in 1998, in which 101 people died and 108 were injured (Bengel, 2001; Teegen, 2003), a total of 1,844 rescue workers (among them 461 ambulance personnel and paramedics) arrived at the scene in the hours after the crash (Oestern et al., 2000). The rescue operation lasted for several days and was hindered by difficulties in freeing the remaining victims from the wreckage because of pressure-resistant windows and the rigid aluminium frame of the cars (Bengel, 2001; NASA, 2007). After Eschede, one third of the emergency and rescue workers involved participated in a Critical Incident Stress Debriefing, and altogether 63% made use of professional care after the disaster. However, 6% of the emergency and rescue workers were suffering PTSDs eight months after the disaster. Earliest arrival at the scene was linked to the highest incidence of stress disorders (Bengel, 2001; Bengel et al., 2003).

Fullerton et al. (2004) who studied rescue workers exposed at plane crash stated that after one year following the event, 40,5% of exposed workers, compared to 20,4% of rescue workers from the comparison group (not exposed at such a disaster), had acute stress disorder, depression or PTSD. Younger and single workers had higher chance to develop acute stress disorder (2 months after disaster), and, as a result, also depression (after 7 month), and PTSD after one year.

Strömberg et al. (2005) reported that emergency workers who face criminal or terrorist attack often experience a continuing sense of powerlessness after being in a situation that they cannot influence. Paramedics interviewed by the regional rescue services of Keski-Uusimaa after the school shooting in Jokela, Finland, reported that in the earliest stages of the emergency response, while the situation was still unresolved, the environment at the scene was chaotic and the information received incoherent. Eventually when they entered the school and attempted to help the victims, there was nothing that could be done and no one left alive for them to help. They experienced feelings of frustration and helplessness being confronted by the corpses of so many young people who had died in such a violent way (Keski-Uudenmaan pelastuslaitos, 2007).

Escribà-Agüir, Martín-Baena and Pérez-Hoyos (2006) did a random survey on 639 doctors and nurses of the Spanish Society of Emergency Medicine. In the total sample (doctors and nurses) 28.9% suffered from emotional exhaustion, 56.2% from decreased personal accomplishment and 36.6% from depersonalisation. Paramedics are a high-risk group for burnout (in the professional quotidian as well as in disaster situations); prevalence rates are higher in paramedics than in the general population. 10% of paramedics are probably affected by burnout and a further 20% are jeopardised by burnout (Bengel, 2001). A French study on physicians showed that emergency doctors were more likely than other groups to report symptoms of burnout, particularly burnout associated with work-family conflict and low quality of teamwork. An intention to leave the profession was also more prevalent among emergency staff (Estryn-Behar et al., 2010).

In a study by Bennett et al. (2004), 617 ambulance drivers answered to a questionnaire on post-traumatic stress disorder, depression and anxiety. 10% of the respondents reported clinical levels of depression. After the earthquake in Taiwan on 21 September 1999, 1,104 emergency workers involved in the disaster were enrolled in a study conducted by Liao et al. (2002). Symptoms of depression were reported by 14% of respondents.

In a study, ambulance personnel identified the following incidents as the most disturbing: situations where children or people known to them are involved; situations involving severe injuries and death; situations in which ambulance staff experience helplessness; where support from colleagues is needed but lacking; and where information is incorrect or imprecise about the needs of the victim/s, details at the scene or the conditions under which the accident occurred (Alexander & Klein, 2001; Haslam & Mallon, 2003). According to Gallagher and McGilloway (2007), incidents that involve children, suicides, or grotesque mutilation are the most distressing for ambulance personnel. Furthermore, physical proximity to the incident is a major contributory factor to psychological effects on the emergency workers (Adams, Figley, & Boscarino, 2008; Shiri et al., 2008; White, 2001). The most stressful aspects of work mentioned by Dutch police officers were failing or poor management and emotionally demanding situations (Kop et al, 1999).

Also, long shifts, erratic work schedules, time pressures, and extreme fatigue constitute occupational hazards for emergency workers (Palm, Polusny & Follette, 2004; Young et al., 1998). For example, following the terrorist attack on WTC, all emergency workers worked long shifts and had little or no opportunity to escape from the site (Palm et al., 2004). Young et al. (1998) suggest that 'disaster workers have a deep commitment to working long hours without breaks, and may quickly dismiss suggestions about using time to relax'. Scottish police officers identified the most stressful aspects of their work as staff shortages, inadequate resources, time pressure, work overload, lack of communication, and lack of consultation (Biggam et al, 1997).

Naude and Rothmann (2003) in their study on occupational stress among emergency workers (medical practitioners and pathologists, fire-fighters, ambulance drivers, emergency staff, paramedics, support services) in South Africa stated that the main groups of stress factors for emergency workers are related to:

- poor or inadequate supervision/management, lack of participation in policy-making decisions, inadequate support by supervisors/management, lack of recognition, inadequate salary, lack of specialised personnel,
- frequent changes from boring to demanding activities, critical on-the-spot decisions, experiencing new/unfamiliar emergency situations, performing duties in dangerous situations,
- negative attitudes of other health care personnel towards emergency services, unnecessary call-out and public abuse, constant scrutiny by traumatised relatives and the public at emergency scenes (Naude and Rothmann, 2003).

Lack of preparedness is indicated as one of the factors contributing to excessive stress experienced by emergency workers. Gabriel et al. (2007) studied people with different levels of exposure to the terrorist attacks of 11 March 2004 in Madrid, concluding that while the attacks had substantial psychological consequences, police officers had an unexpectedly low prevalence of depressive and anxiety disorders. The most likely explanation for this, according to the researchers, is that the police officers interviewed had extensive experience and training in how to handle terrorist attacks. The study's findings therefore suggest that highly trained emergency workers may have a lower prevalence of psychopathology following disasters than other emergency workers (Gabriel et al, 2007). Wallace and Brightmire (1999) and Perrin et al. (2007) suggest that preparedness and experience reduces the stress faced by emergency workers in disaster situations.

4.6. Negative health outcomes of radioactive exposure

Many studies related to nuclear exposure of emergency workers have been carried out in relation to Chernobyl accident (1986). Bennett et al. (2006) report that acute radiation syndrome (ARS) had been originally diagnosed in 237 emergency workers involved in this disaster. Among these emergency workers, 28 died from ARS in 1986, and further 19 fatalities occurred between 1987 and 2004. Studies also investigated the health effects on Chernobyl emergency workers exposed to lower doses of radiation than those causing ARS (Bennett et al., 2006). An important cohort mortality study examined 65,905 Russian male emergency workers who were exposed to 'documented' low external radiation doses (Ivanov et al., 2001). During the study period (1991 to 1998), 4,995 of the people examined died due to (1) malignant neoplasms, (2) cardiovascular diseases, (3) injuries, poisoning and violent deaths and (4) 'other reasons' (Ivanov et al., 2001).

Rahu et al. (2006) found statistically significant increases in thyroid and brain cancer in Latvian male clean-up workers who were deployed in the aftermath of the Chernobyl accident. However, neither for thyroid nor for brain cancer could a dose-response relationship be proved. A statistically significant increase for thyroid cancer was also revealed in a study reported by Ivanov et al. (2008) for Russian emergency workers. The period under study was 1986–2003 and covered 187,451 emergency workers exposed to radiation in the Chernobyl accident.

Bennett et al. (2006) concluded from other sources that the total mortality rate did not significantly differ between the Russian emergency workers employed during the period 1986–1987 and the general Russian population. This might be due to the fact that many cancers (except leukemia and thyroid cancer) have latent periods of at least 10 years. More recent observations suggest an increase in mortality and morbidity among Russian emergency workers due to solid cancers, circulatory system diseases and leukemia (Bennett et al., 2006).

Many researchers refer to uncertainties regarding radiation impact studies on emergency workers, which should be taken into consideration when conducting predictions for future mortality (Bennett et al., 2006). There are studies reporting that the 'latent period for induction' of solid cancers due to radiation exposure is less than 10 years. Ivanov et al. (2009) investigated the latent time for induction of solid cancer in emergency workers that were present in a 30km zone around the Chernobyl nuclear plant in 1986 and 1987. The authors revealed that the latent time for induction of solid tumors is 4 years. The inference that the latent period for induction of radiogenic cancers could be less than 10 years is also reported in UNSCEAR (2008). In a study researching temporal chromosomal aberrations, Slozina, Neronova and Nikiforov (2001) studied 243 clean-up workers deployed in Chernobyl in 1986. After a six-year follow-up, it was determined that the frequency of dicentrics and rings did not decline. This means that unstable chromosomal aberrations occur even six years after exposure to low dose ionising radiation.

The possibility of clean-up workers exposed to ionising radiation at Chernobyl developing leukaemia (Petridou et al, 1996; Ivanov et al., 1998), posterior sub capsular cataracts, cardiovascular disease, and mental health problems (Bennett et al., 2006) have also been discussed in the literature. The exposure of firemen to radionuclides resuspension as a result of forest fires in the contaminated area was investigated by Kashparov et al. (2000). That study revealed an increase in firemen's external exposure doses during forest fires in the 30km zone around Chernobyl. The negative effects of the Chernobyl accident among emergency workers have also been discussed in studies carried out by Bennett et al. (2006); Ivanov et al. (2001, 2008, 2009); Kashparov et al. (2000); Rahu et al. (2006); and Tkachenko, Kaplan, & Zamulaeva (2008).

A recent study (Milham, 2009) suggests that radio frequency radiation exposure may be a cause of cancer in fire-fighters more often than inhaled carcinogens. The author calls attention to the observation that the list of cancers in fire-fighters overlaps the corresponding list in workers exposed to electromagnetic fields (EMF) and radiofrequency radiation (RFR). Fire-fighters are exposed to RFR from the mobile two-way radio communication devices they use. The effects of electromagnetic fields on human health, however, are still open to question.

4.7. Negative health outcomes related to chemical risks

Many scientific studies have assessed the effects of exposure to and contamination from hazardous materials and dangerous combustion products. Bearing in mind that there are inconsistencies among different studies about the uncertainties surrounding the available information about exposure, the main health impacts on **fire-fighters** related to chemicals are considered to be:

- acute effects such as asphyxiation and chemical pneumonia which may result in serious health consequences, including death, due to the exposure to dangerous substances; these include carbon monoxide, ammonia, phosgene, sulfur dioxide (Stefanidou, Athanaseli, & Spiliopoulou, 2008);
- eye irritation, headache, dizziness and nausea (Reisen & Brown, 2009; Miedinger et al., 2007);
- respiratory disorders such as respiratory irritation, coughing, shortness of breath, asthma, emphysema, persistent cough and bronchial hyper-responsiveness, chronic lung dysfunction (Zeitz et al., 2000, Reisen & Brown, 2009; Tepper, Comstock, & Levine, 1991; Musk et al., 1979; Sheppard et al., 1986; Large, Owens, & Hoffman, 1990; Leonard et al., 2007; Betchley et al., 1997; Landrigan et al., 2004; Miedinger et al., 2007; Gu et al., 1996) and non-malignant respiratory diseases leading to deaths (Rosénstock et al., 1990);
- asbestosis (Bridgman, 2000; Claudio, 2001);
- skin disorders, such as injuries due to skin contact with corrosive substances like acids (IAFC, 2009), chloracne and other symptoms in case of exposure to substances such as

polychlorinated biphenyls, polychlorinated dibenzofurans and dibenzodioxins including 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (NIOSH, 1986);

- reproductive disorders due to exposure to materials hazardous to human reproductive systems (Stefanidou et al., 2008; McDiarmid et al.,1991);
- changes in biochemical and blood parameters (Al-Malki, Rezq, & Saedy, 2008)
- benign neoplasm (Baris et al., 2001)

Fire-fighters may be exposed to dangerous substances which may include carcinogens (benzene, benzo[a]pyrene, 1,3-butadiene, formaldehyde, etc.). Many studies have investigated whether fire-fighters are at increased cancer risk. These studies suggest that there might be a risk of:

- brain cancer (Guidotti, 2007; Bates, 2007; Demers, Heyer & Rosenstock, 1992)
- kidney cancer (Guidotti, 2007; Youakim, 2006; Baris et al., 2001)
- testicular cancer (Ma et al., 2006;Bates, 2007; LeMasters et al., 2006)
- lung cancer (among non-smokers, according to Guidotti, 2007; in instances of the release of biopersistent fibers, according to Bridgman, 2000 and Claudio, 2001)
- bladder cancer (Ma et al., 2006; Guidotti, 2007; Youakim, 2006; Sama et al., 1990; Deschamps, Momas & Festy, 1995)
- leukaemia (Bates, 2007; Feuer &Rosenman, 2007; Demers et al., 1992)
- prostate cancer (Bates, 2007; LeMasters et al., 2006)
- non-Hodgkin's lymphoma (LeMasters et al., 2006; Sama et al., 1990; Baris et al., 2001)
- Hodgkin disease (for female fire-fighters according to Ma et al., 2006)
- multiple myeloma (LeMasters et al. 2006; Baris et al., 2001)
- malignant melanoma (Bates, 2007; Sama et al., 1990; Howe & Burch, 1990 cited by Nelemans, Verbeek & Rampen, 1992)
- thyroid cancer (Ma et al., 2006; Bates, 2007)
- cervical cancer (Ma et al., 2006)
- male breast cancer (Fentiman, Fourquet & Hortobagyi, 2006)
- oesophageal cancer (Bates, 2007)
- colon cancer (Kang et al., 2008; Youakim, 2006; Baris et al., 2001)

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A French study on a sample of 830 fire-fighters showed that, while compared to average French male, fire-fighters had a lower overall mortality, however, a greater number of deaths caused by genitor-urinary cancer, digestive cancer, respiratory cancer, and cerebrovascular cancer (Deschamps et al., 1995). It must be noted that studies may report contradictary results. For example, a recent study (Bates, 2007) suggested that there was little evidence for bladder cancer, non-Hodgkin's lymphoma, multiple myeloma, colorectal or lung cancers. The differences among studies may be related to the different study groups and uncertainties surrounding the available information. Straif et al. (2007) note that 'for intermittent, but intense, exposures to highly variable complex mixtures, conventional measures, such as years of employment or number of fire fighting runs, can be poor surrogates for exposure. The available epidemiological studies are inherently limited by this issue'. In addition, they note that, in an updated meta-analysis study, the average increase was consistently significant for testicular, prostate cancer and non- Hodgkin lymphoma (Straif et al., 2007). According to Austin (2008), '…exposure patterns to intermittently high levels of smoke of variable composition are difficult to quantify in studies of cancer in fire-fighters. This limits the ability of traditionally designed studies, such as those that have been conducted so far, to properly identify cancer rates in fire-fighters.

The exposure to chemicals within the police force varies with the role demanded of them, but can include the handling of CS (*o*-chlorobenzylidene malononitrile) incapacitant sprays, lead (armed personnel), fingerprint powder, solvents and radioactive isotopes (forensic personnel) (Rappert, 2003; Trottier & Brown, 1994). A study suggests that the use of pepper sprays may lead to corneal erosions (Holopainen et al., 2003). A study of the Canadian Police research Centre showed an increased prevalence of respiratory illness due to exposure to occupational hazards in police forces (Papple, 1993).

Sister chromatid exchanges, (SCEs) – the exchange of genetic material between two identical copies of a chromosome) were reported after the Tokyo subway sarin disaster. Three years after the incident, it was found that the frequency of SCEs was still significantly higher in fire-fighters and police officers compared to the control groups (Li et al., 2004). Nishiwaki et al. (2001) report a chronic decline of memory function in emergency workers who responded to this disaster.

As has been mentioned, the chemical risks for healthcare workers arise from secondary exposure. Okumura et al. (2005a), examining the Tokyo subway sarin disaster noted that '…approximately 23% of hospital staff experienced secondary exposure' because they did not have personal protective equipments when the victims arrived at the hospitals. The development of illness due to secondary exposure in health care workers was also noted by Koenig et al. (2008) in the which the authors observed that 'in 2005, an industrial chemical spill in Indiana resulted in symptomatic exposures to hospital staff as a consequence of vapours trapped in victims' clothing' (Koenig et al., 2008).

An extreme case of exposure to dust and smoke was encountered after the collapse of the WTC. Rescue and recovery workers (including fire-fighters and policemen) were exposed for several months to dust and hazardous toxic pollutants including asbestos, lead, mercury, polychlorinated biphenyls and dioxin (Landrigan et al., 2004, Herbert et al., 2006; ILO, 2003; Kokayi, 2006) as well as to perfluorochemicals (Tao et al., 2008). Many rescue and recovery workers, despite being in direct contact with dust and debris, carried out their duties without appropriate respiratory protective equipment or gloves (ILO, 2003; Feldman et al., 2004).

In the literature, several epidemiological studies refer primarily to respiratory disorders experienced by emergency workers involved in the response to the WTC attack in 2001 (Dahlgren et al., 2007; Pak, O'Hara & McCauley, 2008; Salzman et al., 2004; Skloot et al., 2004). A Mount Sinai hospital study concluded that nearly 70 percent of Ground Zero workers experienced pulmonary problems. The study predicted that many of these workers would probably have symptoms for the rest of their lives (ETUI, 2009). In the study prepared by CDC (2004), WTC-related lower respiratory symptoms were reported by 60% of respondents, and upper respiratory symptoms by 74%. Respiratory symptoms resulting from exposure to the WTC site include the 'World Trade Centre cough', i.e. a persistent cough that developed after the exposure and was accompanied by respiratory symptoms that were severe enough to require medical leave for at least four weeks (Buyantseva et al., 2007; CDC, 2002; Landrigan et al., 2004; Prezant et al.,2002; Salzman et al., 2004; Skloot et al. 2004), vocal cord dysfunction (De la Hoz et al., 2008a), sarcoidosis or 'sarcoid-like' granulomatous pulmonary disease (Izbicki et al., 2007), asthma (Wheeler et al., 2007), and pulmonary symptoms (Banauch et al., 2003; Banauch, 2006; Banauch et al., 2006a). It was also noted that respiratory symptoms increased over time (Buyantseva et al., 2007), which indicates that the persistence of the symptoms should be investigated in the long term in order to monitor their effects, including possible malignancies (Herbert et al., 2006). Other incident-related persistent symptoms reported by WTC emergency workers included heartburn, eye irritation, and frequent headache (Berríos-Torres et al., 2003; CDC, 2004; Feldman et al., 2004).

The Institute for Southern Studies (2010) reports that clean up workers deployed in the Deepwater Horizon oil spill have suffered from symptoms similar to those of a disease known as Toxicant-Induced Loss of Tolerance (TILT). The clinical pattern of TILT includes flu-like symptoms such as headache, fatigue and an upset stomach, memory and concentration problems, and a loss of the ability to tolerate exposure to household chemical products, medication and even some foods. TILT has been defined as a chronic and recurrent disease by the National Institute of Environmental Health Science (cited by the Institute for Southern Studies, 2010).

4.8. Negative health outcomes related to biological risks

Rischitelli et al. (2001) conducted a systematic review in order to assess whether personnel in emergency medical services face a higher risk of acquiring hepatitis B or C through occupational exposure. Transmission of hepatitis B or C is mostly a result of exposure to blood or body fluids as a consequence of needle stick injuries. They estimate that in the US each year, between 600,000 and 800,000 such injuries occur among approximately 8 million healthcare workers. The authors revealed an elevated risk in comparison to the general population for hepatitis B infection, but not for hepatitis C infection. This was also true of emergency workers in general (Dailey and Dunn (2000).

Sarrazin et al. (2005) report on transmission rates of 30% for hepatitis B and of 3% for hepatitis C caused by needle-stick injuries with needles used to treat sufferers. According to Dailey and Dunn (2000), for every 1,000 needle-stick injuries with needles previously used for HIV-positive people, three people will become HIV-positive. The quota is thus 0.3%. In line with this, Sulsky et al. (2006) also conclude in their meta-analysis an estimated transmission rate of HIV to health-care workers of less than 0.5%.

Bohnen et al. (2010) indicate that factors that contribute to the risk of needle-stick injuries include shortcomings in ambulances, inefficient disposal of used injection materials, inadequate disposal boxes, an insufficient number of disposal boxes or overfilled disposal boxes at hospitals or emergency/disaster sites.

4.9. Early retirement

Ambulance personnel and emergency medical service workers retire early more often than other professionals (Sterud, 2008, zur Mühlen et al., 2005). The main reasons for early retirement given in one study included psychosomatic complaints, musculoskeletal disorders, infectious diseases, and skin diseases (Schönberger, 2006).

Many studies also indicate shorter life expectancy for emergency workers. Life expectancy is around ten years shorter for fire-fighters than for the general population in Germany (Heilingbrunner, 1990 cited by Ungerer et al., 1993). This estimate is confirmed by Weissgerber (2002) and by Bethge (1999), who both report a life expectancy shorter by eight years than the average among German fire-fighters. Bethge (1999) also states that fire-fighters have a significantly higher chance of dying immediately upon retirement than other professional groups. However, Wagner et al. (2006) found that in Hamburg, Germany, the life expectancy of fire-fighters was two years longer than that of the national male working population, at 75.3 years, which can be explained by the ‘healthy worker effect’, rigorous selection criteria with regard to the physical fitness of fire-fighters and the regular medical examination of fire-fighters. In Finland, the life expectancy of fire-fighters in 1995 to 2000 was 76.2 years. Among fire chiefs it was three years shorter. Police officers' life expectancy was 77.9 years (Statistics Finland, 2008). Those figures show almost the same life expectancy in fire-fighters and increased life expectancy in police officers compared to the general Finnish male working population, for which the life expectancy was 76.4 years in the same period.

5. Preventive measures

This chapter presents some general and more specific preventive measures that can be employed to prevent mental or physical harm caused by the OSH hazards that emergency workers may be exposed to while carrying out their professional activities. In Europe, the Framework Directive 98/391/EEC regulates the health and safety obligations of employers. However, because of the nature of their work, special emergency services such as police, the armed forces and fire brigades are exempted from those rules. Nevertheless, safety and health of the emergency workers must, and can, be protected, and primary and secondary prevention measures should be used wherever possible.

5.1. International communication and coordination

Responding to major disasters requires coordination, with good communications and exchange of information among different authorities and different occupational groups, and developing a multichannel communication system for disaster management is essential. The use of identical communication channels among all stakeholders actively involved in disaster control ensures that all stakeholders receive the same information. The European research project CHORIST aims to increase 'the rapidity and effectiveness of interventions following natural or industrial disasters' and it has 'integrated several channels to warn the population in parallel through several means like radio, TV, cell broadcast, sirens' (European Commission, 2010a). Moreover, broadcast stations should be constructed so that they are resistant to major disasters, and multiplicative systems should be established so that if a broadcast station is damaged another one will be able to send out the same information. Besides more traditional techniques, a cost-effective satellite-based communication system should also be used. A common working language must be established by countries involved in common activities, and common way of interpreting monitored data must be established. Common training and joint drills between different organisations and different groups of emergency workers, possibly from different countries, would further increase safety in crisis or emergency situations.

In preparation for emergency interventions, action plans have to be drawn up at Member State and European levels. In 2007, the Council of the European Union established a Community Civil Protection Mechanism. The aim of this mechanism is 'to facilitate reinforced cooperation between the Community and the Member States in civil protection assistance intervention in the event of major emergencies or the imminent threat thereof' (Council of the European Union, 2007). The mechanism comprises a variety of actions. A key action is the establishment of a 'Monitoring and Information Centre (MIC)'[3]. The centre is run by the European Commission and the contact points in the EU countries, functioning as a communication and information centre, and operating 24 hours a day (Council of the European Union, 2007). In the event of major emergencies and disasters, the Member States can contact the MIC and receive information on possible civil protection assistance from other Member States. The centre aims to provide an overview of the available emergency and civil protection services in the EU countries. Training programmes for the EU's assistance and intervention teams are drawn up to improve the effectiveness of their cooperation (Council of the European Union, 2007).

5.2. Emergency policies

In 1982 EU Directive 82/501/EEC, known as the Seveso Directive, which applies to industrial establishments at which dangerous substances are present in quantities exceeding specific thresholds, was adopted. It was later replaced by Council Directive 96/82/EC, and extended by Directive 2003/105/EC. According to this directive, 'a major accident shall mean an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive, and leading to serious danger to human health and/or the environment, immediate or delayed, inside or outside the establishment, and

[3] http://ec.europa.eu/echo/civil_protection/civil/prote/mic.htm

involving one or more dangerous substances' (European Commission, 2003). The application of the Seveso Directive is mandatory in the European Union to prevent and limit the consequences of major industrial accidents involving hazardous materials in fixed installations (Wettig, Porter & Kirchsteiger, 1999; Wood, 2009; Pey et al., 2009). The requirements of the Directive include risk assessment of hazards for the identification of appropriate protective measures, the implementation of a major accident prevention policy, establishing safety management systems, plans for public information, land-use planning, emergency planning (on-site, off-site), and notification of accidents to public authorities. The OSH of emergency workers is not addressed in this document as a separate subject, although numerous references are in place regarding application of the directive in the Member States, together with general codes of practice for emergency response procedures regarding accidents in hazardous materials installations (Mitchison & Papadakis, 1999; HSE, 1999, 1999a; Bierlein, 1988).

The EU Council Directive 2010/32/EU of 10 May 2010 also implements the Framework Agreement on prevention of sharps injuries in the hospital and health care sector concluded by HOSPEEM and EPSU. One aim of this Framework Agreement is 'to prevent workers' injuries caused by all medical sharps (including needle-sticks)' (EUR-LEX, 2010a).

In the UK, the Health and Safety at Work etc Act 1974 (HSWA) applies to all activities of Fire and Rescue Authorities as the employers of Fire and Rescue Service staff. In 2010 the UK Health and Safety Executive (HSE) published a special statement and guidance to clarify how the Fire and Rescue Service should comply with health and safety at work requirements during their operational work. The document aims to help balance the risks emergency workers inevitably encounter in the course of their work while meeting OSH standards [25].

Regulations for prevention of and response to accidents in installations involving hazardous materials also apply in other, non-European countries. For example, the OSHA 29 CFR Part 1910.119 'Process safety management of highly hazardous chemicals' is the corresponding regulation in the USA. Important issues regarding the regulations in the USA can be found in the literature (Walter, 1998; Musselman, 1989). Corresponding regulations, codes of practice and general protective measures are also described in the literature regarding nuclear safety (IAEA, 1997, 2002, 2002a; Malcolm, 1996; Pauwels, Hardeman & Soudan, 1999). Coal mine disasters in 2006 in the US led to the Supplemental MINER Act, new legislation to improve the safety and health of miners and the quality of emergency responses. For instance, breathing apparatus containing enough oxygen for two hours per miner must be available every 30 minutes on the escape-way, which must also have directional lifelines, a rope to help miners head in the right direction towards an exit. Mines must also be equipped with bidirectional communication and tracking systems so that surface rescuers can communicate with underground miners (CDC, 2006).

Adequate safety policies and legislation are also essential for responses to traffic accidents. These policies include issues such as preplanning of traffic control strategies, and the development of a multidisciplinary training programme in order to make emergency workers aware of the mutual agreements between different agencies (fire-fighters, police, etc.) and different jurisdictions in the event of transport accidents. Laird (2003) also mentions multidisciplinary communication and coordination as an element that must be included in policies. An example here can be the 'slow down and move over' laws developed in the US, in order to oblige people to move over when passing an accident scene or an emergency worker's vehicle at the side of the road (Wisconsin Department of Transportation, 2007).

5.3. Organisational measures: Safety and health management

Jackson et al. (2004) suggest that the protection of emergency responders should follow a safety management cycle, and those responsible for safeguarding emergency workers must always weigh up whether deploying emergency workers is sufficiently beneficial by taking into account the emergency worker's OSH risks. The risk management process is divided into three steps:

1. Information gathering: information on potential hazards to emergency workers generated by the disaster, the number and specific capabilities of emergency workers available for disaster control, and information on actual injuries and exposures to hazards of emergency workers at the disaster scene.

2. Analysing alternative options for action and decision making: in this next step, in which alternatives for action are weighed against each other, the point at which disaster control shifts from a rescue to a recovery operation must be planned in advance. Additionally, personal protective equipment needed for the different groups of emergency workers must be determined, and the forms of additional safety resources which may be needed by them during disaster control must be anticipated.
3. Action taking: when action is finally taken, safety and risk-related communication must reach all organisations involved in the response operations equally, and safety measures must be implemented. Effective strategies are therefore needed. These comprise, for instance, the provision of emergency workers with appropriate PPE, and medical care for their physical and mental health. With regard to provision with appropriate PPE, logistics solutions must be established.

Sehrig and Geier (2004) emphasise that to coordinate activities of emergency workers efficiently, authoritarian leadership is the most appropriate style because it functions well in situations requiring unambiguous and rapid instructions. However, during standby outside actual call-out, cooperative leadership works better because it is more likely to increase the motivation of emergency workers. In order to guarantee efficient working in disaster situations, emergency workers need to be prepared for them.

The available equipment, available technical and personnel resources, distribution of the tasks, roles of the emergency organisations/teams/workers, and management tasks must therefore be identified and assigned to organisations/teams/persons before disaster strikes, in order to make disaster control as efficient as possible. Strategic planning and implementation of standardised systems and procedures that have been tested beforehand enhance the probability of successful disaster control (Jackson et al., 2004).

Laird (2003) emphasises the importance of limiting the numbers of personnel at the scene to the minimum necessary, and releasing personnel no longer needed at the scene as soon as possible. This limits the exposure of emergency workers to hazards at the accident scene. A method for minimising the exposure of emergency workers and the public to hazards is the creation of 'protective-action zones' as a function of the distance from the accident's source and the intensity of the phenomena resulting from the accident (Kiranoudis et al., 2002; Sorensen, Shumpert & Vogt, 2004; O'Mahony et al., 2008; OECD, 2003; Markatos, Christolis & Argyropoulos, 2009; Birk, 1996; Planas et al., 2008). Emergency responders approach the site of the accident by following instructions about how to operate in a specific zone. The principle of dividing an accident scene into different zones as a function of the distance from the accident's source can not only be used in industrial accidents, but also adapted to other kinds of accidents. For instance, Willis et al. (2006) have adapted this principle to structural collapse events.

Organisational measures should also embrace good work organisation. Whenever possible job/tasks rotation should be considered to reduce exposure to risks and overstrain. Another example of preventive measures mentioned in the literature is a comprehensive slips, trips and falls (STF) prevention programme for hospital employees, including EMS workers, which may efficiently reduce the number of STF accidents (Bell et al., 2008).

The report on the Columbine school shooting incident stresses that different response organisations should also be prepared for the intense media attention surrounding such incidents. The report recommended that each major response agency should have a designated public information officer (State of Colorado Columbine Review Commission, 2001).

5.3.1. Risk assessment

Risk assessments should follow general principles and cover all possible risks emergency workers may encounter. Risk assessment at a disaster scene must for instance include whether domino effects are possible; for instance, whether the present event may cause further damage and danger, whether a fire may lead to further explosions, or if collapsed structures present a risk of short circuits, electrocution and fire. All past accidents and near-accidents should be taken into consideration while looking for possible risks. Developed on this basis, pre-planning should anticipate the likely response requirements and establish all necessary preventive measures (Department of Homeland Security, 1999; Wallace & Brightmire, 1999). An example of protective measures that can be taken against radioactive exposure is presented in Table 3.

A balance between OSH risks for emergency workers and possible benefits of emergency actions must be achieved. A UK HSE statement based on the Health and Safety at Work act (UK, 1974) says that 'employers (have) to ensure the health, safety and welfare at work of their employees and that their operations do not adversely affect the health and safety of other people. These health and safety duties are not absolute and each is qualified by the test of what is reasonably practicable'. Not all OSH risks can be eliminated, and HSE recognises that 'even when all reasonably practicable precautions have been taken to deal with foreseeable risks, harm could still occur'. Duties are also placed on employees to 'take reasonable care of themselves and others and to co-operate with their employer…employees should act sensibly and responsibly within the command and control of their employer; they should not act recklessly' [25].

Tabel 3: Example of possible protective measures against radioactive exposure (source: IAEA, 2006)

Protective measures against radioactive exposure	
1	Identification of the contaminated area and establishment of: ▪ a safety perimeter ('inner cordoned area'), which corresponds to an area where protective measures should be applied in order to protect emergency workers and the public from potential external exposure and contamination. ▪ a security perimeter ('outer cordoned area'), which is considered as being secure.
2	Protecting emergency workers against effects of nuclear radiation by reducing the exposure time and increasing the distance from the hazardous source, by: ▪ deployment of robots, avoid touching suspected radioactive materials, use of appropriate respiratory protective equipment and appropriate protective gloves and other equipment, avoid touching mouth with hands, or smoking, drinking or eating, changing clothes and showering as soon as possible at the end of the intervention.
3	The recording, assessment and final control of the radiation dose received by emergency workers, carried out according to international standards. ▪ emergency workers should wear personal dosimeters, i.e. devices for measuring radiation dose received which include alarm systems that alert the wearer when the dose received exceeds the relevant limits. ▪ pregnant female emergency workers must be excluded from such emergency duties. ▪ for the protection of emergency workers, it is also recommended that '…all reasonable efforts shall be made to keep doses to workers below twice the maximum single year dose limit, except for life-saving actions, in which every effort shall be made to keep doses below ten times the maximum single year dose limit in order to avoid deterministic effects on health. In addition, workers undertaking actions in which their doses may approach or exceed ten times the maximum single year dose limit shall do so only when the benefits to others clearly outweigh their own risk'.

5.3.2. Training

Emergency workers have to be provided with knowledge of all the types of OSH risks they may encounter during their professional activities, the consequences of those risks and possible preventive measures. They should know how the human body reacts to the different physical, chemical, biological or psychological risks, which it may not be possible to avoid in the course of their duties, and how to be able to employ possible protective measures as soon as possible. The training should cover physiological symptoms of being exposed to hazardous substances, appropriate decontamination procedures, proper manual handling, specificity of functioning while under great pressure and stress, proper selection, use, care, and maintenance of personal protective equipment.

It has been also recommended that emergency workers of any profession should be trained and prepared for different types of events (Oikeusministeriö, 2009), including terrorist attacks (OSHA, 2003). Developing and giving training in standard operating procedures (SOPs) related to different scenarios is being recommended in the literature as good practice (Deverell et al., 2007; NTIMC, 2006). Development of common training procedures and joint drills for emergency workers from different professional groups is also recommended (Strömberg et al., 2005; Jackson et al., 2004; Vernon, 2007; Wallace and Brightmire, 1999). Special training equipment such as simulation tools may help in decision-making process learning, particularly in multi-risk events (Corvinno Technology Transfer Center, no date).

Training might be essential to help emergency workers better cope with violence at work. EMS workers, paramedics and fire-fighters have a higher risk of experiencing violence in the course of their duties than workers in general. Fatal or serious injury of a rescue worker affects their colleagues, seriously imparing their response at the emergency scene. There is some evidence that abusive behaviour can also take place within emergency service teams, as in any other workplace setting, such as psychological harassment (Höök & Huttunen, 2007). Personnel should be trained in how to deal with such a situation.

Appropriate training procedures should be developed and strictly followed to prevent accidents and injuries which, as statistics show, tend to happen with significant frequency during training activities.

5.3.3. Vaccination

Vaccination is an effective prevention measure and should be provided where workers might be at risks of hepatitis B, water-borne diseases (cholera, typhoid fever, rotavirus), or exposed to other biological agents that may be used in bioterrorism such as botulism, tularaemia and smallpox.

5.3.4. Personal Protective Equipment

The use of specific personal protective equipment (PPE) according to the given risks is of great importance in preventing adverse health effects among emergency workers. PPE must be selected according to the type of disaster that has occurred, the hazards at the scene, and the typical duties assigned to a specific group of emergency workers. For instance, fire-fighters must normally be protected against thermal risks by personal protective clothing, footwear, helmets, etc. In the event of potentially harmful exposure (exposure to chemicals, fire by-products, or nuclear radiation), appropriate respiratory protective equipment must be provided, including protective gloves, suits, shoes, caps, and eye protection. The need for protection against substances or combinations of substances that present multiple hazards (for instance, both flammable and toxic) is also discussed in the literature. The PPE with which special groups of emergency workers are equipped in order to perform their day-to-day duties is often not suitable or sufficient for major disasters. The person responsible for disaster control or for the emergency workers' group in question must therefore take responsibility for selecting additional or alternative PPE. Fit, adjustment, combination with other PPE, specific properties and performance must all be considered. For hazard assessment and monitoring at a disaster scene, risks can often be evaluated only by sight, since more complex and detailed monitoring is not possible. The correct PPE must not only be selected; it must be available at the scene and workers must be familiar with it to be able to use it properly (Willis et al., 2006).

The European Committee for Standardization (CEN) has published a technical report on the 'Selection, use, care and maintenance of protective clothing' (CEN, 2006a) and another technical report on 'Guidelines for selection, use, care and maintenance of protective clothing against heat and flame' (CEN, 2003b). In the field of respiratory protection, EN 529 is a European standard that provides recommendations for selection, use, care and maintenance of respiratory protective devices (CEN, 2005). The harmonised standards define safety requirements for personal protective equipment that must be met during testing as a precondition for their approval within the European market according to the PPE Directive (89/686/EC). Selected examples of product-related European standards are:

- EN 340 (CEN, 2003) includes general requirements for protective clothing.
- EN 374-1 (CEN, 2003a) sets out specific performance requirements for protective gloves against chemicals and micro-organisms, including the terminology.
- EN 471+A1 (CEN, 2007) refers to test methods and requirements for high visibility warning clothing for professional use.
- EN 1486 (CEN; 2007a) refers to personal protective clothing for fire-fighters and includes test methods and requirements for reflective clothing for specialised fire fighting.
- EN 659+A1 (CEN, 2008) refers to protective gloves for fire-fighters.
- EN 15090 (CEN, 2006) refers to footwear for fire-fighters.

Examples of PPE which can offer protection from chemical agents include different types of masks:

- self-contained breathing apparatus (SCBA)
- full-facepiece air-purifying respirators (APR)
- powered air-purifying respirators (PAPR)

A study by LaTourrette et al. (2003) points out that in response to terrorist attacks, in particular, the issue of providing protection for emergency workers is not without complications and uncertainties. Uncertainty makes it difficult to design protection programmes and acquire the necessary technology. Emergency workers may remain uncertain about how well the available personal protective equipment will work in anticipated situations. While protection against hazardous materials is predominantly covered by standards and certification procedures, the protocols are designed for response to industrial accidents. Consequently, much of the available equipment is neither designed nor approved for terrorism response and workers do not know what kind of protection should be used when facing a terrorist attack (LaTourrette et al., 2003).

In case of terrorist attacks and gun rampages where emergency workers might be soft targets, they might at least be partly protected by bullet-proof and knife-proof vests, safety shoes, helmets and protective clothing. It is important that special personnel such as the military and police are able to defend themselves, to minimise threats at the scene of an accident to make it safe for paramedics. However, sometimes victims can be violent and armed, increasing the risk of physical harm. The possible use of bullet-proof and knife-proof vests, safety shoes, helmets and protective clothing for rescue workers should therefore also be considered in critical cases and could at least be routinely available in ambulances.

Standard safety equipment should include high-visibility reflective material (apparatus, such as cones and signs, and personal protection clothing, such as vests and helmets), and additional warning signs and lights. This is of particular importance for the safety of emergency and rescue workers in transport accidents, or at disaster and emergency scenes where heavy machines such as cranes and excavators are deployed and visibility is reduced. Moreover, personal location monitoring systems and monitoring systems for physiological measures, chemical detection equipment, gas detectors, radiation alarm systems, fire systems, and the use of safe vehicles may be advantageous.

Appropriate protective clothing has to be provided (skin and body protection from physical risks and dangerous substances). Some examples may be the use of mosquito nets that are treated with insecticides and the use of indoor insect spray, and also appropriate clothing with long sleeves when the disaster scene demands such protection (WHO, 2009b; CDC, 2007a). The use of body bags, and the possibility of washing and decontaminating hands frequently can also help to minimise the risk of infection (Morgan, 2004; Ligon, 2006).

It has to be remembered that infected people should also be provided with special equipment (such as surgical masks) to protect others (Deitchman, 2002). In some situations, however, it has to be necessary to isolate infected individuals, whether victims or emergency workers, in order to prevent the spread of infection (Deitchman, 2002; CDC, 2009a).

In order to protect emergency workers from any infection and to allow clean and antiseptic working, it is important that personal protective equipment such as gloves be used and changed regularly. It has to be noted, however, that even the use of protective equipment may sometimes lead to adverse health effects. For instance, emergency medical staff, police and health care workers in general are particularly at risk of latex allergies due to frequent use of protective latex gloves (Bousquet, Flahault & Vandenplas, 2006; Medical Devices Agency, 1996). In addition, according to Georgopoulos et al. (2004), 'the self-contained breathing apparatus (SCBA) required for levels A and B adds 35–45 lbs to the back, creating physical instability and constraints due to weight and the added cardiovascular load. In warmer climates, heat illness also becomes a very serious concern'. To minimise risks for emergency workers, ergonomically designed equipment should be employed whenever possible.

Protective and safety equipment needs to be used and maintained appropriately, including its cleaning and de-contamination. Within a Swedish collaborative project called Healthy Fire-fighters (European Good Practice Awards, 2010-2011) special procedures to deal with contaminated equipment have been developed. The basic principles recommend that:

- all contaminated material from alarm/training/education is transported separately from personnel during the return to the station;
- all contaminated material from alarm/training/education is stored separately in an appropriate container until cleaned/repaired;
- all washing of alarm clothing is done in a separate locale in a washing machine designated for this purpose alone;
- all drying and re-treatment of alarm clothing takes place in a separate locale designed for this purpose;
- all decontamination of air fittings (smoke/diving equipment) takes place in separate area in washing machine only used for this purpose;
- all firehoses are stored in a water-filled, covered container while awaiting cleaning;
- all other contaminated material is sanitised in a separate, appropriate locale;
- all vehicles are kept clean and free from hazardous substances;
- alarm personnel have clean and appropriate clothing and equipment;
- alarm personnel have a personal, individual respiratory filter available with alarm clothing.

5.3.5. Ergonomic equipment

Alexandru Obregia – EU-OSHA photo comptetion

Ergonomic equipment which can reduce workers' strain and their exposure to risks should be considered, such as mobile equipment to carry bodies or any necessary apparatus. In some emergency events it may be also possible to use such devices as lifts when rescuing people from large and tall buildings (ISO, 2010). Other possible measures are vibration-reducing seats in ambulances to reduce strain on the musculoskeletal system, and the transportation of first aid kits in a backpack rather than bags when walking long distances to the emergency/disaster scene (Bohnen et al., 2010).

Any explosion-proof, low-noise, and low-emission equipment should be considered. Robot fire-fighters may be used in inaccessible areas where there is a risk of explosion or toxic gas emission.

Emergency medical staff should be should provided with syringes incorporating safety features that prevent needle-stick injuries and reduce infection risks. That should be complemented with special disposal boxes in which needles or sharp devices can be disposed of safely after use at the scene, and special training (Boal et al., 2005).

5.3.6. Primary and secondary prevention of mental health problems

Psychological preparedness

Psychological preparedness at work should help emergency workers to cope with the emotional burdens of their jobs. Possible primary prevention measures include:

- As much sufficient and adequate information as possible about the nature of the disaster, how many people are dead and how many are injured, where injured people are at the time, which other emergency workers are at the scene, whether also survivors are at the scene, etc. Information on conditions at the scene should be as exhaustive as possible (Brauchle et al., 2000).
- Boosting emergency workers' internal locus of control may help them accomplish their task without consequent mental health impairment. Self-esteem, self-confidence and self-image are all factors that impact on how an individual copes with stress reactions during and after a traumatic event.
- Experiencing feelings of trust and safety can act as a buffer for negative stress reactions. Social support from family and colleagues, and having a good personal network (being able to 'talk about it') can help emergency workers to put traumatic events behind them (Brauchle et al., 2000; Jonsson & Segesten, 2004).
- Well-coordinated team work, with the support of colleagues, provides feelings of security and belonging that can reduce mental and emotional strain at the scene. Since disaster-experienced emergency workers seem to be less at risk of mental health problems,(Brauchle et al., 2000) teams with a mix of experience might offer enhanced social support for the less-experienced.

An individual's ability to deal with difficult emotions and stresses may be also enhanced by training in stress management, relaxation techniques, and cognitive-behavioural techniques that can be used when taking decisions under pressure. Throne et al. (2000) showed that training on a simulated fire scene may significantly decrease the level of physiological stress reaction (lower pulse and the mean arterial pressure), and stress-related anxiety among fire-fighters.

There are also studies showing that enhancing psychological features such as sense of coherence, hardiness and psychological resilience may facilitate coping with difficult, traumatic situations. Sense of coherence is related to comprehensibility (perceiving the world as understandable), manageability (considering all available resources adequate and efficient to effectively manage or control life events), and meaningfulness (feeling that it makes sense to care about what happens, it is really worth the effort and satisfying) (Antonovsky, 1987). Hardiness defines people with a high level of commitment, control, responsibility, who treat challenge as an opportunity for personal growth (Orr and Westman, 1990). Resilience can be defined as individual capacity to use available psychological, social, cultural, and physical resources to sustain wellbeing, and also capacity to obtain those resources (Ungar, 2008). In the workplace these features may be enhanced by team cohesion, collective identity, shared values, good leadership, trust, and mission objectives (goal orientation).

Post-interventions psychological help

One of the most popular (but also controversial, as shown below) psychological intervention strategies after an emergency is critical incident stress debriefing (CISD). CISD aims to help emergency workers and victims cope with the physical and psychological symptoms that can arise after a disaster (Bierens de Haan, 2005; Davis, 1998). It can be also useful where the psychological strain of daily work leads to stress and mental ill-health among emergency workers (Manz, 2008;

Haslam & Mallon, 2003; Jonsson & Segesten, 2004). Kaplan et al. (2001) define three therapeutic components of CISD: ventilation in a context of group support, normalisation of responses, and education about post-event psychological reactions. The technique consists of reviewing the traumatic experience, encouraging emotional expression, and promoting cognitive processing of the experience. These debriefing moments give the opportunity to talk about experiences and emotions during the crisis response. The debriefing should be planned as soon as possible after the disaster (ideally between 24 and 72 hours after the event). During debriefing it is essential to leave room for the venting of emotions and thoughts (described in the literature as 'defusing'). Mitchell (1988) and Young (1994) state that fewer short-term and long-term stress reactions and trauma are reported if the Critical Incident Stress Debriefing is organised between 24h and 72h after the event. Their research suggests that emergency workers who do not have a CISD develop more acute stress reactions and mental health problems.

Although CISD is now a widely used technique to help emergency workers and victims to deal with the experience of a traumatic event, it has to be noted that some researchers are not wholly convinced of the healing aspects of CISD or other forms of debriefing. The results of a meta-analysis by van Emmerik et al. (2002) show that CISD does not decrease the symptoms that lead to PTSD and other mental disorders caused by traumatic events. The results of a study by Kaplan et al. (2001) support the findings of van Emmerik et al. (2002) by reporting that research on the effectiveness of debriefing is ambiguous, some showing a positive impact on the mental health of emergency workers and others failing to measure any effect, or even to find that debriefing leads to fewer negative effects in the long term.

Van Emmerik et al. (2002) suggest, in fact, that CISD goes against the 'natural' method of coping with traumatic events. Normally this 'natural' process is a combination of intrusion and avoidance. CISD might interfere with this natural process, because persons are exposed to the memories and thoughts all over again and this forced 'reliving' of the event might be detrimental. CISD puts the focus on the normal manifestations of stress after a trauma and seeks to normalise these reactions. However, telling workers to beware of these manifested reactions could be perceived as maladaptive. CISD confronts victims with the stimuli of the traumatic event and so may not allow the victim to habituate. CISD is also offered to all, regardless of their level of risk of severe psychological disorders. This makes it difficult for studies to detect the true effectiveness of CISD on, for example, PTSD. Last but not least, CIDS should be used as part of a broader, multidisciplinary approach (Van Emmerik et al. 2002).

The National Defence University of Finland (Maanpuolustuskorkeakoulu, 2007) suggests that offering listening and calm discussion can usually help a person who is experiencing acute stress after a disaster, whereas formal debriefing does not seem to have significant effect on stress. Equally, Strömberg et al. (2005) found that rescue workers had mixed feelings about an arranged debriefing carried out after the Myyrmanni bomb detonation. Instead, they preferred their own personal and collective stress management means, such as discussions with team members. The paramedics interviewed by Mäkinen (2008) after the Jokela shooting incident, as well as the emergency workers studied by Strömberg et al (2005) after the bomb detonation, reported that most helpful for them was unravelling the situation by talking about their experiences and feelings with colleagues straight after returning from the site.

Social support during and after deployment in a disaster and opportunities to talk and have calm discussions with colleagues or a psychologist have been found to help emergency workers to cope with psychological strain. However, in the case of serious or long-lasting symptoms of mental health problems such as post traumatic stress disorder, professional help may be necessary. Bengel (2001) emphasises the need for psychological long-term care for emergency and rescue workers following disasters. For example, a hotline was established during the Eschede disaster in 2000. Emergency and rescue workers were thus able to seek information about which institutions to contact for CISDs, personal or team counselling. A study by Bills et al. (2008) on the mental health of the workers responding to the 9/11 attack also concludes that there is a need for a specific psychological programme for disaster workers and they should have access to a mental health treatment service supported by comprehensive post-disaster surveillance and an emphasis on pre-disaster mental good health. In this respect Bohnen et al. (2010) stress the importance of discussing the stereotype of the 'calm rescuer' who keeps one's head in any situation, coping with all emotionally demanding situations, during the vocational education of emergency workers. It should be made clear that every emergency worker will face traumatising situations in his/her career, and that it is natural and human to be unable to cope with too great an emotional burden, and to seek external help to deal with the consequent problems. It should be emphasised that seeking external help is sensible and acceptable behaviour that prevents negative health outcomes, and not a sign of weakness.

5.3.7. Long-term-care and health surveillance

The health surveillance of emergency workers by periodical medical examinations has been emphasised by different authors (Kales et al., 2003; CDC, 2006; Berríos-Torres et al., 2003). Health surveillance should be adapted to the tasks required of emergency workers, and take into consideration potential exposures to different hazards, e.g. those not existent in a particular country, but possible to encounter when emergency workers are providing international help.

Physical fitness has been shown to have great importance in the prevention of cardiovascular diseases. Studies of fire-fighters and of Chernobyl emergency workers recommend regular examination for cardiovascular diseases (Bennett et al., 2006). The use of heavy and bulky protective clothing and the use of breathing apparatus, in conjunction with the presence of toxic chemicals, may contribute to the development of heart disease over time (ILO, 2003; Musselman, 1989). Mandatory annual medical examinations and medical examinations following deployment in major incidents are not only of great importance for the assessment of the physical fitness (including cardiopulmonary testing) of emergency workers but also for the detection of possible diseases and injuries caused by hazard exposure. This makes an appropriate response to possible health impairments and injuries possible, offering the treatment and rehabilitation necessary at an early stage to protect workers from more severe effects, and to improve their prospects of recovery. An examination immediately after a major incident might also reveal the need for antidotes to specific chemicals. Mandatory medical examination after each needle-stick injury is important for the detection of infections and so that appropriate medication can be offered. Health must be monitored after all radioactive exposures or contamination.

Regular health monitoring is necessary because it provides insights into the physical fitness of an emergency worker and permits early recognition of adverse health effects. Recommendations for healthy behaviour and for treatment in the event of adverse health effects being discovered can be made swiftly after the event. Both help to prevent more severe adverse health effects. Another possibility is the implementation of long-term health promotion projects, such as providing support or special facilities for workers to help them maintain fitness levels.

- ***Guidelines***

Some selected publications which may be helpful on this topic:

Occupational health, safety and welfare: Guidance for Fire and Rescue Services London, August 2009, available online at http://www.communities.gov.uk/documents/fire/pdf/1336353.pdf

Wisner, B. & Adams, J., *Environmental health in emergencies and disasters, a practical guide*, World Health Organization, Geneva, Switzerland, 2002, available online at: http://www.who.int/water_sanitation_health/hygiene/emergencies/emergencies2002/en/

Psychological First Aid for First Responders; SAMHSA Disaster Kit, US Department of Health and Human Resources, Rockville, Maryland, USA, January 2011, available online at: http://store.samhsa.gov/product/SMA11-DISASTER

Further books and guidelines are available, published by the OECD (Organisation for Economic Co-operation and Development, http://www.oecd.org/), the World Health Organization (WHO, http://www.who.int/en/), the International Labour Organization (ILO, http://www.ilo.org/), and the CDC's (NIOSH) 'Emergency Preparedness and Response', available online at, http://www.cdc.gov/niosh/topics/emergency.html .

6. Conclusions

Emergency workers are community forces created to handle daily emergencies and major disasters. They are experts in disaster control and vital to a community's return to normality following a catastrophe. This report looks at a wide spectrum of professions carrying out emergency activities such as fire-fighters, rescue workers, body handlers, police and military personnel, medical personnel, municipal workers, psychologists and psychiatrists, as well as volunteers. The possible occupational health and safety risks for emergency workers are presented in the context of natural disasters, industrial accidents, transport accidents, terrorist attacks, and negative scenarios during massive public events.

Recent data reveal a trend which suggests that major disasters will hit the Earth's population with increasing regularity. Increased energy use, dispersion of industrialisation around the globe, expansion of transportation, global warming, increasing pollution, continuous population growth, and the growth of terrorism are only some of the underlying phenomena that may exacerbate the frequency and intensity with which disasters strike, together with the vulnerability of people to them. Both major disasters and daily emergencies may occur in the future with a higher frequency.

The nature of the work done by emergency forces makes it impossible to eliminate, or often even significantly reduce amount of risk they are exposed to. The hazards they face range from more general issues related to managerial practices, a demanding work environment, physical and psychological overstrain, and violence, to more specific dangers related to the character of a given event, such as exposure to chemical substances, biological agents and radiation.

Studies of emergency workers show many possible negative health outcomes stemming from occupational health and safety risks, including fatal accidents and serious injuries, musculoskeletal problems, various kinds of cancer, infectious diseases, and serious problems with mental health. Some studies indicate a shorter life expectancy for emergency workers.

Past disasters and more recent events demonstrate that communities are often not fully prepared for dealing with major disasters and that the protection of emergency workers against OSH risks exhibits shortcomings. They need more extensive support, better preparedness, good disaster management, and reliable risk assessment in order to be better prepared and protected in the future. Awareness of OSH issues has to be raised, especially in the light of the increasing demands that are made upon emergency workers. The present literature review indicates some areas in which additional research is necessary. Very general preventive measures begin with reducing the vulnerability of people to disasters and ameliorating the severity of an event. This would lead to a smaller number of emergency workers being placed in the way of harm, and a reduction in the strain placed on them.This may involve issues such as responsible land-use, taking into account whether areas for newly built houses are vulnerable to natural disasters, or the construction of buildings adapted to the natural disasters that may occur there, or building in easy accessibility for emergency workers. It is also essential to improve detection and early warning systems for disasters and to make them commonly available. Some more specific recommendations can also be formulated.

- The OSH of emergency workers should be taken into consideration at the stage of **designing buildings**, especially with elements such as glass (Mallonee et al., 1996). Further studies which explore what kind of building/lift design makes it possible for lifts to be used to evacuate people in different types of emergencies are needed, since **using lifts** would decrease physical loads when carrying people, evacuation times and exposure to hazards.
- Better preparedness: the **OSH of emergency workers should be included in emergency response planes**. Bodies at international, national, and organisational level should ensure good coordination and communication between different groups of emergency workers involved in a disaster scene, establishing common language and communication systems, common training procedures. In order to disburden emergency workers deployed in disaster control, response organisations should be prepared to cope with intense media attention by designating a public information officer.
- **Different terrorist attack scenarios should be developed** to predict the possible hazards for emergency workers and to give guidance to manufacturers about the design of specific PPE.
- **Further development of PPE**, especially against multiple hazards and bioterrorism, taking into consideration the possibility of physical overstrain and the difficult working environment of emergency workers. Representatives of emergency and rescue organisations should be engaged in standardisation activities for PPE in order to give input to the constant improvement

of PPE. Distribution of PPE must be well coordinated and special procedures developed in case of major disasters.

- **Further longitudinal research** on the negative health effects on emergency workers of their jobs is essential to improve their protection. That includes studies on the causal relationships between chemical substances, radiological radiation and cancer, and the investigation of new construction materials such as synthetic polymers, and the disclosure of their nature and toxicological properties.

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