iProcure Security

SOLUTIONS FOR EMERGENCY MEDICAL SERVICES

The EMS Ecosystem
Main Gaps and Challenges

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Introduction

Fostering the response capacities and increasing the cooperation of the European Emergency Medical Services Systems (EMSS) is of decisive importance for strengthening the resilience of European societies in the light of multiple hazards, calling for close cooperation of public safety and health authorities on an international level.

iProcureSecurity responds to this challenge by identifying the major issues the diversity of the Emergency Medical Services (EMS) ecosystem poses to the capability of working together, stimulating R&I uptake with a focus on increasing harmonisation of operations across Europe, while delivering requirements for R&I activities to boost the development of more homogeneous EMS systems.

To enhance the response capabilities of the EMS organisations across Europe and facilitate a clear needs assessment of a major innovation procurement action, the project seeks to:

MOBILISE practitioners of emergency medical services, researchers and experts from the field to build synergies among existing actor constellations and initiate knowledge exchange.

ANALYSE the European medical emergency services ecosystem, its capability gaps, challenges, and needs, and monitor R&D initiatives to create a catalogue of innovative solutions.

ADDRESS legal issues, ethical and societal aspects that should be taken into account by the design, development, and deployment of new solutions in the emergency medical field.

PROVIDE specifications about common requirements and technical tender documents for the procurement of R&D, ready-to-use by the upcoming PCP action and external procurers.

This document provides an overview of the main gaps and challenges for the **EMS Ecosystem** against ten main areas which were identified during the iProcureSecurity project. In the following each area is briefly described.

The Scene

The components of the scene which mainly affect the response time and effectiveness are: number of casualties, number of patients, bystanders, communication model, accessibility, location information, scene safety, mechanism of injury, medical history, etc.

The scene can be any place, such as at home, in the workplace, in a vehicle, on land, avenue or street, where an emergency patient or an injured person is reported to be. The properties and the safety/security conditions of the scene, including of course the technological infrastructure (cameras, the alarm system, elevators and stairs etc.) are crucial to the success of the intervention of the EMS professionals. The outcome is influenced also by other elements: whether the incident happens in forest areas, rivers, lakes, at sea or on small islands, how the weather and the season of the year are, whether it is close to a border, in urban or rural areas, in high rise buildings etc.

In life threatening emergency situations, delivery of appropriate medical interventions on time is essential for better clinical outcomes. Prolonged EMS responses are known to have negative impact on trauma victims and cardiac arrest patients.

The scene presents many challenges to emergency medical services to provide high quality medical care in emergency situations and it strongly differs from relatively controlled working environment of hospital emergency rooms. Accident environments often are dynamic, chaotic, unpredictable, uncontrolled, sometimes even dangerous, and there is a significant time pressure. So, it is difficult for EMS providers to oversee all aspects of the scene and make the right decisions.

The reduction of obstacles to reach the patient is an important aspect of pre-hospital healthcare planning. Becker et al. identified a number of obstructions to access in an urban environment, including limited space, broken elevators, heavy patients, hostile bystanders, bad weather conditions and locked doors. It is conceivable that limited spaces, damaged elevators, and heavy patients may significantly have an impact on the patient access interval in the apartments of high-rise buildings. The accessibility, availability, and the speed of vertical transportation in high-rise buildings are especially relevant in large urban or metropolitan settings. (Becker LB, 1991)

Also the aged population creates a high demand for EMS. There is a recognized increase of elderly patients using EMS who would have been taken care of adequately with better quality, greater dignity, and lower costs in alternative settings than in the traditional emergency services. These patients aren´t always able to call emergency services after an accident due to deterioration in their health status.

Experiences throughout the world with mass casualty events and other life-threatening emergencies have highlighted the important role of bystanders. Bystanders are persons at the scene of an event who voluntarily step forward to help, and their early assistance may reduce morbidity and mortality. Because bystanders usually outnumber professional rescuers, their involvement may strengthen response to emergency events. Vivid examples of bystander intervention during emergencies are available. After the explosions during the Boston marathon in 2013, a high survival rate was noted, in part, due to the response of bystanders and first responders. In a report of 619 survivors of the Haiti earthquake, it was found that 71% of the injured people reported that a "friend, family, or neighbour" had pulled them from the rubble and that less than 1% were rescued from professional rescue forces.

In contrast to these examples, scholars have written about the well-known "bystander effect" in which the likelihood of a person helping others in distress grows smaller when there are more people available to provide help. That is, when an emergency occurs, observers are more likely to act if there are few or no other witnesses. However, much of our knowledge on the bystander effect and helping behaviours comes from artificial means. Academic literature relies heavily on the self-reporting of respondent actions after reading mock written scenarios.

Studies evaluating bystander behaviour obtained from natural experiments in real world settings have demonstrated beneficial health outcomes. For example, bystander-initiated CPR produced a 27% survival rate compared to a 13% survival rate when CPR was delayed until the arrival of EMS personnel. Another CPR study revealed a nearly double rate of survival if the bystander performed CPR instead of waiting for the EMS provider (18.3% vs. 10.9%). Furthermore, it has been noted that successful resuscitation of drowning victims was most often performed by bystanders. Bystanders have also been successful in saving lives by reversing opioid poisoning through the administration of naloxone. Similarly, the absence of people available to intervene in motor vehicle crashes has been cited as a factor in higher rural fatality rates among car crash victims (Faul, Akiman, Sasser 2016).

Main Gaps and Challenges

- Inadequate numbers of citizens who are able to apply first aid.
- Bystanders not being able to decide to start CPR on time.
- Missing tools for EMS to support bystanders during first aid.
- Bystanders stay inactive because of lack of knowledge or support or because of fear in harming the victim.
- Finding experienced first aid volunteers in the area of the event.
- In disaster or crisis situations bystanders enter to help into the scene unaware about the circumstances and become injured too.
- Insufficient access to AEDs.
- AED training and distribution regulations are not the same all over Europe.
- Limitations due to the use of only traditional communication channels.
- Aging population will require more resources and smarter services.
- Patients at home are insufficiently monitored. In case of emergency alerts are delayed and relevant information on the patient‘s status is not immediately available.
- It is problematic to determine the patient‘s location and get into his/her home if he/she loses consciousness and is alone.
- Difficulties due to scene conditions (e.g. distance and geographical difficulties, traffic density, large/high-rise buildings, overcrowded areas).
- Missing tools and strategies to optimize EMS resources and response times in rural areas.
- Quickly detecting all victims in mass casualty incidents is difficult.

Project: SECONDS | **Type:** H2020 | **Grant agreement ID:** 855607 Website

For Emergency Medical Services (EMS), long response times constitute losses in lives and higher hospitalization costs. 5 minutes is the best response time to save more lives and 12 minutes is the maximum threshold EMS estimate for an ambulance to be helpful. These times, however, are hard to meet. Speed is critical, so pre-positioning vehicles is the key to meet the required response time. The high complexity of the system produces uncertain demand and supply, which gets worse due to traffic, incident severity, multiple/simultaneous incidents, and different types/sizes of ambulances and associated equipment.

Project: IN-PREP | **Type:** H2020 | **Grant agreement ID:** 740627 Website

Transboundary crises pose a specific set of complex challenges for which Europe is – despite recent policy initiatives (e.g. Decision No 1313/2013/EU) – still ill prepared. There are three challenges that need urgent attention. First, member states need to develop shared response planning. Second, countries need to share information in real time. Third, countries need to coordinate the use of critical resources to ensure a timely response and to avoid waste and misspending. These challenges are hard to meet in any type of crisis or disaster, but especially in a transboundary context that lacks a dominant actor.

Project: RAMSES | **Type:** EIT | **Grant agreement ID:** 740627 Website

In an increasingly mobile but ageing society, people are facing greater difficulties in health crisis situations. Professionals who are contacted remotely may have to deal with information gaps, resulting in inefficient health care. To ensure correct diagnoses and allow for better-informed decisions, professional medical services need to be able to obtain reliable and comprehensive information.

Ambulances

An ambulance is a medically equipped vehicle which transports patients to treatment facilities, such as hospitals. In some instances, out-of-hospital medical care is provided to the patient during the transport. Ambulances can be categorized in three main areas which are ground, air and marine ambulances. Following three different types of divided road ambulances are used in prehospital care to different degrees in EU Member States (CEN (1978:2007 and CEN A2:2014)).

Ambulance Type A: Patient transport ambulance. Ground ambulance which is designed and equipped for the transportation of the patients who are not expected to develop a critical condition.

Ambulance Type B: Emergency ambulance. Ground ambulance which designed and equipped for the transportation, basic treatment and monitoring of patients. (Basic life support ambulance).

Ambulance Type C: Mobile intensive care unit. Ground ambulance which is designed and equipped for the transportation, advanced treatment and monitoring of patients. (Advanced Life Support ambulance).

The European Standard 11.160 – 43.160 which was accepted in 2007 specifies requirements for the design, testing, performance and equipment of ambulances used for the transport and care of patients. It also contains requirements for the patient‘s compartment. This European Standard does not cover the requirements for approval and registration of the vehicle and the training of the staff which is the responsibility of the authorities in the country where the ambulance is to be registered (CEN - EN 1789 2007).

There is a pending application for revision on the previously mentioned standard on medical vehicles and their equipment since 2018. There are more requirements added to this document on monitoring and treatment of patients. It also contains requirements for the patient‘s compartment in terms of the working environment, ergonomic design and the safety of the crew and patients. However, this document does not cover the training of the crew which is the responsibility of the authorities in the country where the registration of the ambulance takes place. This document also specifies requirements for ambulances intended to carry transport incubator systems that was not mentioned in the scope of the still available standard (CEN - PREN 1789 2018). Renewed EU Standards for Pre-Hospital EMS are shown in Table 1 (Worseling, 2017)

Table 1: Renewed EU Standards for Pre-Hospital EMS

Title	Standard
EN 1789:2007+A2:2014	Medical vehicles and their equipment – Ground ambulances
EN 13718-1:2014	Medical vehicles and their equipment - Air ambulances Part 1: Requirements for medical devices used in air Ambulances
EN 13718-2:2015	Medical vehicles and their equipment - Air ambulances Part 2: Operational and technical requirements for air Ambulances
EN1865-1:2010+A1:2015	Patient handling equipment used in road ambulances - Part 1: General stretcher systems and patient handling Equipment
EN 1865-2:2010+A1:2015	Patient handling equipment used in road ambulances - Part 2: Power assisted stretcher
EN 1865-3:2012	Patient handling equipment used in road ambulances - Part 3: Heavy duty stretcher
EN 1865-4:2012	Patient handling equipment used in road ambulances - Part 4: Foldable patient transfer chair
EN 1865-5:2012	Patient handling equipment used in road ambulances - Part 5: Stretcher support
EN 794-3:1998+A2:2009	Lung ventilators - Part 3: Particular requirements foremergency and transport ventilators

These voluntary standards aim at "improving safety, quality and reliability of products, services, processes; reinforcing the Single Market and supporting the economic growth and the spread of new technologies and innovation" (CEN, 2016a). In the field of pre-hospital EMS, multiple CEN standards have been published that have been taken up by most EU member states and beyond (CEN standards are in use in Turkey for ambulances). Standards that were identified mainly focused on medical vehicles and their equipment.

The WHO made an extensive research on European EMS systems. Their study focused only on ambulances, with insufficient collection of data with regard to other means of transportation (helicopter, airplane, boats etc.) and the collection of complete and accurate information on the utilization of ambulances proved extremely difficult (World Health Organization. Regional Office for Europe & European Union, 2008).

Helicopter Emergency Medical Services (HEMS) missions are also important for responding to health emergencies. Research of Jones A. in 2016 showed that within Europe there is a large variation in the number of helicopters available for emergency care, regardless of whether assessed with reference to population, land area or Gross Domestic Product (Jones, Jansen, 2018). Funding of these services varies and does not seem to be clearly related to the availability of HEMS. The smallest and least prosperous countries have no dedicated HEMS provision. Luxembourg has the highest number of helicopters by area and population, day and night. Alpine countries have high daytime HEMS coverage and Scandinavia has good night-time coverage (Zakariassen, Østerås, Nystøyl, 2019). Most helicopters carry a doctor. Funding of the services comes from public to charities and private institutions. Most services perform both primary (from the scene) and secondary (interfacility) missions.

The ambulance standards which need to be revised are for medical equipment, ergonomics – safe work environment, design and etc. European Commission regulations that further need to be considered regard to the harmonization of ambulances so that types (external design) are recognizable by the citizens/public and first responders in every European country. The ambulances need to be similar in internal design so that EMS staff from one country is able to quickly adapt to the use of a vehicle from another country, if required. Interoperability in communications will decrease response time and increase treatment and response quality can be achieved by European wide harmonization of ambulances too.

On the other hand, classification of ambulances in 3 different categories as ground, air and marine ambulances may not be valid in the future because thanks to future technologies, ambulances on land can also be designed to go in the air and by sea. Similarly, there are drawbacks for the definitions of ground ambulances in the 3 different categories (Type A, B, C). In the future, it will be beneficial to convert ambulances into vehicle types, with specific equipment and number and teams of EMS personnel. In this way, every tool can be used for all types of cases. Initially, there may be 2 types of ambulances for urgent and non-urgent transportations. Then, with some minor changes, every ambulance can be sent to any operation. Depending on the characteristics of the case, the medical support capacity can be increased by giving remote medical support to the personnel in the vehicle. Specially equipped ambulances are needed to respond to Mass Casualty Incidents and disasters. These types of ambulances may not be used in routine transports, but they should be kept in reserve so that they can quickly enter the system if necessary. Especially for infectious diseases (e.g. COVID-19) and chemical incidents (CBRN), the ventilation system needs to be designed accordingly, and ambulances that can carry more than one patient will be needed in the future.

Main Gaps and Challenges

- The different ambulance types and related various management approaches confuse first responders and the public.
- Distribution of ground and air EMS is uneven across Europe.
- Types, colours and medical technical equipment of ambulances are not uniform.
- Limited capabilities for deployment of HEMS and marine ambulances.
- No HEMs enabled for night flight in some countries.
- Restricted availability of special equipment for transportation of obese patients.
- Different standards regarding the equipment in the ambulances across Europe.
- Victims or EMS personnel are located in dangerous or highly inaccessible areas.
- Low and not equal representation of A, B, C types of ambulances.
- Lack of standardization regarding the team composition of the different ambulance types.
- Missing optimization of scarce transport capacities.
- Unexploited potential of new technologies such as telemedicine and AI for ambulance services
- The priorities of choosing ambulance type (ground, air and boat ambulances) during transportation are not standard and sometimes unclear.
- Specially equipped ambulances to transport new-born patients are not available in all countries.

Innovation Projects and R&I initiatives

Project: SAEPP | Type: H2020 **| Grant agreement ID:** 644329

Website

It is estimated that in the UK alone by providing appropriate on-the-spot treatment, up to 40 per cent of patient journeys to hospital could be avoided, which would result in several benefits for the patients and the health care system as a whole. There is lack of ICT solutions which are capable of combining patient transport and treatment, reducing hospital admissions and handover times as well as decreasing overall costs.

Project: MOMENTUM
Type: Project financed by the BMBF under 16KIS1031

Website

There are many issues, that cut off first responders from the information flow of the scene. Before the ambulance arrives, only little data about the transported patient is available in the shock room. At the same time, an operating theatre is immediately reserved and held until the examination of the patient is completed, which can sometimes take several hours. It is also not possible to prepare for a specific emergency intervention because hardly any information is available on the injuries, the patient's current clinical condition or the measures already taken. Systems that satisfactorily support these complex processes of an emergency intervention are lacking.

Safety and Situational Awareness

Situational awareness is important for effective decision making and performance in any complex and dynamic environment. It was originally an aviation term used to describe awareness of tactical situations during aerial warfare. It has now been adopted in emergencies, and increasingly in other dynamic, complex, situations requiring human control. A general, widely applicable definition describes situational awareness as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future”. Endsley (1988) discusses three levels of situational awareness.

Level 1: situational awareness involves perceiving critical factors in the environment. Often this information will come directly from an individual(s) that is actively sensing the environment. This can include visual perceptions, such as seeing smoke, auditory perceptions, such as hearing an explosion, tactile perceptions, such as feeling the earth rumble, as well as verbal and nonverbal communications with other individuals.

Level 2: situational awareness understanding what those factors mean, particularly when integrated together in relation to the decision maker’s goals. This requires integrating the somewhat unrelated factors from level one to develop a prioritized list of the combined information’s significance and its meaning with respect to the objectives of the decision maker. This implies not only seeing or hearing data but being able to correctly understand the meaning of information. In order to obtain this level of understanding a fairly developed knowledge base or level of experience is required to allow the synthesis of disparate data nuggets. Therefore, an individual who has limited experience in a given situation may have a difficult time obtaining this level of situational awareness.

Level 3: situational awareness is the highest level, an understanding of what will happen with the system in the near future. This means obtaining the data in level 1, understanding its meaning (level 2) and predicting what will happen. This prediction can only be accurate if it is accompanied by a high level of domain expertise. However, domain expertise alone is not enough, it is important there is adequate mental resources, that is to say that the predictor is not overloaded with other information processing tasks.

From the above it is obvious that situational awareness, by definition, has an information component, a perception component and a meaning component.

To provide the information component required for situational awareness, the system must be capable of collecting, filtering, analysing, structuring, and transmitting data. Situational awareness is not only the correct perception of reality, it the correct perception of the relevant elements of the current reality necessary for correct, protective, tactical, and strategic response.

The information component of situational awareness depends on both the particular domain and the users’ dynamic information needs. To determine the information required it is necessary to focus on the basic goals of the decision maker and the major decisions that they need to make to achieve the goals.

From the information required it is then possible to determine the individual data nuggets that need to be collected. This emphasizes one of the difficulties with obtaining situational awareness; developing static and anticipated goals. A few general characteristics can be stated about data requirements.

Collect the data required to satisfy the decision maker's goal. The data collected needs to directly support the decision maker in arriving at their objective. While there is often more data collected that is actually required it is important to group and present the data as information that can be directly used to achieve a desired result. For example, if the users' goal is to determine an appropriate evacuation route, some of the data to support this goal could be damage reports for bridges. While the detailed data would present types of damage, severity, etc., the information presented to the user should be focused on bridge usability

Data collected should be the attributes necessary to sufficiently describe a required piece of information. For example, if an information requirement was a damage report, data collected might be current condition, location, and circumstance (or type).

Data must provide the ability to describe relationships between things. In the above example, instead of simply a damage report the information needed could be evacuation destinations (relative positions, combinations of circumstances).

Data must provide the ability to link the attributes for any given piece of information to time. It is important to maintain a timeline of what changes occurred in data values. This will allow the user to obtain Level 3 situational awareness by being able to predict future states.

Data must be of sufficient quality to meet the decision making and action needs of the moment—completeness, timeliness, accuracy, consistency.

Emergency response is dynamic by nature - in every step from taking the call to responding on the scene. Upon dispatch to an incident, responders immediately get in a search of their most valuable commodity: information. Initially, responders are provided with the key information from the person reporting the incident and upon arrival, they obtain more information about the surrounding situation at hand. While treating the patient, additional information about the situation becomes relevant.

During these initial phases of information gathering, it is of utmost importance to ensure the EMS teams' safety and taking care of the patient. Situational awareness (Seidel Gary E, n.d.) can be explained as that responders:

- **Understand their environment**
- **Can determine what's happening around them**
- **Are able to predict what can/could occur**
- **Can respond to or withdraw from it**

In order to support the accurate formation of situational awareness, critical information should be identified. Furthermore, good information flow is required when making decisions about a single case or multiple casualty incidents. It is necessary to get information from different sources to create a correct picture of what is going on. Decisions based on low-grade information can lead to poor patient outcomes and/or put rescuers at risk (Norri-Sederholm, Paakkonen, Kurola, Saranto, 2015).

As the nature of the calls has become more complex (due to increasing citizen age, obesity and other comorbidities, people's mobility, immigration, technology use, terrorist attacks, use of dangerous substances, infectious diseases etc.), EMS providers' safety and situational awareness is becoming more important (Mentler & Herczeg 2015).

During major disasters, at a point in the decisional process the persons in charge must consider the necessary situational awareness to perform decision making. The transition to decision making for these emergency leaders is influenced by the following five factors (Glick and Barbara; 2013): 1) Analogue Factor: the decision maker's previous knowledge and experience from analogous disaster situations; 2) New Paradigm Factor: the degree to which the disaster situation is very atypical to the decision maker due to hazard type and or situation severity, 3) Data Capture Factor: the quality, amount, and speed of disaster situation data conveyed to the decision maker; 4) Data Integration Factor: the decision maker's ability to integrate situational data elements into a mental framework picture; and 5) Time Urgency Factor: the decision maker's perception as to time available before a decision has to be made.

The mission of a situation awareness software is to improve public health emergency planning and response. By analysing critical information about many kinds of hazards that can affect public health, this information can be transformed into tools that dispatchers and responders can use to help victims stay safer and healthier. The tools must gather, organize, check, and share information to help leaders and responders make science-based decisions and actionable recommendations.

Data from many sources must be collected, analysed and validated. Secure and adaptable systems have to be designed for gathering and sharing data. Data must be checked to be sure they are as accurate as possible; and recommendations must be provided on the process and systems used to collect, analyse and validate this information. Those data and analyses into accessible, easy-to-use tools by creating reports, charts, maps, databases and more, ensuring that information is clear and accessible, using processes, tools, and information to predict future circumstances, working with all the stakeholders to develop and maintain resources that support information-sharing.

Main Gaps and Challenges

- Feeling of unsafety disturbs EMS professional’s attention and affects their decision making.
- Available equipment for personal protection of medical rescue teams working in disasters is often not very useful under realistic conditions.
- Current PPE clothing complicates medical intervention of healthcare teams, because they can be heavy and don‘t provide optimal comfort to work properly.
- Upcoming hazards on location may stay undetected which puts EMS staff and victims at risk.
- Lack of knowledge or awareness of safety and risk among EMS personnel.
- Operating with different communication and data systems hinders quick, efficient joint decisions when several organisations have to cooperate during an incident.
- Available data sources (e.g. traffic systems, CCTV, weather forecast etc.) are not or cannot be sufficiently used.
- New communication channels are not used enough. It is necessary to move from the classical system to the age of information technologies.
- Planning of operations at large scale events which are hard to overlook is complicated and bears risks for the safety of EMS personnel.
- Limited availability of geo-localization technology.
- Missing tools for onsite victim identification.
- Lack of guidelines on paediatric decontamination.

Project: SAYSO | Type: H2020 **| Grant agreement ID:** 740872 Website

Current Situational Awareness (SA) solutions are not adapted to operate in cross-border contexts and present several shortcomings related to interoperability, data management/processing, decision making, standardisation and procurement. This hinders a reliable sharing of SA information.

Project: RESPONDRONE | Type: H2020 **| Grant agreement ID:** 833717 Website

There are many issues, that cut off first responders from the information flow of the scene. Before the ambulance arrives, only little data about the transported patient is available in the shock room. At the same time, an operating theatre is immediately reserved and held until the examination of the patient is completed, which can sometimes take several hours. It is also not possible to prepare for a specific emergency intervention because hardly any information is available on the injuries, the patient's current clinical condition or the measures already taken. Systems that satisfactorily support these complex processes of an emergency intervention are lacking.

Project: ASSISTANCE | Type: H2020 **| Grant agreement ID:** 832576 Website

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Project: CoP1stRespond | Type: H2020 **| Grant agreement ID:** 876360 Website

From guarded communities to emergency responders and the military – face many challenges when dealing with emergency situations. One of these is reliable and secure communication.

Medical Treatment

Medical treatment means the management and care of a patient to combat disease or disorder. Before transporting the patient to the hospital, the diagnosis and medical treatment at the scene is one of the most relevant EMS tasks in the field. The European Resuscitation Council has identified five conditions in which EMS play a most crucial role. These are: cardiac arrest, severe respiratory difficulties, severe trauma, chest pain (including acute coronary syndrome) and stroke.

ACS, including Acute Myocardial Infarction, Unstable Angina and Sudden Cardiac Arrest are time-dependent diseases in which any delay in the delivery of the acute-phase treatment may result in a significant negative impact on survival and the outcome. Rapid access to a health system providing early assessment, pain management, control of arrhythmias (especially VF) and early revascularization, are the core elements of treatment which increase the survival chance of the patient.

The scientific evidence demonstrates that early active treatment produces a positive impact on the outcome of stroke patients. EMS in combination with dedicated stroke units are recognised as a fundamental part of CHD and stroke treatment. Rapid access to the treatment is highlighted in all the relevant scientific guidelines. Differences in the outcomes among countries reflect the different levels of treatment provision, as well as access to health care and treatment within the different countries. EMS is a critical part of the development of improved treatment.

The role of EMS in providing treatment to the respiratory patients is relevant not only in that it allows for the provision of vital support in cases of respiratory failure, but also that it delivers medical treatments reversing bronchoconstriction and providing adequate oxygen. These procedures produce a rapid improvement of symptoms in the initial phase, and in some cases can be a source of definitive treatment (Krafft, Garcia Riesgo, Fischer, Robertson-Steel, Lippert, 2002).

The classic distribution of death after an accident, with 30% of the deaths occurring in the first two hours due to the problems such as airway obstruction, respiratory failure or haemorrhagic shock, reflects the relevant role of on-scene treatment. There is also an enormous potential for a positive impact on the outcomes from this on scene treatment, as a variety of these conditions can be controlled by simple interventions. These assumptions justify and explain the improvements in outcome that the implementation of an EMS system produces for trauma patients (Krafft, Garcia Riesgo, Fischer, Robertson-Steel, Lippert, 2002).

Main Gaps and Challenges

- Issues in understanding and diagnosing life threatening heart diseases.
- Issues in understanding and diagnosing a stroke case.
- Issues in understanding and diagnosing a respiratory failure.
- Issues in understanding and diagnosing the severity of the trauma.
- Communication methods between ambulance teams and patients or relatives is insufficient.
- Missing decision support tools for medical treatment.
- Lack of knowledge of medical history of the patient can lead to wrong treatment decisions.
- Need for telemedicine support for quick and accurate decision making and treatment.
- Limited capability to quickly identify new contagious diseases and apply proper spread protection.
- Diagnosis in the field can be complicated due to several factors that distract EMS professionals.

Project: FS-UNIT | Type: H2020 **| Grant agreement ID:** 868579 Website

When a person's heart stops, fast response is needed. Many times, fluid such as vomit clog up a person's airway during a cardiac arrest. Prompt airway clearing can increase survivability in trauma cases by as much as 10%, yet current portable suction devices are not designed with a paramedic-centric view. Instead, they are heavy, bulky, difficult and time consuming to use.

Project: ADRONE4LIFE | Type: H2020 **| Grant agreement ID:** 876759 Website

Up to now, helicopters and vehicles have been widely used to transport vaccines, medications and other emergency medical supplies. The use of drones is starting to take off, to address the limitations of traditional modes of transport. However, safety is still matter of concern.

Project: ZENEO | Type: H2020 **| Grant agreement ID:** 876000 Website

Anaphylactic shock is an extreme allergic reaction that needs to be treated immediately with a shot of epinephrine (adrenaline) to reverse the symptoms. Many people at risk of anaphylaxis carry an autoinjector – a combined syringe and concealed needle that injects a single dose of medication. This needle-based drug delivery device may soon be replaced by a needle-free alternative.

Project: EGM | Type: H2020 **| Grant agreement ID:** 855062 Website

Heart failure (HF) is a major global cause of death, affecting over 26M people, and it represent the most common cause of hospitalisation for people over 65. Over 90% of hospitalisations and deaths in HF patients are caused by lung fluid congestion. Current diagnostic practices for detection of lung fluid congestion are mostly inaccurate, meaning that the condition can only be detected in its advanced stages.

Project: MrDoc | Type: H2020 **| Grant agreement ID:** 876145 Website

Non-communicable diseases such as cardiovascular diseases and diabetes, are by far the leading cause of death in the world and a growing burden for patients, healthcare providers and local economies. Despite many NCDs conditions like cardiac arrhythmia, diabetes, hypertension can be cured with early detection, they don't often show symptoms. During their medical check-up, medical practitioners (GP) can't be accurate as specific examinations represent for Healthcare systems and additional financial burden.

Emergency Medical Communication Centre

In July 1991, the Council of the European Union adopted a decision on the emergency call number. Member States were requested to implement the European emergency call number 112 in order to make emergency services more accessible, especially for travellers. It was foreseen that the single European emergency number 112 would operate alongside the existing national emergency numbers in most countries and would not directly replace the existing ones. 112 is now accessible in every EU Member State and is the single emergency number in several countries in Europe and beyond. The 112 Emergency number has also been used in Turkey since 1996 (Emergency Communications and the EU Legislative Framework Update 2019).

Emergency call differentiated to European Electronic Communication Call by Article 108 in 2018/1972/EU. According to this availability of services „Member States shall take all necessary measures to ensure the fullest possible availability of voice communications services and internet access services provided over public electronic communications networks in the event of catastrophic network breakdown or in cases of force majeure. Member States shall ensure that providers of voice communications services take all necessary measures to ensure uninterrupted access to emergency services and uninterrupted transmission of public warnings“. This directive's deadline for implementation is 21st of December 2020. (ETSI TR 102 299 2019)

In emergency situations, it is very important that bystanders and casualties can reach the EMCC with correct information as quickly as possible. Unnecessary calls and incorrect information will cause misuse of the resources (Dejean, Giacomini, Welsford, Schwartz, Decicca, 2016). Therefore, emergency call numbers should be reached with smartphones, and the location of the caller, medical condition (history), previous diseases, the image of the patient and / or the case and communication with the disabled people should be provided with applications to be developed. New technologies such as artificial intelligence and IP-based software should be integrated in EMCCs to manage incoming calls correctly. The triage and prioritization of emergency calls is of vital importance to decide which type of vehicles and teams will be dispatch to the scene according to the patients' / causalities' location and situation. There should be an uninterrupted communication between the EMCC and ambulance professionals, volunteers at the scene and hospitals. In addition, many EMCCs are connected with home and office alarm and camera systems, signals and security cameras and they could be supported with interactive maps. The information system infrastructure in these centres should be protected against cyber security attacks. Training and working time of the personnel; and technological infrastructure in these centres directly affect the success rate and the quality of operations.

Emergency medical dispatch is a vital link in any chain of medical treatment. Upon the receipt of a call requesting medical assistance, the priorities are to characterise the urgency of the reported incident, give medical instructions via telephone and coordinate the dispatch of appropriate medical resources to the correct location36. The role of emergency medical dispatch is particularly important in certain conditions, such as out-of-hospital cardiac arrest, where the actions of call takers and dispatchers can have a direct effect on the clinical outcome of the patient. That's why dispatcher-assisted PCR or telephone PCR (T-PCR) were included in ERC 2015 Algorithms (European Resuscitation Council, 2015).

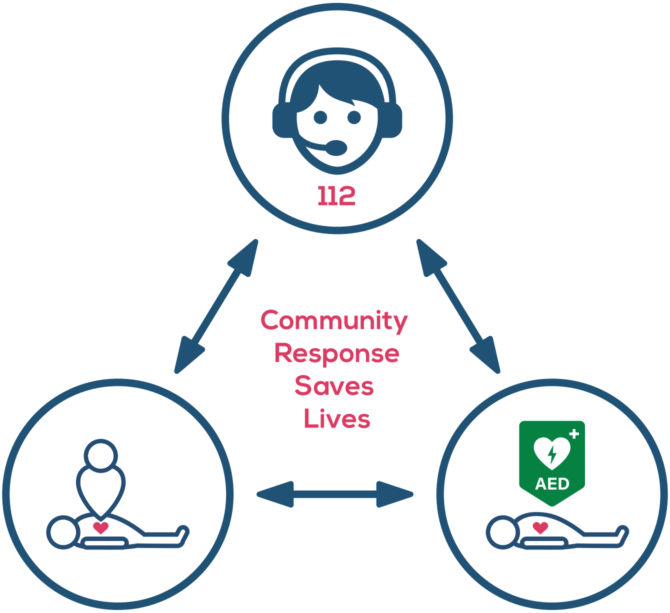

Figure 1: Interaction between Emergency Medical Dispatcher and Bystander

Patients report a wide range of symptoms to the tele communicator (medical dispatcher) and the ultimate question is how to identify what resources are best needed for that specific caller/patient. Ball et al. considered the effect of the primary complaint in relation to over-and under-triage. The results showed that while some of the most common primary complaints are under-triaged, e.g. convulsions/ seizures and breathing problems, others are over-triaged e.g. chest pain, heart problems/ automatic defibrillator, collapse and headache (Bohm, Kurland, 2018).

EENA categorizes the EMCC in Europe according to the call handling, data gathering and resource dispatching processes. According to the EENA report, Public Safety Answering Points used as a terminology for EMCC (European Emergency Number Association, 2019).

There is no Europe wide harmonization for EMCCs. Even the EMCCs could be different in the same country. The needs are different for islands, main lands, rural and urban areas.

There is a need to address "interoperability" especially for EMS. Interoperability is defined as the property that allows for the unrestricted sharing of resources between different systems. Interoperability is key for the Decision Support System of EMS. According to the NATO Research Task Group, interoperability has many layers whereas; knowledge / awareness layer information interoperability is especially important for EMS.

Main Gaps and Challenges

- Especially at larger events where various vehicles of different types are needed, quick and efficient prioritization, allocation and routing of vehicles is complicated.
- Not enough call takers (e.g. during large scale incidents) are available.
- Interruption of communication during disasters creates problems in rapid intervention and evacuation of patients.
- EMCC systems sometimes don't provide the exact location of victims.
- Operating with different communication and data systems hinders quick, efficient joint decisions when several organisations have to cooperate during an incident.
- Communication between the ambulances, emergency call centres and the hospitals is not sufficient.
- Integration with urban camera systems, traffic signalization and building alarm systems (home, workplace, shopping malls) is problematic.
- Limited availability of decision support software and/or computerized algorithms to support EMS.
- It is not possible to share the patient's past medical (records) data online with ambulance teams and receiving hospitals.
- There is no standard for the management of specific calls (like cardiac arrest, stroke, trauma, shock).
- In many countries, social media cannot be used to recieve emergency calls.
- One-to-one communication with the patient is mostly not done by the ambulance team until its arrival on the scene.
- Video emergency call communication is not common due to the poor internet infrastructure and slow speed in some countries.
- There are different approaches across Europe for selecting the right hospital for a victim. Sometimes the ambulance team decide, sometimes EMCC and sometimes a medical advisor makes the decision.
- There is no common implemented protocol in sending patient data (what, when and how) before the ambulance arrives at the hospital.
- There are not enough resources in every country to guide the first aid volunteers to help victims on the scene before the ambulance arrives.
- Most countries do not have T-CPR and video call software implemented.

- Improved fall detection technologies that can activate EMS in a reliable way should be implemented.
- Insufficient availability of medical consultation for call dispatchers.
- Delayed response based on language barriers.
- Accessibility issues: Lack of tools for disabled (deaf, impaired vision, blind, physically impaired etc.) citizens to start emergency calls and communicate properly with EMCC.
- Staff who knows the sign language in EMCCs are almost non-existent.
- The number (demand) of non-urgent calls is increasing and there is no separate centre or number to which they can be routed to in many countries.
- Fake calls or non-emergency calls reduce the response times of EMCC.
- Data storage and cyber security issues are not sufficiently covered.
- EMCC are critical infrastructure and thereby high value targets for cyber attacks and should be better protected.
- Highly fragmented dispatch centre staff.
- No full coverage of 112 emergency network.
- No unified standards for processing 112 calls.

Project: NG112 | **Type:** EENA Project

Website

Most emergency services are only reachable by voice telephone calls, while more and more citizens expect to be able to reach emergency services using modern ways of communication including location information, real-time text, photos, video calls and other data.

Project: EMYNOS | **Type:** H2020 | **Grant agreement ID:** 653762

Website

Emergency systems and 112 services are based on legacy telecommunication technologies, which cannot cope with IP-based services that European citizens use every day. Some of the related limitations are the partial media support, the lack of integration of social media, and the use of an analog modem for providing eCall services with limited data amount. As most operators have started migrating towards broadband IP-based infrastructures, emergency systems need also to be upgraded/adapted in order to fulfil regulatory requirements in terms of Next Generation emergency services.

In Hospital EMS

In Hospital EMS refers to all subsets of medical institutions and hospitals that have the capacity to deliver uninterrupted emergency care 24/7. Emergency Department demands continue to rise in almost all high-income countries, including those with universal coverage and a strong primary care network. Many of these countries have been experimenting with innovative methods to reduce the demand of acute care, while at the same time providing highly needed services that can prevent emergency department attendance and later hospital admissions. A large proportion of patients in emergency departments have minor illnesses that could potentially be handled by a health care provider in a primary care setting. The increasing number of visits to emergency departments causes not only delays in urgent care provision but it also increases the overall costs.

Instead of big and complex hospitals, specialized hospitals that have the ability to intervene in emergency patients (emergency service, intensive care, laboratory and emergency operation) should be implemented. Medical response capacity of hospitals (number of specialist physicians, intensive care bed capacity, medical device and operating room status) should instantly be recognized by ambulance professionals and EMCCs. Hospital emergency department and intensive care personnel should be informed in detail about the medical condition of the patient and the estimated time of arrival to the hospital by ambulances.

A long handover time is not only harmful to the patients, whose condition might deteriorate whilst waiting in the ambulance bay but it can also waste valuable resources of prehospital and hospital emergency services. Prompt handover of care in the hospitals are in the interest of all ambulance related stakeholders. Exact formulation of the targets varies from country to country and their aims are consistent, in as much to reduce the costs, and improve both patient outcomes and the equitable use of resources (of vehicles and crews) (Sasser, Hunt, Faul, Sugerman, Pearson, Dulski, Wald, Jurkovich, Newgard & Lerner, 2012).

Patients whose condition deteriorates acutely while they are hospitalized often exhibit warning signs (such as abnormal vital signs) in the hours before experiencing adverse clinical outcomes. In contrast to current cardiac arrest or „code blue“ teams, which are summoned only after cardiopulmonary arrest occurs, rapid response teams are designed to intervene during this critical period, usually on patients on general medical or surgical wards.

There are several different models of "Rapid Response Systems" (RRS) as presented below:

- **Medical Emergency Teams (MET)** comprises a team of doctors and nurses with advanced life support skills, which are hospital based, who respond to emergency calls following a deterioration in a patient's clinical condition. The role and contribution of such approaches promoting the early recognition and intervention of these vulnerable patients demands critical appraisal. (Barbetti J1, Lee G. 2008)
- **Rapid Response Team (RRT)**; composed of critical care nurse, respiratory therapist, and physician (critical care or hospitalist) backup. RRTs respond to emergencies, follow up on patients discharged from ICU, proactively evaluate high-risk ward patients, educate and act as liaison to ward staff. (PSNet 2019)
- **High Acuity Response Team (HART)** was introduced in British Columbia, Canada, to fill a gap in transport for rural patients that was previously being met by nurses and physicians leaving their communities to escort patients in need of critical care. HART services are deployed in partnership with provincial ambulance services, which provide vehicles and coordination of all requests in the province for patient transport. (Kornelsen J, et al. 2018)

MET and RRT are part of RRS based in hospitals. HART is related to rural teams in Canada. As iProcureSecurity focuses mainly on pre-hospital EMS in Europe MET, RRT and HART are of less relevance within the project.

Main Gaps and Challenges

- The overall communication between pre-hospital care, EMCC and hospitals have to be standardised and improved.
- Patient allocation to available hospitals needs to be standardised and improved to avoid overcrowded emergency departments.
- Missing communication between the hospital and the ambulance team during transportation leads to delays in treatment.
- Handover of all relevant data can be time consuming.
- Delays in door to needle time for stroke patients.
- Monitoring and managing the overall patient flow from the scene to the hospital needs improvements.
- Transfer of patient information during transfer to the hospital is not possible in many regions.
- Missing EHR of a patient or a casualty may lead to prolonged treatment time or maltreatment.
- Different Electronic Health Records (or no EHR at all) are used between EMS and hospitals.
- Trauma centres are not available in all regions.
- Experts in hospitals cannot provide proper support for ambulance personnel at the scene.

Innovation Projects and R&I initiatives

Project: NIGHTINGALE | Type: H2020 **| Grant agreement ID:** 727534 Website

Safest, reliable, individualised care of patients at-risk of deterioration needs patients themselves to play an active role in their care whenever possible: late detection or escalation of deterioration causes avoidable harms, and deaths. There is a lack of robust monitoring and communications systems that connect patients, carers and health professionals, provide early warning of acute deterioration in and out of hospital.

Project: Medical Express | Type: H2020 **| Grant agreement ID:** 880707 Website

Delivering services with high quality in the most cost effective and efficient manner in healthcare hinges on patient flow. This refers to the ability to manage patients effectively and with minimal delays. Improving patient flow into, within and out of hospitals is necessary to maximise operational efficiency – a top priority.

Project: InteropEHRate | Type: H2020 **| Grant agreement ID:** 826106 Website

Today, citizens moving across Europe have very limited control on their own health data, spread out in different silos. Legal constraints may prevent controllers of these silos from exchanging the managed data, even in anonymized way, without the intervention of higher authorities. As a consequence, health data cannot be fully exploited for healthcare and research.

EMS Work Force and Training

Emergency medical services (EMS) vary across Europe, with two predominant models: the Anglo-American model which uses mainly paramedics in a prehospital setting, where 'the patient goes to the doctor', and the Franco-German model which uses mainly physicians in a prehospital setting, where 'the doctor goes to the patient'. No perfect model exists, and each country has an EMS model based upon the needs of the community and the available economic resources. The EMCC, the means and the response times are similar. The biggest differences concern the personnel who staff ambulances and their training, although they all have to perform the same emergency procedures and manage similar types of patient. The role of emergency medical professionals is vital in all prehospital EMS systems. However, the training of emergency medical technicians (EMT) with equal skills is very different, with great variations as a function of each country. European harmonization appears to be necessary, even if it seems difficult.

- **EMS organization:** A company or other group of people that works together as an emergency medical service.
- **EMS practitioner:** Skilled professional involved in an emergency medical service. Dedicated professionals, both career and volunteer, who administer emergency medical care to patients in need

In most countries emergency care teams consist of a medical doctor, a nurse or ambulance co-worker, besides an ambulance driver. Non-emergency care teams consist of one or two nurses, other emergency medical personnel and an ambulance driver in most countries. Medical doctors are not part of the ambulance staff in non-emergency ambulance care.

The number, the types and the level of training of ambulance personnel and teams are not harmonized in all European countries. For example, there are ambulances in which two paramedics work together in the UK, while doctors can work in ambulances in northern European countries. In Germany, emergency cars and helicopters are sent to the scene with the hospital doctors. In general, physicians, paramedics, emergency medical technicians, nurses and drivers in some countries are employed in ambulances. There are differences between the training programs, working hours and responsibilities of these personnel. Firefighters and policemen with first aid powers voluntarily assist ambulance personnel in some countries in emergency situations. The characteristics and colours of the clothing of the employees are also different.

There are no standards for EMCC personnel. In some countries (France, Italy, Greece, Turkey, etc.) doctors are working alongside the medical staff as a consultant in EMCC. In some countries (UK, Germany and the Netherlands, etc.), doctors, paramedics, and nurses work in an EMCC.

It is obligatory for EMS staff (EMCC, Ambulance and Support) that trainings are enriched with real cases and scenarios. Augmented Reality techniques should be used in trainings.

Realistic environments should be used in virtual environments as well as advanced technology models. In addition, more effective responses to multiple injuries should be simulated by using computer aided software for disaster and emergency preparedness.

Trainings should be diversified and enriched according to the training level and authority of the personnel (Doctor, Paramedic, Nurse etc.). Health care providers working in the ambulances graduate from similar faculties like vocational schools but the competencies of them may differ among European countries.

All EU Member States provide EMS systems. However, the type of staffing differs. The vehicles in every system are equipped and stocked with supplies to treat the medical needs of any patient needing emergency care in the prehospital environment in that system. As EMS has advanced and new treatment modalities have been introduced, additional certification programmes for advanced qualification of ambulance personnel has been required. This includes Advanced Cardiac Life Support (ACLS), Pre-Hospital Trauma Life Support (PHTLS), and Pediatric Advanced Life Support (PALS) or their equivalents. The curriculum of these courses oriented to improving of medical technical skills. For this reason, many numbers of high-fidelity mannequins needed for opening a course. This makes difficulty to open courses in many places /locations around the Europe.

Patient care begins when the telephone rings. For those calls where information is available, Emergency Medical Dispatchers (EMD) trained to deliver Dispatch Life Support (DLS) through the use of pre arrival instructions can, and do, make a difference. Some systems use protocol driven dispatch algorithms for determining the severity level of the patient, the type of responding resources that may be needed, and the assistance that can be given by the dispatcher prior to arrival of the ambulance. The training level for the dispatcher varies among the different systems. (Krafft, Garcia Riesgo, Fischer, Robertson-Steel, Lippert, 2002)

All the countries need to train and evaluate their EMS staff. In Croatia, Estonia and Lithuania this training is continuous. In the Czech Republic, Germany, Ireland, Latvia, the Netherlands, and the UK staff has to take courses on a yearly basis. In the Netherlands a national assessment procedure is carried out every three years. Belgium skills are evaluated once in five years. In Hungary competency measurements are established irregularly. In some countries the ambulance staff needs re-registration. In Estonia, the Netherlands and Turkey training modules and re-registration are obliged once in respectively two, three, four and five years. (NIVEL, 2015)

Main Gaps and Challenges

- There are significant differences between education levels, training programs, roles and responsibilities of EMS providers throughout Europe.
- Centres where healthcare teams receive training for emergencies and disasters do not exist in many countries.
- There is no platform to share emergency and disaster experiences (lessons learnt) between countries. Experience transfer cannot be made.
- Disaster medical rescue teams are not available in some countries and/ or cannot reach the scene in adequate time.
- EMS personnel working with intensive care patients, babies in incubators, or transplantation need better training.
- The training of health personnel who works in neonate ambulances has to be improved.
- Triage training has to be improved.
- Intuitive training approaches are missing.
- Trainings in real environments are expensive and time consuming in preparation.
- Virtual environments and next generation technologies are not sufficiently used in trainings.
- Medical Rescue Teams need to be better trained for responding for difficult cases (such as mountain rescue).
- Due to differences in the training of physicians, paramedics and emergency medicine technicians, communication problems appear in cross border situations.
- Training with volunteers and other first responders such as fire brigade and police should be improved to reduce communication problems.
- It is vital to keep paramedics and the rest of EMS workers up to date regarding procedures and equipment.
- There is no standard training for dispatchers. Special attention should be paid to the training of staff working in emergency call centres.Volunteer systems are different among European countries and there is a need to make stronger use of volunteers in several countries.
- Problems appear in cooperation between paramedics and emergency doctors due to different competences.
- Lack of systems to reward and motivate ambulance staff.
- Managing ongoing competence development has to be supported with better tools.

Project: eNOTICE | **Type:** H2020
Grant agreement ID: EC-HORIZON2020-PR740521-eNOTICE

Website

There is a lack of efficient interlink between the sectors, actors and disciplines to ensure better preparedness of societies to cope with complex crisis situations.

Project: TEEMothyTS Simulator | **Type:** H2020
Grant agreement ID: 878065

Website

Transoesophageal echocardiography (TEE) is a minimally invasive procedure used to assess the structure and function of the heart. Despite its minimal invasiveness, TEE requires a highly skilled operator with detailed anatomical and clinical knowledge of the heart.

Project: ROG | **Type:** H2020 | **Grant agreement ID:** 889729

Website

There is a lack of technology to enable an advanced medical training approach, as well as to simulate real patient conditions during a pre-operative trial in the healthcare environment.

Project: EndoTrainer | **Type:** H2020 | **Grant agreement ID:** 817335

Website

Minimally invasive surgery (MIS), or ‘key-hole surgery’, has huge benefits for patients and the healthcare system alike. However, its adoption is not as wide spread as it should be and today´s complex procedures can lead to a set of surgery mistakes generating unforeseen patient harm and complication. One of the main reasons for the restrain on this full-release of MIS benefit has been due to the traditional, limited practical training.

Medical Equipment

Medical equipment is used for the specific purposes of diagnosis, treatment of disease or rehabilitation following a disease or injury. It can be used either alone or in combination with any accessory, consumable or other piece of medical equipment. Typical medical equipment of ambulance usually includes the following elements:

- Main stretcher / Combination stretcher / Vacuum stretcher / Dustpan stretcher
- Backboard (with head stabilizer)
- Inflatable splint or vacuum splint set with at least 6 different pieces
- Neck collar set
- KED rescue vest
- Fixed oxygen cylinder and outlet
- Portable oxygen cylinder
- Transport ventilator device (adjustable to pressure [10-50 cmH2O] suitable for adult and paediatric use, with PEEP valve)
- Mechanical ventilator device
- Stationary vacuum aspirator
- Portable aspirator
- Fixed sphygmomanometer (with stethoscope)
- Portable sphygmomanometer (with stethoscope)
- Oximeter
- Thermometer
- Diagnostic set (otoscope, ophthalmoscope, rhinoscope)
- IV pole
- Injector pump
- Defibrillator (With Monitor)
- Automatic external defibrillator
- Defibrillator with external pace maker feature
- Heart monitor
- Resuscitation unit (Balloon valve mask set, laryngoscope set, portable oxygen tube, intubation tubes, airway tube, oro / nasopharyngeal cannulas, colorimetric device)
- Heat insulated container
- Oxygen mask (with reservoir) and nasal catheters (set)
- Aspiration catheters (3 different sizes)
- Various sizes of urinary catheters and bags
- Various sizes of injectors
- Thorax drainage kit
- Pressure infuser
- Pericardial piercing kit
- Central (central) vein probe (catheter)
- Emergency delivery kit
- Blood glucose meter
- Capnometry
- Burn set (Aluminium or gel-based burn dressing, burn dressing and compresses)
- Basic medical equipment bag (ring cutting scissors, tourniquet, sterile sponge, compress, haemostatic material, bandage, elastic bandage and plaster)
- Intracettes with serum set and butterfly set
- Staff duty uniform (with reflective)
- Funeral bag
- Medication bag (including various types of serum)

There is a need for a harmonization for the equipment located inside ambulances. There are also differences in the technical characteristics of the same medical equipment used in ambulances. In addition, the size of the medical equipment carried with the patient and the use of wearable technology are different in each country. Before the ambulances reach the scene, more specialized and life-saving equipment must be deployed and developed for the use of first aiders (such as AEDs).

There exist many recommendations to develop the 'digital ambulance'. Many practitioners argue that an ambulance is not a taxi to ED (emergency department). Modern technology means that patients can often be treated at the scene. But an ageing ambulance fleet means that this is not always possible. It is imperative to provide Wi-Fi access in vehicles, access to electronic patient records, and remote clinical diagnostic tools such as video consultations. There is a general a vision for a digitally enabled ambulance service in the near future.

Main Gaps and Challenges

- Medical equipment and its location inside the ambulance are not standardized in Europe.
- Medical equipment data cannot be sent to hospitals and medical consultants.
- Problems due to outdated equipment and facilities.
- Incompatible communication equipment between EMS and other first responders.
- No availability of wireless broadband in several regions.
- Devices that can be activated and used hands-free (e.g. only by voice) are needed.
- Limited availability of telemedicine consultation.
- Limited availability of real time analytics.
- Limited availability of mobile devices and apps.
- Limited availability of Electronic Health Record (EHR), Health Information Exchange (HIE), Electronic Patient Health Record (ePCR).
- Lack of uniform and standardized access to a computer network for patient data exchange.
- Lack of simple systems to heat the patient during transport to the hospital.
- Due to the problems of remote monitoring AED batteries and security issues of AED devices; their usage and availability is limited. There is no standard on location of AEDs Europe wide.
- Growing dependency on digital networks bears risk if this infrastructure is compromised or unavailable.

Project: WISE | **Type:** H2020 | **Grant agreement ID:** 101010348 Website

There are tens of billions of IoT (Internet of Things) connected devices globally, the vast majority typically powered by a battery. Batteries come with the caveat of battery replacement, that translates into an incremental cost throughout system ownership, a huge environmental impact and safety risks in certain sensitive applications (e.g. medical devices).

Project: ROVER | **Type:** H2020 | **Grant agreement ID:** 872752 Website

Wearable wireless sensor technology has entered the medical realm of diagnosis, monitoring and treatment. From measuring body temperature and blood pressure to monitoring vital signs and providing real-time feedback, this technology can improve patient diagnostic procedures. However, there is an insufficient knowledge in the area of intelligent wireless networks for medical ICT applications such as algorithms and non-invasive validated system prototypes for in-on-, on-on- and on-off-body communications.

Triage Systems

Triage can be defined as "the sorting of patients into priority groups according to their needs and the available resources". It must ensure the efficient use of available resources (e.g. personnel, supplies, equipment, means of transportation and medical facilities). It affects the extent and quality of care delivered by the EMS system (World Health Organization, 2008).

There are different types of EMS triage systems:

- **Disaster Triage Systems:** The first attempt at balancing resources and casualties/ injured and transportation of right patient / causality, to the right hospital, in right time, with using the right means of transportation model
    - o MASS "Move, Assess, Sort, Send"
    - o ESI "Emergency Severity Index"
    - o SALT "Sort, Assess, Lifesaving Interventions, Treatment /Transport"
    - o START / Jump START "Simple Triage and Rapid Treatment" etc.
- **Field Trauma Triage Guidelines**: a decision process known as "field triage," which involves an assessment of not only the physiology and anatomy of the injury but also the mechanism of the injury and special patient considerations. The goal of the field triage process is to ensure that injured patients are transported to a trauma centre or hospital that is best equipped to manage their specific injuries, in an appropriate and timely manner, as the circumstances of injury might warrant. Although this triage method is improved for the field and prehospital EMS but it is not intended as a triage tool to be used in a situation involving mass casualties or disaster (i.e., an extraordinary case with multiple casualties that might stress or overwhelm the local prehospital and hospital resources) (Sasser, Hunt, Faul, Sugerman, Pearson, Dulski, Wald, Jurkovich, Newgard, Lerner, 2011).
- **EMCC Systems**; There are several types of dispatching systems but they can be categorized as two types of systems; the Medical Priority Dispatch system (MPDS) mainly used in Anglo-Saxon countries, and the criteria-based dispatch (CBD) used in Nordic and European countries. The common point of both of these systems is that the tele communicator allocates each call to one of the listed primary complaints. While MPDS is based on codes and scripted questions to put to the caller, the CBD system relies on the experience of the tele communicator to conduct the interview (Bohm, Kurland, 2018)
- **Hospital Emergency Services Triage Systems**;
    - o Ipswich Triage Scale (ITS),
    - o Manchester Triage Scale (MTS),
    - o Canadian Triage and Acuity Scale (CTAS) etc.

In an optimal trauma system, prehospital trauma triage ensures the transportation of the right patient to the right hospital. Incorrect triage results in under triage and over triage. Van Rhein E (2018) evaluated 33 articles completely so as to search effectiveness of prehospital trauma triage systems in selecting severely injured patients. The percentage of under triage ranged from 1% to 68%; over triage from 5% to 99%. Older age and increased geographical distance were associated with under triage (van Rein, Eveline). The death rate was lower for severely injured patients transferred to a higher-level trauma centre.

A study with a good methodological quality showed that the triage protocol identified only a minority of severely injured patients, were transported to higher-level trauma centres. Better EMS provider decisions could lower the under-triage rate, especially for severely injured patients meeting none of the criteria.

In most of the evaluated trauma systems, a substantial part of the severely injured patients is not transported to the appropriate level trauma centre. Future researches should come up with new innovative ways to improve the quality of prehospital triage in trauma patients (Palma, 2014)

Main Gaps and Challenges

- Lack of clarity for the head of operations on the ground and for command-and-control structures and dispatch centres in the background based on missing or unclear data.
- Missing innovative geolocation and cartographic tools for onsite planning.
- Missing information on environmental conditions (traffic conditions and weather conditions).
- No data for decision support to improve resource allocation and casualty transport.
- Lack of centralized clinical information that would allow an early distribution of victims according to their pathology and the availability of hospital resources.
- The information flow directly depends on human performance. In stressful situations professionals can forget important data or be easily distracted by other tasks.
- Lack of integrated solutions for the management of large-scale events.
- Resource allocation is sometimes inefficient due to missing interoperability of used systems.
- An exhaustive analysis of the data generated in the incident is required, both in real time and afterwards, in order to improve resource allocation.
- Current triage is not very flexible. For instance, START algorithm is used in scenarios where it doesn’t fit e.g. for children, blast injuries, etc.

- Need for improvement of re- triage, e.g. monitoring of the condition and vital signs of already triaged victims on site.
- Missing ability to involve telemedicine aspects e.g. for quick consultation during re-triage.
- In many cases it‘s still necessary for the staff on the ground to collect the handwritten information and report this information via radio. In some cases, information is still forwarded through so called "runners", who move paper documents from one place to another.
- Radio messages are prone to confusion and slow down exchange of information.
- Missing interoperability (missing APIs) between applied EMS systems.
- Missing interoperability between all the actors participating in the emergency.
- Missing interoperability with Electronic Health Records.
- Missing performance and risk assessment during incidents due to missing, incomplete or unavailable data.
- Lack of benchmarking to provide accurate performance evaluations.
- Isolated systems and applications create a lock-in situation which hinders EMS to seamlessly connect them with current and potential future applications.
- Current procedures are considered as ad hoc and too much cultural dependent. This may lead to over/under triage.
- Missing compliance with GDPR (Authentication and authorization; Pseudonymisation and Encryption; Backups; Infrastructure security; Application security).

Innovation Projects and R&I initiatives

Project: Toxi Triage | **Type:** H2020 | **Grant agreement ID:** 653409 Website

There is a lack of information on casualties in CBRN incidents allowing to treat patients more efficiently.

Project: ETIMan | **Type:** H2020 | **Grant agreement ID:** 878333 Website

Insufficient information during mass casualties' incidents on emergency patients hinders the proper selection of the patients according to the urgency for help, affecting the quality of treatment and causing increased administrative work.

Project: DosiKit | **Type:** H2020 | **Grant agreement ID:** 876689 Website

There is a lack of irradiation biodosimetry tools that can be used in the event of nuclear accidents where individuals are exposed to potentially dangerous levels of radiation. There are also no devices that can be used by non-specialists in the field to give immediate results in cases of partial-body irradiation (PBI).

Other

There are currently different procedures and practices in every country in Europe. The emergency categories, types of ambulances, types, powers and responsibilities of the personnel working in EMCC and the reaction patterns in case of disaster and crisis are not harmonized. There are great differences ranging from one country to another.

Worseling, K. published a thesis on "The Influence of European Union in the Field of Emergency Medical Services". In this thesis; authority instruments used by the EU that either directly or indirectly affect pre-hospital EMS categorized in 7 fields: Single European Emergency call number; working times; technical requirements for pre-hospital EMS; cross-border collaboration; financing of pre-hospital EMS – a cross-border perspective and public procurement (Worseling, 2017).

Logistics planning is not given enough importance in EMS. EMS planning can be divided into three main parts: the general design of the services, the logistics to provide the services and the analytics of the services. The design of the services is mainly determined by existing laws and regulations and additionally by the decisions which services are offered for the corresponding EMS region. In addition, general decisions, such as deciding if the closest ambulance should be assigned, have to be made. The logistics should assure that the designed services can be offered as intended while serving to the existing laws and the regulations. The main services are certainly emergency rescue and patient transportation, but also the hotline of the EMCC can be considered as a service, especially if they also inform about on-duty doctors/pharmacies or serve calls from in-house emergency call systems. Analytics mainly includes two aspects: (1) forecasts for the logistical planning problems and (2) data analyses of historic data to control the execution of the laws and the regulations and the provided service levels. Statistics from previous year's data are often used to check whether the laws and the regulations were executed or whether they cover the logistics as well as the analytics (Reuter-Oppermann, van den Berg, Vile, 2017).

Main Gaps and Challenges

- The legal regulations of EMS have different characteristics and are not harmonized among all European countries.
- Insufficient funding for Emergency Medical Services
- EMS personnel are not able to get work permits with the certificates they receive in other countries.
- Lack of logistics planning affects the effectiveness of the EMS service.
- Inflexible working hours and models.
- Long shifts leading to deterioration in the provision of emergency medical care.
- Unsatisfying remuneration.
- Unsatisfying employment contracts.
- Long, tiring and hardly transparent process of purchasing new equipment.
- Missing standardization in public procurement and innovative procurement mechanisms.
- Poor access to emergency health care and service provision for disadvantaged people in some areas.
- Lack of common terminology as a basis for mutual understanding on the capability gaps in the EMS systems.
- Lack of psychological assistance for victims and responders.
- Social media and TV programs are not adequately organized in the promotion of EMS and public education.
- The audit and accreditation systems are not standard at European level. In many countries, these tasks are organized by the state. There is a lack of integration of scientific and independent organizations for EMS and ambulance auditing.
- Lack of agreement in international actions against infectious diseases.
- EMS is part of critical infrastructure and thereby a high value target. Strategies for better protection are needed.
- Openness for innovations has to be improved in the EMS domain.

Innovation Projects and R&I initiatives

Project: International Patient Summary (IPS) | **Type:** Project   Website

There is no unified clinical data or EMS vocabulary which are usable and understandable in any country, and can provide support for cross-border or cross-jurisdictional emergency and unplanned care.

Project: Magnet4Europe | **Type:** H2020 | **Grant agreement ID:** 848031   Website

Doctors and nurses are not immune to burnout, which is a combination of exhaustion, cynicism and perceived inefficacy resulting from long-term job stress. In fact, workers in the healthcare sector experience burnout much more frequently than workers in other professions.

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