Helicopter emergency medical services in sudden-onset major incidents

Patterns of use

by

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"You stay completely apolitical and non-ideological, and you stick to what it is that you do. I'm a scientist and I'm a physician. And that's it."

Anthony Fauci

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The smallest feet make the biggest footprints in the heart.

Unknown

List of papers

Paper I

Johnsen AS, Fattah S, Sollid SJM, Rehn M. Utilisation of helicopter emergency medical services in the early medical response to major incidents: a systematic literature review. BMJ Open. 2016:6:e010307. doi:10.1136/bmjopen-2015-010307

Paper II

Johnsen AS, Sollid SJM, Vigerust T, Jystad M, Rehn M Helicopter emergency medical services in major incident management: A national Norwegian cross-sectional survey. PLoS ONE. 2017;12:e0171436. doi:10.1371/journal.pone.0171436

Paper III

Fattah S, Johnsen AS, Sollid SJM, Wisborg T, Rehn M, HEMS Major Incident Reporting Collaborators. Reporting Helicopter Emergency Medical Services in Major Incidents: A Delphi Study.
Air Med J. 2016;35:348-351. doi:10.1016/j.amj.2016.08.003

Paper IV

Johnsen AS, Samdal M, Sollid S, Rehn M. Major incident management by helicopter emergency medical services in south-east Norway from 2000 to 2016: Retrospective cohort study. Acta Anaesthesiol Scand. 2020;64(7):1014-1020. doi:10.1111/aas.13583

Summary

Major incidents happen infrequently and challenge the health care system by demanding more resources than are readily available. Critically injured patients need rapid treatment and swift transport to the right hospital to prevent unnecessary death and disability.

Helicopter emergency medical services (HEMS) are incorporated into emergency medical systems in Norway and other countries around the world. Anecdotally, HEMS have become integrated in the immediate management of sudden-onset major incidents and case reports depict that helicopters may play a key operational role. Although the amount of research on benefits and challenges of HEMS is rapidly growing, the optimal use in major incidents remains unanswered.

The main aim of this thesis is to explore the use of HEMS in sudden-onset major incidents in a systematic way from different angles. The thesis focus on optimizing HEMS role in sudden-onset major incident management by sharing experiences for policy makers to improve major incident preparedness. This is done through four studies, a systematic review, a cross-sectional study, a Delphi study and a retrospective observational study.

With these studies, we found that previous research published on HEMS role in sudden-onset major incident management are mainly case reports and that little systematic research has been done. In the cross-sectional study and the retrospective observational studies, we found that HEMS participation in sudden-onset major incidents are rare in Norway. The cross-sectional study showed that HEMS personnel were experienced but only a little more than half of the crew members had attended a major incident within the previous five years. Further, the retrospective observational study showed that in a major incident, HEMS treat more patients on-scene than they transport to definite care. In this complex environment, the participation of multiple emergency services that not

necessarily cooperate on a daily basis makes communication and coordination (including with HEMS) challenging. These challenges deserve focus in major incident training and planning.

To provide a better knowledge base for future research, data collection from major incidents and major incident exercises should be done systematically. The template developed in the Delphi study would enable other clinicians and researchers to submit structured open access reports, to share lessons learnt, collate data and compare major incident responses.

The lack of a universally accepted definition of major incidents and removal of barriers in recruiting reports to the template remain important areas for future research. To enhance the knowledge on HEMS in major incidents, it remains pivotal that the pre-hospital environment acknowledges and address these challenges.

Abbreviations

CASP	Critical Appraisal Skills Programme
CBRNe	Chemical, Biological, Radiological, Nuclear, and explosive materials
CRED	Centre for Research on the Epidemiology of Disasters
DISAST-CIR	Disastrous Incidents Systematic AnalysiS Through Components, Interactions, Results
DSB	Norwegian Directorate for Civil Protection
DPIA	Data Protection Impact Assessment
EHAC	European HEMS and Air Ambulance Committee
EMCC	Emergency Medical Command Centres
EM-DAT	Emergency Events Database
EMS	Emergency Medical Services
EQUATOR	Enhancing the Quality and Transparency Of health Research
EU	European Union
EUPHOREA	European Prehospital Research Alliance
FAA	Federal Aviation Administration
GDP	Gross Domestic Product
HEMS	Helicopter Emergency Medical Services

ICD	International Classification of Diseases and related health problems
ICU	Intensive Care Unit
JRCC	Joint Rescue Coordination Centres
MI	Major Incident
MIMMS	Major Incident Medical Management and Support
MRMI	Medical Response to Major Incidents and Disasters
NAAF	Norwegian Air Ambulance Foundation
NACA	National Advisory Committee for Aeronautics
NGO	Non-Governmental Organizations
OCHA	The United Nations Office for the Coordination of Humanitarian Affairs
PICO	Population, Intervention, Comparison, Outcome
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analysis
RAKOS	Regional Centre for Emergency Medical Research in western Norway
RTI	Road Traffic Incidents
SAR	Search and Rescue Helicopter
STROBE	Strengthening the Reporting of Observational studies in Epidemiology
TPRN	Thematic Platform for health emergency and disaster risk management Research Network

UN	United Nations
USD	US Dollars
UNDRR	UN office for Disaster Risk Reduction
WHO	World Health Organization

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1 Introduction

1.1 General introduction

Helicopter emergency medical services (HEMS) are an important and integrated part of the pre-hospital emergency medical services (EMS) in Norway with bases distributed throughout Norway.(1) In case reports, HEMS is found to participate in the immediate management of Norwegian sudden-onset major incidents.(2-4) Although there is an increasing amount of research in pre-hospital critical care, the contribution of HEMS services in major incident and disaster management are not fully examined in structured research.(5) This thesis aims to contribute to the evidence in the field of sudden-onset major incident medical management, with the focus on HEMS mission management and not clinical management of individual major incident victims.

1.2 Description of HEMS

The modern EMS system roots back to the Napoleon wars where wounded soldiers were cared for and returned to battle. Lessons from the Civil War in the United States founded the civilian EMS systems in the late 1800s.(6) A case report from 1924 described a fixed-wing evacuation of a seriously wounded Serbian patient by French military and highlighted that evacuation by air should be used with caution and only where the benefits outweighed the risks.(7) During World War II and the following wars, the evolution of rotor-wing evacuation led to reduced death rates and subsequently the foundation of helicopter transport in civilian pre-hospital medical services.(8)

Nowadays, HEMS are integrated in many EMS systems around the world.(9-11) Within Europe, HEMS availability varies. Some countries lack HEMS, whereas others have varying number of HEMS units available. No clear pattern regarding country size, gross domestic product (GDP) or population size exists.(12) The majority of units are physician-staffed, but some services are staffed with nurses or paramedics. Teams with aviation crew (e.g. HEMS crew members (HCM)) in addition to the pilot have been shown to have a higher perceived flight and patient safety.(13) Within the Scandinavian countries there are strong similarities in organisational structure and competence of personnel, with differences mainly on response time, patient volume and catchment area.(11)

HEMS normally perform medical and trauma primary missions, with the capacity to do advanced medical treatment on scene. Further, some services also perform search and rescue missions, as well as inter-hospital transfers of patients in critical conditions.(14, 15) With the novel Coronavirus SARS-Cov2 pandemic, the transport of critically ill and infectious patients from overloaded critical care units to other hospitals has been described as another valuable and safe task for HEMS.(16) In case reports of sudden-onset major incidents, HEMS have played a vital role in the immediate management were they have served several roles in both ferrying extra resources to the incident, overall coordination of the treatment of critical injured and transport of severely injured patients.(2)

1.2.1 Norwegian Air Ambulance structure

Norway is a subarctic country with a scattered population in rural areas where rapid transport of critically ill and injured patients by HEMS remain important to minimize unfavourable outcome.(17-19) The first known air ambulance transport of a patient in Norway was in 1932, and in 1934 the airline Widerøe was established with air ambulance services as one of the company´s purposes. The physician-staffed air ambulance helicopter service was introduced by Jens Moe in 1978 and led to the establishment of the Norwegian Air Ambulance Foundation and eventually a national governmentally funded air ambulance service.(20)

The national, governmentally funded air ambulance service of Norway consists of three operational concepts: fixed wing, HEMS and search and rescue helicopter (SAR). The flight operations of fixed-wing and HEMS are contracted to commercial companies, but integrated into the national health care system.(21, 22) The SAR service is operated by the Royal Norwegian Air Force.(23)

There are 13 helicopter ambulances based on 12 locations and nine fixed-wing ambulances distributed on seven bases. In addition, the Royal Norwegian Air Force, 330 squadron has six SAR bases. There is a rapid response car available for missions in the proximity of the base or when weather or technical issues prevent flying.(22) All bases are staffed with an anaesthesiologist, a rescue paramedic and a pilot, one base has an additional flight nurse. SAR units are further staffed with a co-pilot, a flight engineer and a navigator.(24)

Figure 1 – Map of the area of the SAR services in Norway. From Redningshandboka, reprinted with permission (25)

HEMS are dispatched by local emergency medical communications centres (EMCC) with dedicated HEMS-coordinators providing inter-regional fleet control, advanced operational coordination (e.g. during a major incident) as well as flight following services.(26) SAR are dispatched by one of two joint rescue coordination centrals (JRCC) that liaise with EMCCs on ambulance missions. There is a 24/7 service of HEMS and SAR all year round and they cooperate on selected missions.(22, 24, 27)

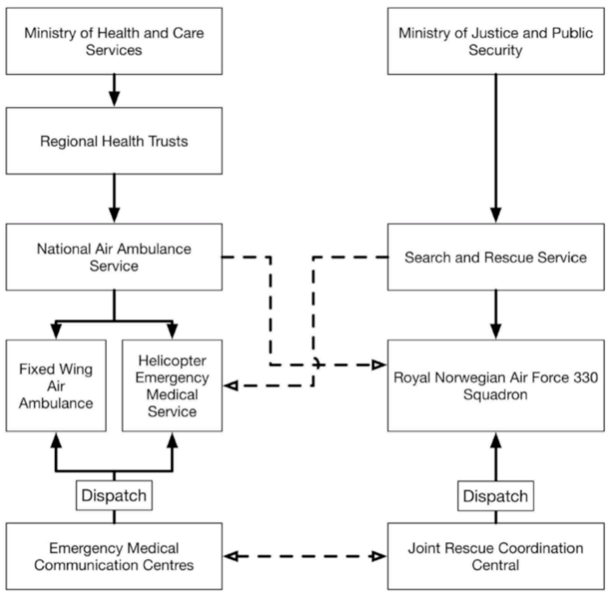

Figure 2 – Organisational structure of Norwegian HEMS and SAR (28)

The Norwegian government expects that 90% of the population should be reached by a doctor-manned EMS within 45 minutes making HEMS an important inter-regional resource.(29) A study from 2015 showed variations in response times and rates between the bases indicating differences in accessibilities for HEMS in between regions.(30) There is a well-established cooperation with the primary care service with general practitioners on-call that play a pivotal role when HEMS are unavailable.(31)

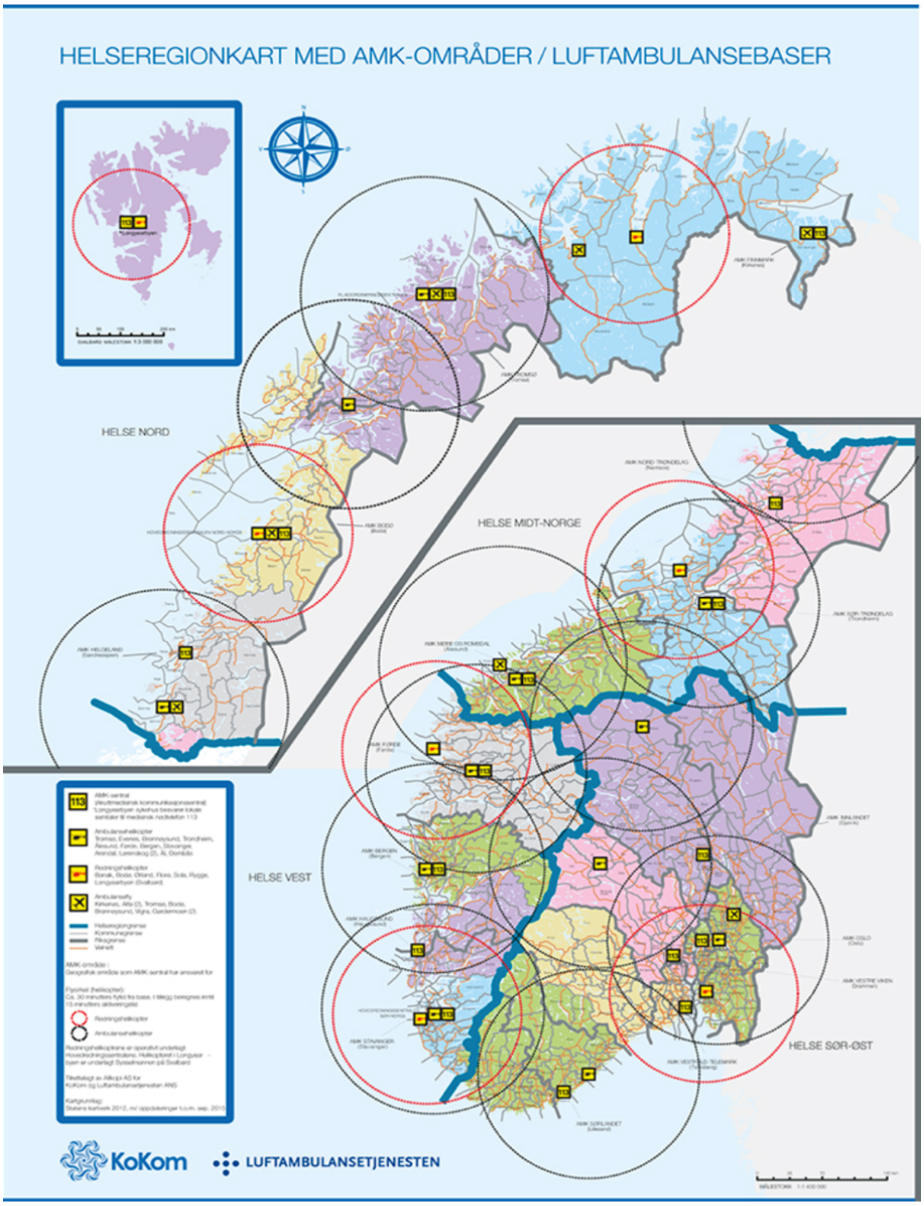

Figure 3 – Map depicting air ambulance bases in Norway. Circles indicating estimated 30 min flying time. In addition, there is an air ambulance base in Kirkenes, in the North-East of Norway not depicted on the map. From: Luftambulansetjenesten, reprinted with permission (21)

1.3 Definitions of major incidents and disasters

Defining major incidents and disasters remains challenging, as the definitions must capture the heterogeneity of incidents e.g. earthquakes, road traffic incidents (RTI) and terrorist attacks. Several definitions of both major incidents and disasters exist with minor variances, highlighting the lack of universally accepted definitions.

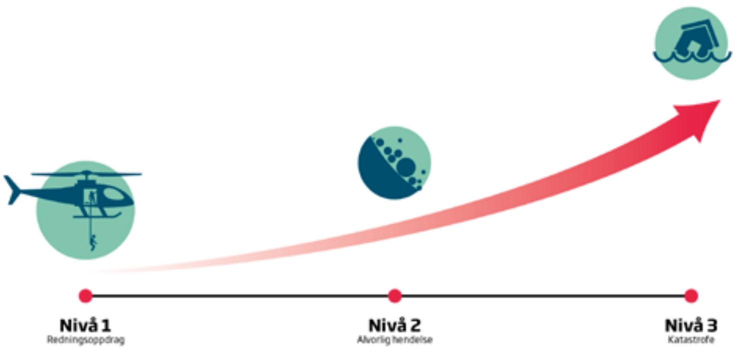

Figure 4 – Level of incidents. 1: ordinary, 2: high number of casualties (MI), 3: high number of dead and need of resources on national/international level (disaster). From Redningshandboka, reprinted with permission (25)

There is a dynamic and gradual transition from major incident to disaster as depicted in figure 4. The society may be capable of managing a major incident with the mobilization of extraordinary resources, but a disaster overwhelms the capacity and requires external assistance. What would be a major incident in one community may be a disaster in another due to vulnerability and reduced capacity to cope.

1.3.1 Definition of major incidents

Some selected definitions are outlined in table 1. The definitions from majorincidentreporting.net and Major Incident Medical Management and Support courses (MIMMS) definitions are similar in that they mention extraordinary resources.(32, 33) The Medical Response to Major Incidents and Disasters courses (MRMI) definition is different as it focuses on the organization of the resources involved.(34) The definition from the Norwegian research organization SINTEF is more detailed in what constitutes a major incident and was developed in a specific context; a summary of major incidents in Norway.(35)

Table 1 – Selected definitions of major incidents

majorincidentreporting.net (32)	*"Major Incident - an incident that requires the mobilization of extraordinary emergency medical services resources and is identified as a major incident in that system*"
Major Incident Medical Management and Support courses (MIMMS) (33)	*"In Health Service terms a major incident can be defined as any incident where the location, number, severity, or type of live casualties requires extraordinary resources"*
Medical Response to Major Incidents and Disasters courses (MRMI) (34)	*"Event that is so extensive or serious that the societal resources need to be organized, led, and managed in a special way"*
SINTEF (35)	*One of the following three criteria:* – *Five or more people deceased* – *Material damage of more than 30 mill NOK (2003), equivalent to 41,5 mill NOK / 3,9 mill EUR in 2020 (36, 37)* – *Extensive environmental damage*

No common definition of what constitutes a major incident has been established in the Scandinavian countries. The different governmental agencies provide more complex descriptions of what constitutes a major incident.

The Danish Emergency Medical Agency states: *"although relatively few major accidents and disasters occur, extraordinary incidents do take place. Man-made or natural, unpredicted or predicted - one feature all* *such incidents have in common is that they require an extraordinary response. Some incidents are so severe, extensive, prolonged, or complex that they require crisis management involving multiple authorities, both at national and local level."(38)*

The Swedish National Board of Health and Welfare defines a major incident as: "*special incidents where resources available do not meet the immediate demands, but where redistribution of resources may enable the maintenance of normal levels of quality."(39)*

The Norwegian Directorate of Health and JRCC state that it is not possible to give a precise definition of a major incident, but provides the following description: *"a mission with a high number of injured, complex evacuation or a demand for resources outside the catchment area. The level of when to use the term "major incident" will vary according to the resources available. Available resources will vary with time of day, time of the year, time of the week and natural variations in basic preparedness "according to geographical and demographical factors."(25, 40)*

The definitions, although not uniform in wording, provides a similar message; a major incident occurs when the circumstances require extraordinary resources, but may vary as to where and how it occurs.

1.3.2 Definition of disasters

Leading agencies within disaster management provide their own definitions with minor differences as described in table 2. Common for all definitions is that a disaster causes serious disruption to the community. The Emergency Events Database (EM-DAT) and The International Federation of Red Cross and Red Crescent Societies add that even with mobilisation of extraordinary resources the affected area still needs help at a national or even international level.(41, 42) Similar to the definition from SINTEF, the EM-DAT definition is developed for a database and is more detailed in what constitutes a disaster.

Table 2 – Selected definitions of disasters

United Nations Office for Disaster Risk Reduction (UNDRR) (43)	*"A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts."*
The Emergency Events Database (EM-DAT) (41)	*"A situation or event that overwhelms local capacity, necessitating a request at the national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering conforming to at least one of the following criteria:* – *10 or more people dead* – *100 or more people affected* – *The declaration of a state of emergency* – *A call for international assistance"*
The International Federation of Red Cross and Red Crescent Societies (42)	*"A sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's ability to cope using its own resources. Though often caused by nature, disasters can have human origins."*
EU Civil Protection Mechanism (44)	*"Any situation which has or may have a severe impact on people, the environment, or property, including cultural heritage."*

This thesis is linked with the majorincidentreporting.net project where Fattah et al. conducted an expert consensus meeting regarding major incident reporting that also provided a major incident definition.(32)

Given the absence of a commonly agreed definition and the coherence of this thesis with majorincidentreporting.net, the abovementioned definition was applied in the current thesis.

This inclusive definition allows for variances between services and locations. An incident may overwhelm the pre-hospital services in rural areas with limited resources, whereas urban, high-volume services will handle a similar incident without extraordinary mobilization.

The major incident definition deviates from e.g. EM-DAT in that all disasters are major incidents, but not all major incidents are disasters. Society may be capable of managing a major incident with the mobilization of extraordinary resources, but a disaster overwhelms the capacity and requires external assistance. The type of incident may also play a role; a Chemical, Biological, Radiological, Nuclear and explosive materials (CBRNe) event may qualify as a major incident although the number of injured may be low, as treatment and transport may be more challenging than in conventional incidents.(45)

1.4 Classification of major incidents and disasters

Major incidents and disasters may be further classified as:

- Natural vs man made
- Simple vs complex
- Compensated vs uncompensated

1.4.1 Natural vs man-made

The Centre for Research on the Epidemiology of Disasters (CRED) is a cooperation between the World Health Organization (WHO) and the Belgian government.(46) CRED provides EM-DAT, a database aiming to capture core data from disasters all over the world from 1900 to present date.(41) The classification of natural disasters in EM-DAT is made according to trigger hazard as shown in figure 5 where six different categories cover 17 subgroups. Some of the categories are sudden-onset disasters such as earthquakes (Haiti 2010 (47)), whereas others are slow-onset disasters like drought (India 2002 (48)).

In addition to collecting data from natural disasters, the database includes man-made disasters under the collective name technological disasters, capturing subgroups like industrial, transport and miscellaneous accidents.(49)

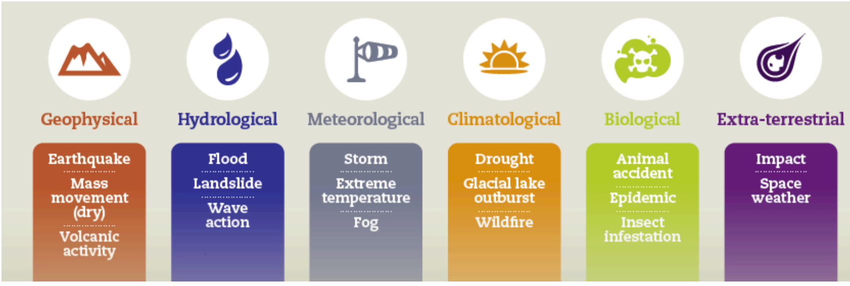

Figure 5 – Classification of natural hazards according to EM-DAT. Reprinted with permission (50)

Natural disasters are shaped by the vulnerability of the affected society and the measures of resilience. A recent example is the quick clay landslide in Gjerdrum, Norway 30th December 2020 with ten deceased. The Norwegian government appointed a commission of experts that will investigate the causes of the incident and concider measures to avoid similar incidents in the future.(51) There are increasing concerns that natural disasters will increase in number and magnitude due to climate change.(52)

1.4.2 Simple vs complex

In a simple incident, infrastructure like roads, hospitals and communication remain undamaged allowing for transportation of resources to the incident site and patients to the hospitals. When the incident becomes complex, infrastructure is damaged leaving rescue services, transportation, communication and other vital infrastructure inefficient.(33) An incident may start as a simple incident, but as the system becomes overwhelmed, it may turn into a complex incident.(53)

1.4.3 Compensated vs uncompensated

A compensated incident may be managed with mobilization of extraordinary resources. An uncompensated incident is an incident where the mobilization of all resources available are insufficient to cope with the number of affected people.(33) Uncompensated incidents are typically natural disasters where the mobilization of international support is needed. A compensated incident may become uncompensated as the situation deteriorates, or reversibly, an uncompensated incident may become compensated as more resources become available.(53)

1.5 Epidemiology of major incidents and disasters

In 1975, Prof. Lechat highlighted that emergency response to disasters would benefit from research and epidemiology to learn from past incidents, thereby easing the burden in future disasters.(54) WHO called for the 1990s to be the decade for disaster risk reduction fostering international cooperation.(55) Disaster epidemiology is the use of epidemiology to assess short- and long-term adverse health effects and to predict consequences of future disasters to provide scientifically sound information.(56, 57) This may be done through the disaster management cycle where the main phases are:

– Pre-disaster prevention and preparement strategies
– Emergency response in the disaster to prevent or reduce the number of deaths, injuries and affected
– Recovery phase for sustainable development (58)

This helps in understanding current needs, plan the response and gather the appropriate resources.

EM-DAT covers information of more than 22 000 disasters from 1900 - present from various sources like United Nations (UN), non-governmental organisations (NGO) and research institutes. The total numbers of injured and affected in this database remain imprecise and disaster costs are estimated.(41) No similar global database for major incidents exists given their heterogenous nature and dependency on available local resources. In the absence of an international database on major incidents, it remains challenging to provide a similar overview of major incidents. These incidents remain unrecorded or depicted in non-indexed literature thereby creating a barrier for international comparisons.(35, 59, 60)

1.5.1 Global major incident and disaster epidemiology

In the period 2000 - 2019, data from CRED and EM-DAT indicated that 7 348 disasters inflicted 1.23 million deaths, with more than 4 billion persons affected, where some individuals suffered from more than one disaster. The total cost was estimated to 2.97 trillion US dollar (technical and biological disasters not included).(50) Compared to the 4 212 disasters registered in the previous 20 years, this represents a sharp increase that partly may be explained in better recording but may also be due to climate change.(50) The human impact of deaths, affected and costs probably remain underestimated, especially on the African continent.(61)

As figure 6 shows, several disasters occurred in countries with high population density, such as the China and the Philippines, whereas the European countries are more spared. These densely populated countries have less developed HEMS systems to be used for major incident responses compared to European countries.(62)

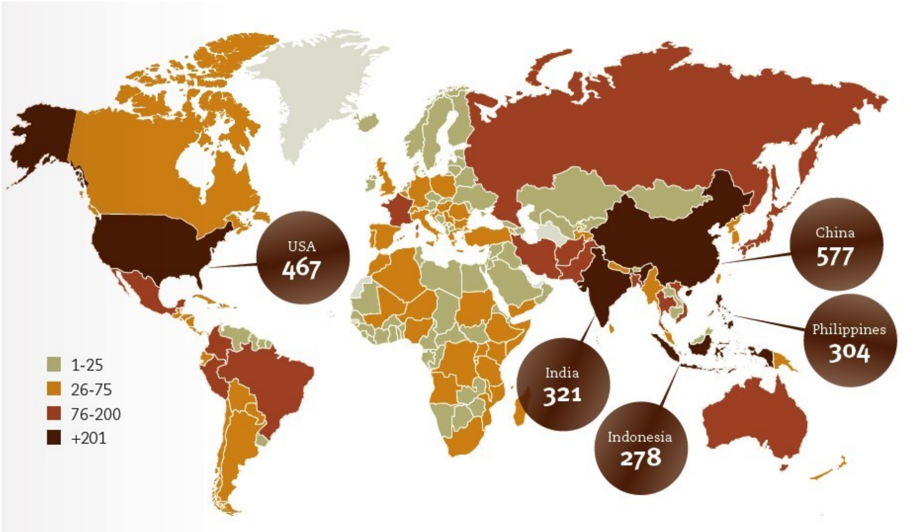

Figure 6 – Number of disaster events by country / territory 2000 - 2019, from CRED (technical and biological not included). Reprinted with permission (50)

Floods and storms are frequent disaster events with a total of 72% of the recorded natural disasters in the period. Three disasters inflicted more than 100 000 deaths (earthquake and tsunami in the Indian Ocean 2004, a storm in Myanmar 2008 and an earthquake in Haiti 2010) thereby heavily influencing the statistical average.(50)

Approximately one third of the disasters recorded in EM-DAT are technological disasters. In the time period 2000 - 2019 EM-DAT reported 5 143 technological disasters of which 3 532 were transport incidents. Industrial accidents accounted for 16% of the accidents but involved 64% of the affected victims. Transport accidents only reported 6% of the total number of affected.(49)

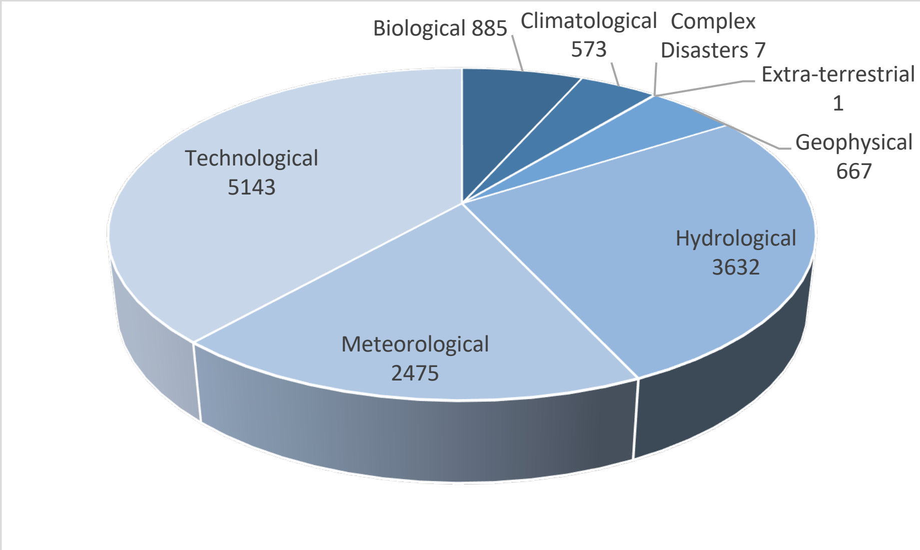

Figure 7 – Total number of disasters 2000 - 2019 according to disaster subgroup. Used with permission (63)

RTIs are found to be the leading cause of major incidents in some studies as they may involve multiple injured and occur in remote places, making them particular relevant for HEMS response.(64, 65) When WHO reported top ten global causes of death, RTIs remain the eight-leading cause of death.(66) In low- and middle-income countries RTIs are considered a burden when it comes to disability adjusted life years, but even in high-income countries, RTIs is a serious health care issue. The epidemiology of RTIs is important for identification of subgroups to target road traffic safety programs.(67)

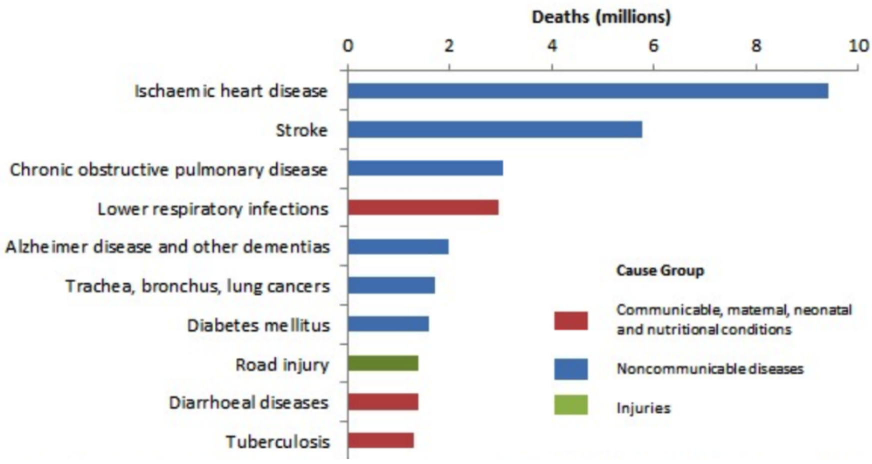

Figure 8 – Top ten global causes of death 2016, from WHO. Reprinted with permission (68)

1.5.2 European disaster epidemiology

In Europe, 1 552 disasters (including biological and technical) have been recorded in EM-DAT within the period of 2000-2019 causing an estimated 162 349 deaths, 14.9 million victims affected at an estimated cost of 233 billion USD.(63) Meteorological and hydrological disasters account for more than half of the disasters registered.

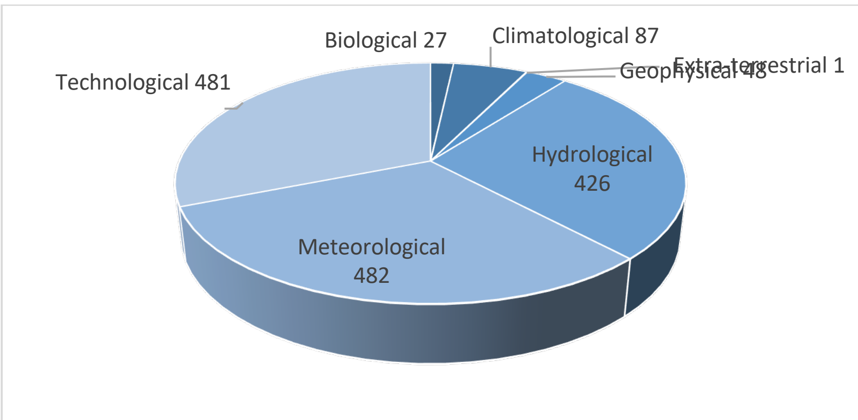

Figure 9 – Total number of disasters in Europe 2000 - 2019 according to disaster subgroup. Used with permission (63)

1.5.3 Scandinavian disaster epidemiology

In the Scandinavian countries, meteorological disasters (mainly storms) account for a majority of the 24 disasters recorded in the 20-year period. Only seven disasters registered affected persons and only five estimated costs.(63) These reported 78 deaths and 5 112 victims affected at an estimated cost of 4,4 billion US dollars.

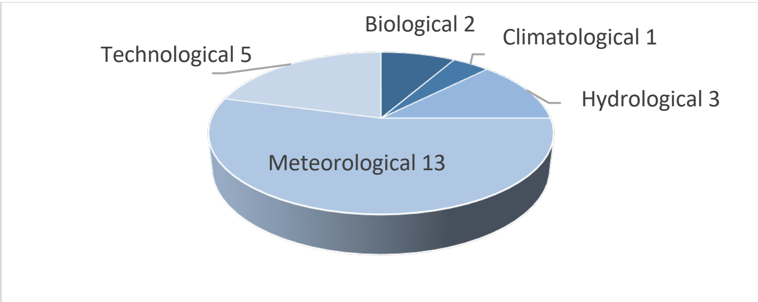

Figure 10 – Total number of disasters in the Scandinavian countries 2000 - 2019 according to disaster subgroup. Used with permission (63)

Two of the largest technological disasters in Scandinavia in the recent years include the fire on the Scandinavian Star ferry in 1990 with 159 deceased and the loss of the ferry Estonia in 1994 with 852 deceased. In both these incidents HEMS and SAR from different countries cooperated in the immediate disaster management.(69, 70)

1.5.4 Norwegian major incident and disaster epidemiology

Major incidents and disasters are rare in Norway. EM-DAT has registered nine disasters in Norway in the period 2000 - 2019 with three storms, two floods, one landslide and three transport disasters (one air, one railway and one water-related). There were 55 registered dead, 2 892 persons affected and an estimated cost of 130 million US dollar although only one disaster estimated cost.

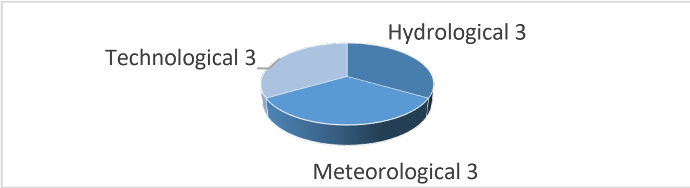

Figure 11 – Total number of disasters in Norway 2000 - 2019 according to disaster subgroup. Used with permission (63)

In 2003, the Norwegian research institute SINTEF published a report on major incidents in Norway 1970 - 2001 and described a total of 80 major incidents with 1 174 deceased.(35) As this report has a definition of major incident that deviates from the EM-DATs disaster definition the numbers and categories will vary.

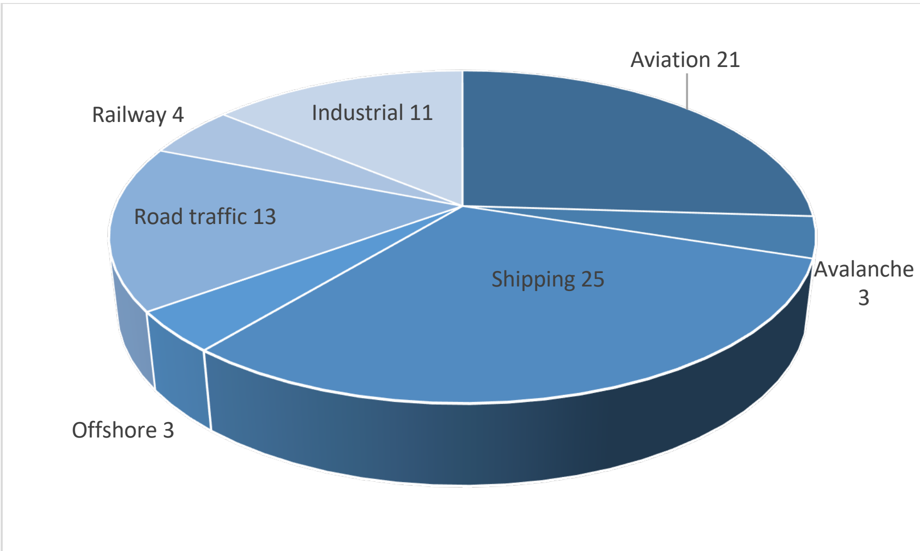

Figure 12 – Major incidents in Norway 1970 - 2001 according to SINTEF.(35)

Transportation accounts for a majority of the registered major incidents in Norway. Shipping and aviation dominate both in number of incidents and deceased (total of 783). The Scandinavian Star disaster in 1990 alone accounted for 159 deaths and a Russian airplane crash at Operafjellet, Svalbard in 1996 counted 141 deaths. Another incident with more than

100 deaths was the Alexander Kielland oilrig incident in 1980 where a drilling rig in the North Sea capsized and killed 123 workers.(35, 71) Both in the Scandinavian Star and the Alexander Kielland incidents SAR participated in the rescue of survivors.(70, 72) In the incident at Svalbard, a helicopter with two policemen and three health care workers were transported to the incident site with helicopter to search for survivors but all 141 passengers perished instantly.(73, 74)

In recent years, Europe has been hit by several terrorist attacks as seen in Paris, Madrid and London.(75-77) In Norway, the Utøya twin terror attack with a bomb explosion in Oslo governmental district and a shooting spree at a youth camp July 22th 2011 killed 77 people, many of them teenagers and stands as one of the most tragic incidents in Norway in recent time. HEMS participated with transportation of extra equipment and personnel, triage and treatment on-scene and transport of severely injured to hospital.(2, 78) The government appointed commission that investigated the response concluded that the EMS services had resources available and were well organized. Consultant anaesthesiologists from the HEMS services performed precise triage based on pre-existing knowledge on the structure of the hospitals in the region, triaging and transporting severely injured victims directly to Oslo University Hospital, Ullevål major trauma centre often using helicopters. The commission recognized challenges in communication and coordination and warranted the need for common guidelines for emergency services in disaster management. Further, they highlighted the risk posed by the armed perpetrator as a cause for delayed response on the island.(78) Mass-shootings remain a particular challenge to rescue personnel due to the threat posed by an armed perpetrator.(79) A national inter-disciplinary procedure for on-going life threatening incidents has been implemented with courses to address this challenge.(79)

The Norwegian Directorate for Civil Protection (DSB) publishes yearly reports of crisis scenarios, highlighting pandemics and lack of pharmaceutical products as the scenarios with highest risk. Norway is also increasingly more at risk for incidents like flooding and storms, due to climate changes.(80)

1.6 Response to major incidents and disasters

Operational principles of major incident management need to be recognised by decision-makers to appropriately plan preparedness and response for EMS and HEMS to provide optimal care to as many injured as possible.

1.6.1 Guidelines for major incident response

The American Incident Command System emerged in the 1970´s due to extensive forest fires. Their guidelines have played a central role in the response to several disasters.(81) A review on medical incident command found that experienced commanders were important and could not be fully compensated by guidelines. The review could not conclude on a superior command system.(82) Practices and guidelines developed in one culture may not work in other countries as the strategies that facilitates cooperation may not be transferrable.(83)

National guidelines for major incident management are available in Denmark and Norway.(38, 40) In Sweden, a project with the aim to establish best practice in major incident management published a report in 2020 to form a knowledge base for the different counties in the development of major incident guidelines. In principle, each county remains responsible for having an updated plan for major incident management.(84)

The beforementioned guidelines build on some common principles:

– Sector-responsibility; the agencies responsible for a similar type of incident in smaller scale will remain responsible in a major incident. E.g. HEMS will treat and transport the most critically injured in the incident.

- Cooperation; both public services and NGOs have a responsibility to cooperate in the rescue effort, both in the preparedness and incident management phases. E.g. both in major incidents and SAR missions HEMS may cooperate with NGOs like the Red Cross.
- Similarity; the organisational structure in major incident management should be equal to the daily structure. E.g. HEMS have the same responsibilities in a major incident as they have in everyday missions.(38, 40, 84)

Norwegian authorities have developed similar national guidelines for mass casualty triage (85), national trauma plan (86), CBRNe incidents (87) and on-going life threatening incidents.(79) These national guidelines allow inter-regional resources like HEMS to better achieve uniform inter-disciplinary recognition of triage priority, treatment and transport of major incident patients.(85)

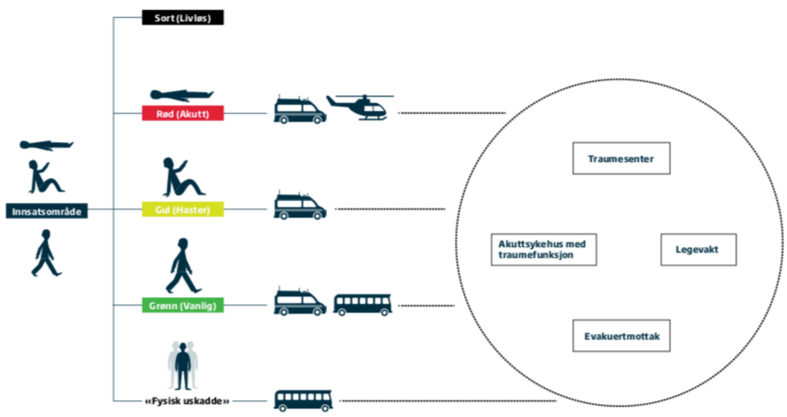

Figure 13 – Evacuation line in mass casualty triage (in Norwegian) emphasizing HEMS role in managing the red category of patients. From the national standard of mass casualty triage, Helsedirektoratet. Reprintet with permission (85)

The Best Practice Advice of the European HEMS and Air Ambulance Committee (EHAC) describes how HEMS and pre-hospital critical care teams may maximise the impact in major incidents. This report underlines the importance of up-to-date major incident plans. Further, it highlights that training of HEMS crews on major incident management should be coordinated with other rescue services to reflect the inter-disciplinary nature of major incident management as described in national guidelines.(88)

1.6.2 Global response to disasters

In complex and uncompensated disasters, local and national resources are overloaded and an international response may be warranted. A well-coordinated response is needed to avoid deficiencies and overlaps in delivered aid to ensure that the help benefits as many victims as possible and to avoid overflowing local authorities with unnecessary help. No organization can probably manage this alone. Several models for coordination of relief from NGOs exists, all with benefits and challenges.(89) One approach for coordination of complicated disaster responses is the UN cluster approach were groups of humanitarian organizations organize themselves into main groups of the disaster response. The aims are to provide clear leadership and structure in different areas of the humanitarian response and to strengthen preparedness and capacity of disaster response in cooperation with local and national authorities.(90)

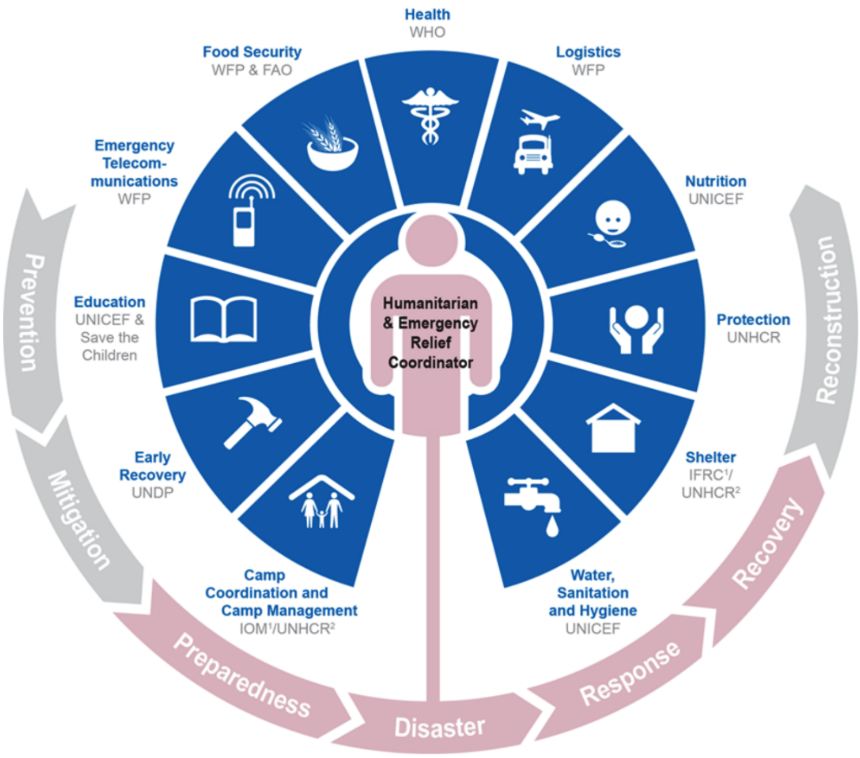

Figure 14 – Cluster approach to humanitarian response, with the UN organization responsible. Reprinted with the Creative Commons Attribution 4.0 international licence (90)

The cluster approach is applied to all kinds of disasters in cooperation with both governmental organizations and NGOs.(91) Some disasters require a complex response and when infrastructure is damaged there may be difficulties in rapid establishment of the cluster system.(92) The UN Office for the Coordination of Humanitarian Affairs (OCHA) often coordinates the international emergency response.(93) The North Atlantic Treaty Organization (NATO) established a similar Euro-Atlantic Disaster Response Coordination Centre in 1998 that coordinates requests and offers relief to disaster-stricken countries in cooperation with OCHA.(94) For the civilian-military collaboration to be a success, it is important with both knowledge on the skills of the staff, but also non-medical routines and logistics should be harmonized by mutual testing of systems and exercises.(95)

In resemblance of the cluster system, there exists a Civil Protection Mechanism within the European Union (EU) and cooperating states with the goal to strengthen cooperation between the member countries and improve prevention, preparedness and disaster response. By pooling the member states resources, they provide one, rather than many, contact points for the affected country. The mechanism also provides opportunities for help to build disaster resilience. They provide a training programme with large-scale exercises to build capacity within the teams. The capacities include firefighting planes and helicopters, medical evacuation and field hospitals and various experts capable of helping with assessments of the needs in the disaster response.(96) In 2018, large forest fires in Sweden launched a European Civil Protection operation with the mobilisation of 360 firefighting personnel, seven planes, six helicopters and 67 vehicles from seven member countries.(97)

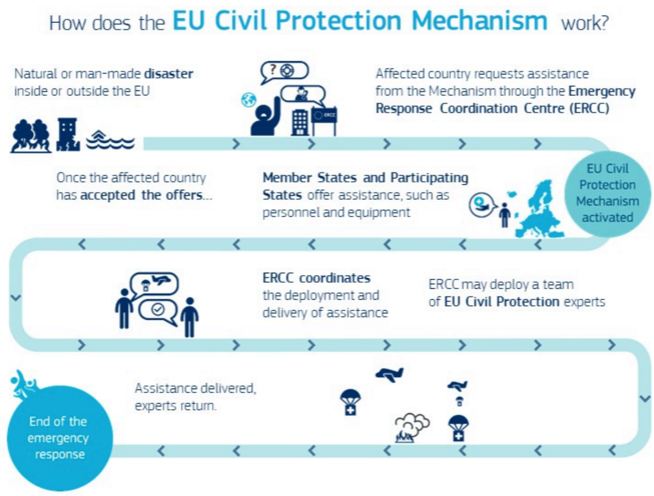

Figure 15 – EU Civil Protection Mechanism. Illustration: EU/ECHO. Reprinted with the permission granted from the copyright note (96)

1.6.3 Scandinavian response to major incidents and disasters

The major incident response in Scandinavia is based on a cooperation between EMS services, NGOs and private companies.(40, 98, 99) The main rescue services coordinate leadership on-scene, where the police have the overall coordinating role. According to the principles of sector-responsibility and similarity, the different rescue services carry their normal responsibilities during the management of a major incident, aiming to maintain a structure similar to the daily routine. The main rescue services coordinates their work in a multi agency incident command for exchange of information and experiences.(40)

The national guidelines in Norway and Denmark do not specifically mention who has the authority to declare a major incident, but the police has the overall authority on-scene and the EMCC may declare a major incident based on the report from the incident scene. Equally important in this system is the ability to scale down when the need for resources decreases. Sweden has a concept of “Serviceman on call” that gets a notification of possible major incidents and carries the responsibility for overall coordination.(38, 40, 100)

In Norway, the medical responsibility is divided between the medical incident commander, usually an experienced paramedic that coordinates medical resources and the medical command physician often responsible for triage and treatment of patients on-scene and in the casualty clearing station. The role of HEMS is not specifically described in the major incident guidelines, but the main principles of similarity, sector-responsibility and cooperation makes HEMS a natural part of major incident management.(40) HEMS doctors are often experienced consultant anaesthesiologists thereby taking on the responsibility as medical command physician. This creates a dilemma for the HEMS crew of whether to stay and manage the scene or transport patients to definitive care.(2) The inter-disciplinary communication system Terrestrial trunked radio (TETRA) enables coordination between all relevant agencies across of health regions.(40, 101)

The Danish guidelines have descriptions on the use of drones and establishment of helicopter landing sites but do not mention HEMS responsibilities specifically.(98)

Unlike the national guidelines in Norway and Denmark, the Swedish guidelines are region-oriented. HEMS is mentioned in the guidelines for disaster management in Stockholm where the fire services are responsible for creating a landing site, but specific tasks for HEMS remain undescribed.(99)

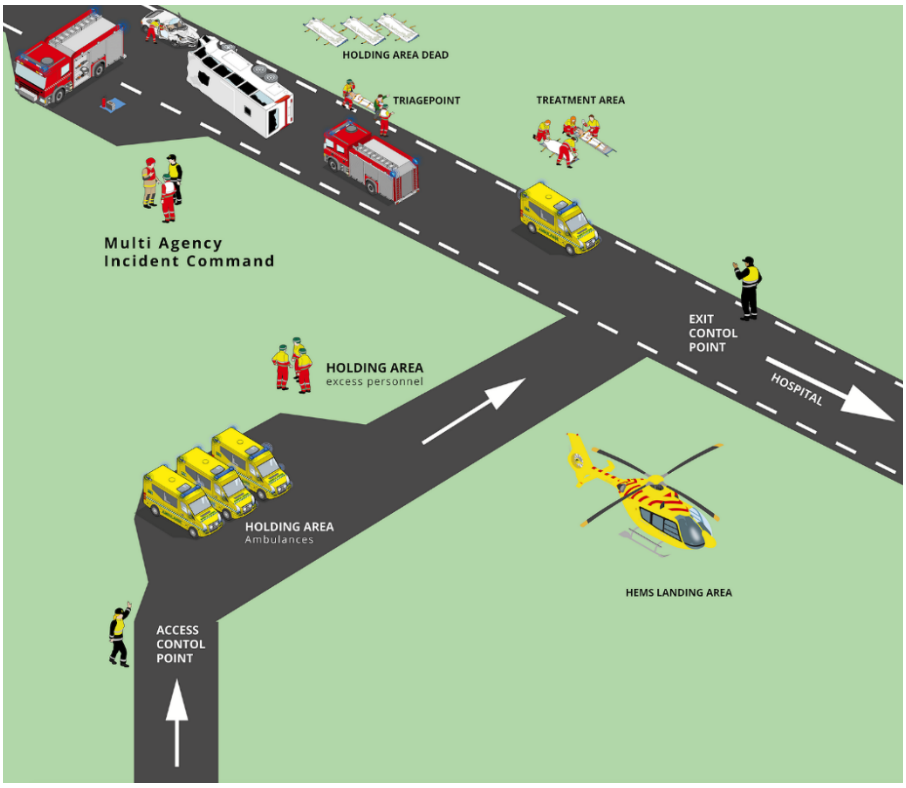

Figure 16 – Example of command structure and organization of the emergency services in major incidents in Norway. J.Strand, NAAF, reprinted with permission

1.6.4 HEMS response to major incidents and disasters

The use of HEMS in previous major incidents has been described as a beneficial asset to the pre-hospital response.(2, 75, 102) A report from the Federal Aviation Administration (FAA) in the United States described 18 major incidents and disasters with helicopter involvement in the rescue work and outlined several functions and challenges for HEMS.(103) They recommended that disaster planners should consider how and when helicopters should be used in disaster operations, highlighting that communication remains a challenge and called for a structured command and control system.(103) An advisory circular report followed in 1998 and highlighted the importance of integrating HEMS into disaster management plans.(104)

HEMS role in major incident management is integrated in the medical response and include swift deployment of extra staff and equipment, medical treatment, triage, air surveillance, search and rescue, access to remote sites and medical evacuation.(88, 105)

Although the use of HEMS may be beneficial, challenges were also associated with the use of HEMS:(103)

– Coordinating helicopter activity with multiple units in an uncontrolled airspace (2, 106)
– Challenges with communication (2, 3)
– Landing zone setup (107)
– Poor weather conditions (108, 109)
– Rotorwash and aircraft noise interfering with ground communication and operations (106, 110)

1.6.5 Building resilience for major incident and disaster risk reduction

Resilience, in the context of disaster risk, is the ability of a society exposed to various hazards to resist or adapt to and recover from the effects of this hazard in an efficient manner.(111) The UN general assembly endorsed the Sendai Framework in 2015 that aims for: a "*substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries."(112)*

Resilience is related to capacity, strengths and resources available to cope with the challenges and coping capacity, i.e. the ability to face disasters. It does not only relate to the emergency services, but also to economic and cultural assets. Among trends to measure resilience is technological capacity, political structure and infrastructure.(111)

(VULNERABILITY + HAZARD) / CAPACITY = DISASTER (42)

When a hazard strikes a vulnerable population and their capacity to cope is exceeded, a disaster emerges. Disasters are to some extent determined by insufficient human action and preparedness.(113)

Increased resilience makes systems and communities more robust to handle disasters and major incidents and includes a wider range of stakeholders than traditional preparedness.(114)

Disaster risk reduction policy coincides with the concept of resilience with the goals to:

- Understand and prevent risks
- Share experiences and learn from other communities
- Work in coordination across sectors that not necessarily cooperate under normal conditions
- Include the most vulnerable in planning, including low-income or small countries that are at risk for major incidents or disasters (111)

Complex natural disasters, such as the 2004 tsunami have raised awareness of the need for prevention initiatives like tsunami warning systems.(115)

The principle of similarity in major incidents makes the system robust as HEMS already is an integrated part of EMS response in Norway. A nationally coordinated HEMS improves resilience by increasing the ability to respond across regions. HEMS have the capacity to rapidly mobilize and enhance resources in remote areas thereby reducing the time in a decompensated phase.

1.7 Research on HEMS in major incidents and disasters

The need to integrate HEMS into major incident and disaster response has been highlighted previously, but the question on optimal use remains scarcely described in structured research.(88, 104) Heterogenous case reports and evaluations dominate both indexed and non-indexed literature.(2, 78, 116)

1.7.1 HEMS research in general

The effect of HEMS in general remains somewhat controversial with studies either praising or condemning the service.(14) Endpoints in HEMS research may be divided into patient related outcomes (e.g. death or disability), and system focused outcomes (e.g. transport times, transport of special patient categories or crew configuration).(14, 117, 118) Systematic reviews have not been able to establish the link between physician-staffed HEMS and its impact on mortality or quality of life due to the heterogeneity of the included articles highlighting the need for more structured research.(119, 120) A review article from 2019 regarding HEMS research articles from 1972-2017 identified over 1 700 articles appearing in over 370 journals, where 112 articles (6,5%) were related to pre-hospital and disaster medicine. The number of publications increased in the new millennium.(121)

1.7.2 Major incident and disaster research

Major incidents and disasters are infrequent, heterogeneous events. The gold standard of most medical clinical research is the randomized controlled trial. This study design is challenging to apply to interventions performed in major incident management. Accordingly, major incident decision-making is hard to base on high quality research.(122) Study designs like computer simulation and exercises may be designed as prospective trials with randomisation of strategies, but the transferability to real incidents may be limited.(122) Further, terminology and definitions in major incident and disaster management should be as precise and uniform as possible before designing surveillance and data collection systems.(123)

The Sendai Framework established a research network for health emergencies and disaster risk management in 2016 and an expert meeting in 2018 identified key areas for further research. Among the areas mentioned was health data management before, during and after a disaster with the WHO Emergency Medical Team Minimum Data Set. This enables standardized data collections by emergency medical teams but implementation remains a challenge. In addition, research methods and ethics were mentioned and standarisation of definitions and research methods were considered important to move beyond case study design.(124)

Epidemiological research on disasters has led to more effective prevention strategies, such as housing in tornado areas and warning systems for flooding, but evidence on how to manage scarce resources remain low.(122, 125) Further, it is important to depict what assets are needed in the acute phase of the incident, and what the needs are in the aftermath. Both short- and long-term health effects are difficult to assess and more structured research on populations in major incidents and disasters are warranted to build better resilience.(126)

Given the variations in health systems where HEMS operate, study findings of e.g. risks and cost-benefits are difficult to extrapolate.(15, 127) The challenge of HEMS in major incident management research is both that major incidents and HEMS and EMS systems are heterogenous making data comparison challenging. Key lessons from one system are not necessarily transferrable to another.(83)

1.7.3 Need for standardized reporting

A thesis by Fattah developed a consensus-based template for reporting of major incidents and incorporated it into the website majorincidentreporting.net. The aim was to create a global, open-access website for reporting and reading reports from major incidents. The challenge of recruiting reports was highlighted.(128) A pilot study of the first reports indicated that systematic reporting could identify trends and common lessons learnt, but the sample size was too small to draw definitive conclusions.(129)

In 1963, Swedish authorities recognized the knowledge gap on major incident management and formed a committee of disaster medicine (KAMEDO). The main aim was to send observers to major incidents and disasters with the task of collecting knowledge and presenting them in KAMEDO-reports. The reports are thorough, but not necessarily structured in a homogenous way. The first 35 years are summarized in KAMEDO report nr 73 and the communication and media coverage in report 60-98 (1993-2013) are summarized in a separate report.(72, 130)

DISAST-CIR, Disastrous Incidents Systematic Analysis Through Components, Interactions, Results, is a tool developed by the medical department of the Israeli Home Front Command that collect and analyse relevant data related to disaster management. In a similar manner, medical personnel from the Israeli Homefront Command are sent to the disaster zone to collect information for the operating centre and pass important information back to the EMS personnel. During debriefing, data is collected in a structured way with description of the incident, response and interaction of the participating agencies.(131) No pubmed-indexed publications from this source has been released in recent years.

The examples mentioned above, all represent different attempts for structured data collection in major incidents. New publications emerge with structured templates, but it still remains for the EMS community to agree on a common and structured template and recruit reports to a database.(132)

2 Aims of the thesis

2.1 Overall aim of the thesis

This thesis focused on HEMS response to sudden-onset major incidents. As such, the aim was to collect existing relevant literature (article I), experiences from Norwegian HEMS crew members (article II) and depict operational aspects from HEMS reports (article IV). The Delphi study (article III) with the HEMS template aimed to create a structured system for a prospective observational data collection. With article IV the aim was further to test the feasibility of this template. The overall aim was to create an overview of and to help create a more robust system of HEMS in sudden-onset major incident management.

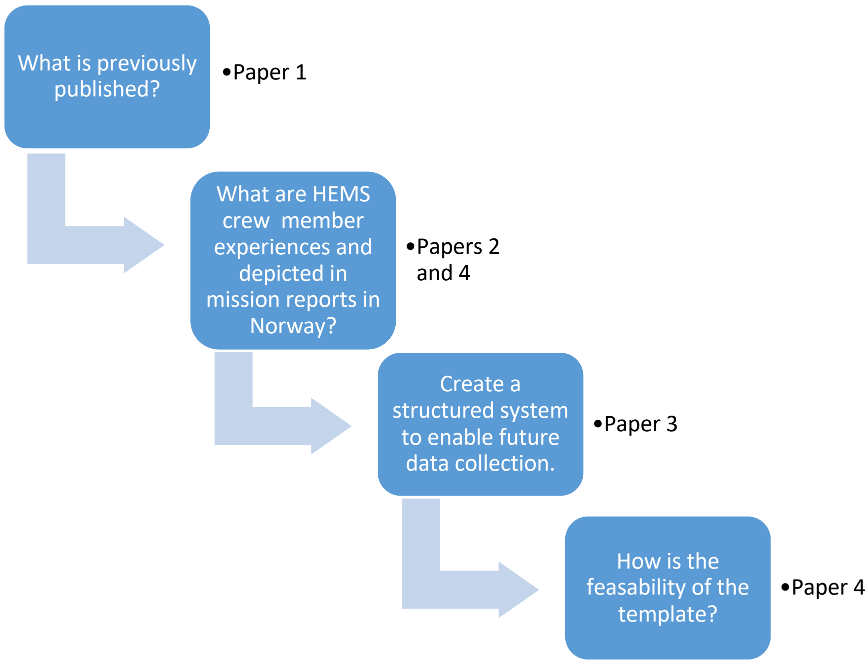

Figure 17 – Coherence of the aims in the articles

2.2 Paper I – Systematic review

Paper I aimed to systematically identify, extract data and appraise the quality of literature on HEMS involvement in major incidents. We wanted to provide an overview of literature on the topic and no limitations were applied with regard to type of study design. Given the nature of the included papers, a meta-analysis was not applicable.

2.3 Paper II – Cross-sectional study

Paper II aimed to describe experiences with major incident management, preparedness and training among all doctors, rescue paramedics and pilots in Norwegian HEMS and SAR. Further, it aimed to identify areas of improvement for major incident response. Such knowledge could be used for developing relevant training programmes and guidelines for major incident management.

2.4 Paper III – Delphi study

Paper III aimed to develop a consensus-based template based on expert opinion for reporting on HEMS use in major incidents. Paper I identified a lack of systematic reporting. Therefore, we aimed to construct a platform for both future research and a place where clinicians could freely access case reports. Prospective, uniform reporting using a consensus-based template could facilitate exchange of experiences as well as systematic collection and analysis of data.

2.5 Paper IV – Retrospective observational study

Paper IV aimed to test the feasibility of the HEMS template (paper III) by applying it in retrospect to real-life incidents with Norwegian HEMS/SAR participation. We aimed to systematically report major incident characteristics, HEMS role and tasks, challenges faced and patient characteristics.

3 Methods and materials

3.1 Research design

Table 3 – Historical timeline of the articles

Timeline	2013-2016	2013-2017	2015-2016	2016-2020
Paper number	I	II	III	IV
Design	Systematic review	Cross-sectional study	Delphi study	Retrospective observational study
Publication	2016	2017	2016	2020

This thesis consists of four papers applying different methodologies. It starts with a systematic review to provide a literature overview, then follows a cross-sectional study describing Norwegian HEMS crew member experiences, a Delphi study for prospective data collection and finally a retrospective observational study of major incidents in Norway with HEMS involvement.

3.1.1 Guidelines and protocols

The systematic review, cross-sectional study and retrospective observational study used guidelines from EQUATOR, (Enhancing the QUAlity and Transparency Of health Research) network as a help in sustaining rigour throughout the research process.(133, 134) The Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) statement for systematic reviews with a 27-item checklist was relevant in the first study and the Cochrane Handbook for Systematic reviews of interventions was consulted.(135, 136) The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement for reporting observational studies were relevant in the second and fourth study.(135, 137) The Delphi method has no clear guideline and some studies make modifications to the technique.(138) A clear analysis plan in the protocol sought to compensate for the lack of guidelines and made the study findings more credible and reduced the risk for data-driven decisions.

The protocol for the systematic review was published in PROSPERO (CRD42013004473) and in BMJ Open for other researchers to identify prior to initiating new projects to prevent unnecessary duplications.(139)

3.1.2 Paper I – Systematic review

The systematic review summarizes results of available healthcare studies, mainly controlled trials, and provides a high level of evidence on the effectiveness of healthcare interventions.(136)

Paper I collected information that fitted pre-specified eligibility criteria in order to assess a specific research question. When planning the review, the mnemonic "PICO"; Population, Intervention, Comparison, Outcome, was used to structure the research question and inclusion of studies.(136) In this thesis the research question was "What has been published regarding utilisation of HEMS in major incidents?", with the PICO structured as following:

Table 4 – PICO questions

Population	All HEMS/SAR crews involved in major incidents
Intervention	Use of HEMS in major incidents
Comparison	Other emergency medical services
Outcome	Description of HEMS involvement in major incidents

3.1.3 Paper II – Cross-sectional study

The cross-sectional study is an observational study that measures the participants experiences or exposures and may estimate a prevalence of this.(140)

The cross-sectional method was chosen as there was no hypothesis in the protocol. We described experiences of a population with the purpose of finding the prevalence of the studied outcome, in this case the HEMS crew members experiences in major incidents.(141, 142) We collected the experiences of HEMS/SAR crew members in Norway in a structured questionnaire.

3.1.4 Paper III – Delphi study

The Delphi survey technique is a qualitative method that systematically collect and aggregate opinions from the participants.(143) The method is chosen to transform expert opinions into group consensus through a series of structured questions and is a method used in areas with lack of structured research as depicted in study I.(138)

In paper III, there was a clearly defined research problem; i.e. to define data variables suitable for a HEMS-specific major incident template for the immediate pre-hospital medical response to a major incident. The participants were chosen in a transparent manner and the rounds were structured a-priori.(138)

3.1.5 Paper IV – Retrospective observational study

The retrospective observational study is a study that aims to estimate the incidence of major incidents in data from medical records.(140) As major incidents are rare, this methodology allow us to depict trends quicker compared to a prospective design.

Data were collected from the medical records in the LABAS database, where the HEMS/SAR crews report their missions. This complements the data from study II by viewing Norwegian HEMS participation in major incidents from another angle.

3.1.6 Triangulation

Basic geometry informs us that multiple viewpoints allow for greater accuracy. The metaphor triangulation derives from navigation and military strategy using multiple reference points to locate an exact position.(144) Denzin divided triangulation into "between methods" – two or more different methods that yield comparable data and "within methods" – where different techniques are used within a method to collect and understand the data.(144, 145) The research question in this thesis is triangulated by applying multiple research methods with the potential to provide more information and increase the validity of conclusions.

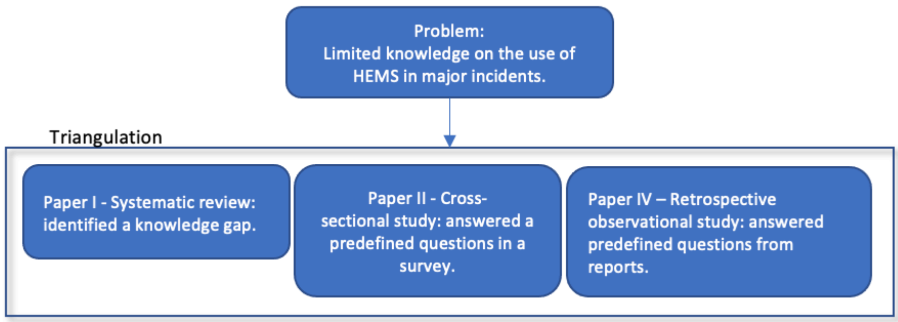

Figure 18 – Triangulation of the question "HEMS roles in sudden-onset major incident management"

3.2 Study population and data sources

The participants in this thesis were Norwegian HEMS/SAR crew members (paper II) and European pre-hospital researchers (paper III). The data sources included a systematic literature search (paper I) and the recorded mission journals written by the HEMS/SAR doctors on selected HEMS/SAR bases in Norway (paper IV).

In the systematic review, all literature stating that their incident was considered a major incident was included, not necessarily providing a definition to avoid exclusion of possible relevant studies.

The study population in the cross-sectional survey included HEMS/SAR crew members; doctors, pilots and rescue paramedics on all HEMS and SAR bases in Norway. By including different occupational groups, we captured a broad perspective of HEMS and SAR use in major incidents and the crew members experiences. The optimal sample size in a cross-sectional survey is difficult to estimate, but the invited crew members constituted the entire crew of pilots, rescue paramedics and doctors working in Norway; thereby approaching a national survey-design. The flight nurses, mechanics and radar operators working on some bases in Norway were left out as they are limited in numbers and profession specific questions would be hard to anonymize.

The participants in paper III were current or former HEMS doctors recruited through the European Prehospital Research Alliance (EUPHOREA) network, an informal network of European researchers within the field of pre-hospital critical care.(146)

In paper IV, the HEMS bases at Lørenskog, Arendal and Ål and the SAR base at Rygge represented urban, rural and coastal areas in south – east Norway and were chosen to be representative of Norwegian HEMS. Aborted missions were excluded as they lacked detailed information on the incident and people involved.

3.3 Setting

The setting in this thesis was web-based as both the cross-sectional study and the Delphi study were communicated by e-mail, and the medical records in the retrospective observational study were electronical.

In the systematic review, Endnote bibliographic database (2011; Thomson Reuters, USA) was used to systematically search all the titles and abstracts. The chosen studies were carefully read by the authors in pairs for data extraction and quality appraisal.

In the cross-sectional study, we used the survey platform that cooperates with University of Stavanger, SurveyXact (Rambøll Consulting, Oslo). The author group consisted of three doctors, a rescue paramedic and a pilot to represent the real crew setting and to ensure that questions in the survey were formulated in a clear manner for the entire crew. Some questions in the survey were occupation specific, answered only by doctors, rescue paramedics and pilots respectively and the program was designed to collapse non-relevant questions. The authors piloted the questionnaire on the survey platform prior to sending it to the participants on their work e-mail. To strive for a high response rate, the participants received a welcoming letter explaining the background of the survey one week before the questionnaire was launched and two reminders were sent afterwards.

In the Delphi study, the interaction went through e-mail with five rounds. The results from each round were summarized, categorized and communicated back to the participants that resulted in a consensus-based template.

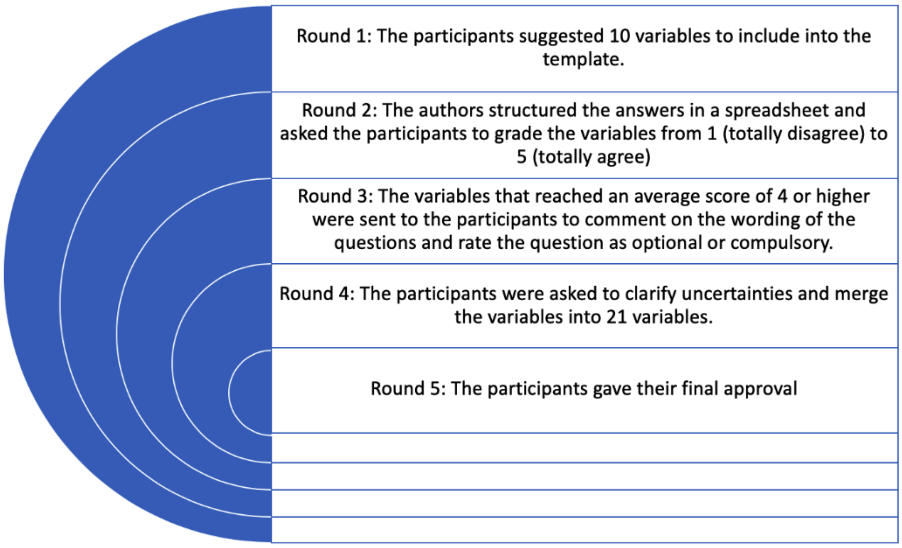

Figure 19 – The structured rounds in the Delphi study

In the retrospective observational study, some of the missions were eliminated based on the International Classification of Diseases and Related Health Problems (ICD) diagnosis and one author (ASJ) screened the remaining and eliminated the incidents clearly not fitting the major incident definition. The remaining incidents were evaluated by MR and MS, and in cases with divergent opinions, SJS weighed in and consensus was sought through discussion.

3.4 Data variables

The variables in the questionnaire in paper II and the variables in paper III were developed through consensus as there are, to our knowledge, no existing validated questionnaires on the topic. Some questions in paper II were presented with a Likert scale from 1- 5.(147) In both papers the variables were stratified into categories: HEMS/SAR characteristics, major incident characteristics, major incident response and patient characteristics. These categories are also reflected in the data extrication seen in the systematic review and were also used in paper IV to investigate to what extent variables could be reproduced from LABAS.

In paper IV the severity of the injured patients was given as a National Advisory Committee on Aeronautics (NACA) severity score. This ranges from zero (uninjured) to seven (lethal injuries) and has been used in the Norwegian air ambulance services since the 1980s. The score is shown to predict mortality and needs for interventions with reasonable accuracy.(148)

Table 5 – Common main data variables included in the papers in this thesis. MI: Major incident

Paper number	**I**	**II**	**III**	**IV**
Demography				
Basic info affected area / other pre-event info	X			
HEMS and HEMS crew description				
HEMS service area /crew combination	X		X	
Pre-planned role of HEMS physician / crew			X	
Experience with leading roles in MIs		X	X	
Rating MI competences / courses / exercises		X		
Incident characteristics and response				
Time / date / timeline for response	X	X	X	X
Location / description of the MI	X	X		X
Scene access / distance to hospital	X		X	X
Weather conditions		X		X
Scene safety / hazards	X	X	X	X
Participating agencies	X	X		X
Communication / coordination	X	X		
HEMS first EMS team / first physician?			X	X
HEMS: nr of crews / nr of flights	X	X	X	X
Bring extra personnel /equipment	X	X	X	X
What tasks did HEMS perform	X	X	X	X
Number patients treated / transported by HEMS	X		X	X

Reason for inoperable HEMS			X	
Other incident / HEMS characteristics	X	X		X
Patient characteristics				
Number of involved / deceased / injured	X			X
Age group	X			X
Dominating injuries / severity classification	X	X	X	X
Triage	X	X		X
Key lessons		X	X	X

3.5 Statistics

Data was entered into Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) spread sheets in all the papers. In paper II, SurveyXact provided a file of data directly transferrable to IBM SPSS for statistics version 25 (IBM, Armonk, NY, USA) for further analysis. SPSS was also used in the paper IV.

In papers II and IV, categorical data were presented as counts (n) and proportions (%) and continuous data were presented as medians with quartiles as data did not display normal distribution. Missing data were presented in brackets in study IV for transparency thereby highlighting that some fields suffered from significant proportion of missing data.

The Kruskal-Wallis nonparametric test was used in study IV when testing differences in response times, number of people involved, injured, dead on-scene and treated by HEMS/SAR between urban and non-urban (rural, semi-rural, alpine, maritime) incidents. The test was chosen as we had one nominal and one measurement variable where the last-mentioned did not meet the normality assumption.(149)

3.6 Ethical and legal considerations

Research conducted today need to be reviewed by ethical committees to ensure that ethical standards are followed and that research individuals are treated well.(150) In disaster settings, extraordinary circumstances require regulations that ensure protection of humans involved, both victims and researchers. A systematic review of ethical guidelines in research in disaster settings identified 14 guidelines where most had a narrow scope on particular research activities, not portraying the researcher overview on how to conduct ethically sound studies. Vulnerability of research subjects and risks involved in the disaster research were highlighted as core themes.(151)

In paper II, the Regional Committee for Ethics in Medical Research concluded that ethical approval was not needed (2014/720/REK Sør-Øst D) and the Norwegian Social Science Data Services approved the study (38408). As it was an anonymous survey, written consent was not considered necessary. A personal privacy and ethical approval disclaimer was enclosed in the first e-mail.

In paper IV, the Regional Committee for Ethics in Medical Research concluded that ethical approval was not needed and gave exemption from the duty of confidentiality with the condition that no person would be recognizable. (2017/2175-3 and 2017/2148-3 REK Sør-Øst) The Norwegian Social Science Data Services concluded that no approval was needed for the study (60670/3/HJP/LR) and the data protection officers from three local health enterprises responsible for the respective HEMS/SAR services gave their permissions.

Both the main major incident report and the HEMS major incident report developed in paper III were incorporated into the website majorincidentreporting.net.(32) The HEMS template is not considered a health registry, as individuals may not directly be identified and variables with less than five individuals are not reported. The legal approval for the data registry was granted by the Norwegian Data Protection Agency (written confirmation dated 28.05.14). The authors of the reports have to follow local ethical regulation when submitting reports to the database. In addition, authors sign a disclaimer which clarifies the responsibilities of the content and the reports undergo a peer-review and editorial process before publication to ensure the quality of the content, to further reduce risk of publishing information violating personal privacy.

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4 Results

4.1 Summary of results

The systematic review, cross-sectional and retrospective observational studies together described common major incident characteristics, tasks and challenges for the HEMS participating in sudden-onset major incident management. The template from the Delphi study provided an opportunity for structured prospective data gathering that was tested in the retrospective observational study.

Table 6 – Summary of papers

Paper	Main findings
1	Included 42 articles with weak methodology. Described HEMS used for treatment, triage and transport, especially when infrastructure was damaged and from incidents in rural areas. Communication and safety issues including air crowding were reoccurring challenges.
2	RTI and rural areas most frequent, blunt trauma dominated. HEMS personnel were experienced with tasks of triage, treatment, transport and coordination of other HEMS units. Challenges were communication. A call for more exercises with focus on major incident management, communication and coordination.
3	21 variables included in 4 categories: HEMS background, major incident characteristics, HEMS response and key lessons learned. Incorporated into the website majorincidentreporting.net as both a separate and an add-on template for reporting.
4	50 incidents. RTI and rural areas most frequent. HEMS/SAR played diverse role with interdisciplinary coorporation. Treated more severely injured patients than they transported to trauma care. Weather and lack of designated landing site were challenges. Some information were hard to collect as a majority of information were collected in the free-text area.

4.2 Paper I – Systematic review

The literature search identified previous research fitting the eligibility criteria and provided an overview of published literature and included a total of 42 articles.

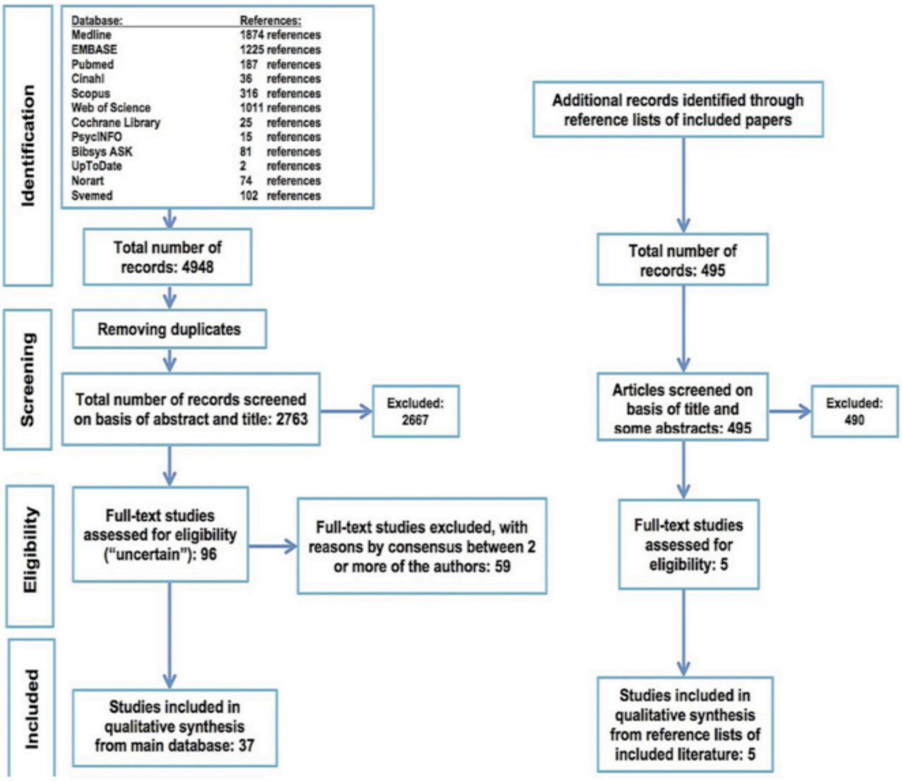

Figure 20 – Prisma diagram for article I (152)

The methodologies applied in the included articles were weak: 35 case reports, four case reports reporting more than one incident (seven, four, two and two incidents respectively), one commentary of a case report and two prospective observational studies.

Only seven articles mentioned a major incident or a disaster definition, all different in wording but with similar message: "an incident without enough resources".(3, 106, 153-157)

Data extrication and quality appraisal were conducted according to the a-priori published protocol.(139) None of the included articles contained all variables in the data extrication list.

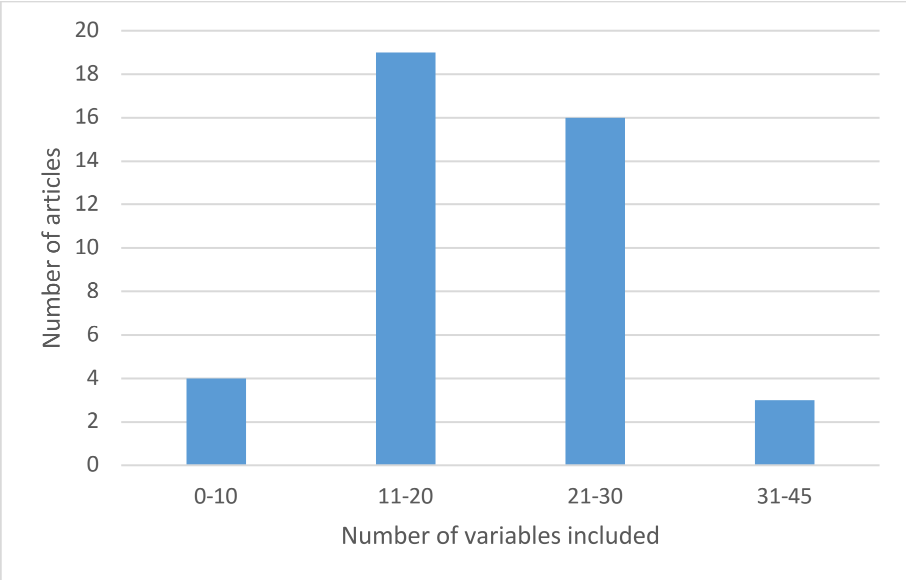

Figure 21 – Number of data variables in the included articles

The incidents described were heterogenous in nature. Incident characteristics were described in all articles and no article had all incident variables included, but most of included articles provided a good overview of the incidents that ranged from natural disasters like earthquakes to RTIs. Of the included incidents, 12 were related to the weather, where 11 were geophysical or hydrological disasters (tropical storms, hurricanes and earthquakes). Transport incidents were described in 19, terrorist attacks in seven, fires in four, natural gas explosions in two and one described a riot.

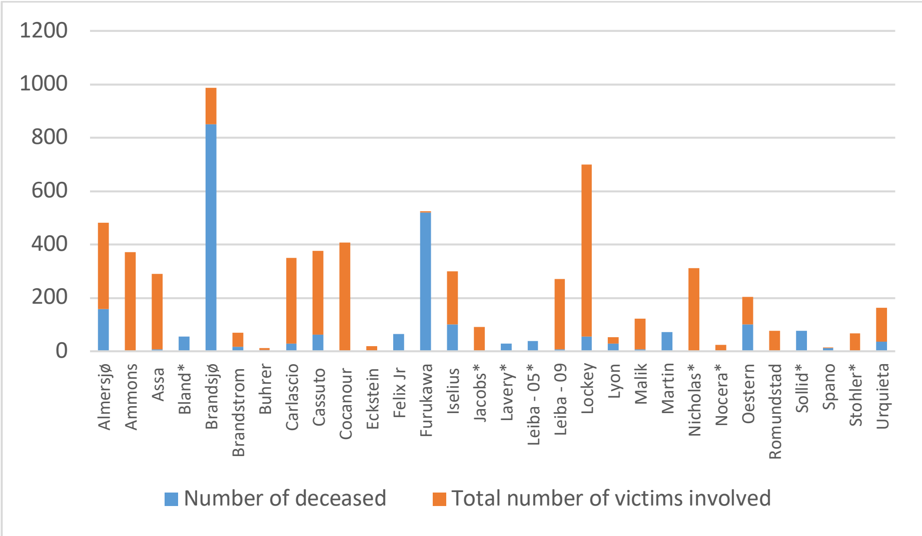

Figure 22 – Total number of victims and deceased in the articles mentioning less than 1000 involved. * marks lack of reporting either number of deceased or victims involved

Of the included articles, six did not have an exact number of victims and deceased and 13 did not mention the total number of victims. There were six articles with more than 1000 victims, five natural disasters and one hotel fire.(106, 158-162)

The weather was mentioned in 18 of the articles, mainly relating to earthquakes(159, 163-165), hurricanes and flooding (158, 160-162, 166), where HEMS were an added benefit due to damaged infrastructure. The KAMEDO-reports relating to the loss of the ferries Sleipner and Estonia described bad weather at sea where HEMS hoisted victims from the water and transported them ashore and to hospitals.(4, 69)

The declaration of the major incident was described in 14 articles, of which JRCC/EMCC declared in four(2, 69, 70, 167), hospitals in seven (4, 131, 158, 160, 168-170) and EMS in three incidents.(153, 171, 172) The response time was reported in 19 articles and lack of resources in 12. HEMS transported equipment and personnel to the scene, performed triage, treatment, transport of patients from the scene to hospitals and secondary transports to specialised units. Air surveillance and search and rescue missions were also described.(69, 70, 105)

In most of the 34 articles that described communication, it was failing. Safety issues reported included inadequate air traffic control and an active shooter.(2) Three of the articles described lack of helipad at the hospital. Two described evacuation of hospitals where improvised helipads solved the issue.(158, 166) One described the response after a terrorist attack where time gained with HEMS transport was lost due to landing site a distance from the hospital.(173) The receiving hospitals were not described in detail in any of the articles, but seven articles mentioned HEMS transport to level I trauma centres further away from site.(2, 131, 153, 161, 168, 169, 174)

The data variables from the external validity check-list were reported more frequent than the internal validity in the quality appraisal. The incident was clearly described in 40 (95%) articles and study design in 32 (76%). Only 19 (45%) studies reported where the data was obtained.

Table 7 – Quality appraisal in the systematic review

	Data variable	**Number of articles reporting variable**
Internal validity	Is the author directly involved in the MI medical response?	7
	Does the literature provide reference to where the data was obtained?	19
	Does the literature provide reference to how the data was obtained?	14
	Author conflicts of interest?	6
	Ethical approval?	3
External validity	Describe the local HEMS and EMS structure before the incident?	20

	Is the major incident clearly described?	40
	Are the medical resources used in the major incident response clearly described?	21
	Does the literature report the type, number and capacity of HEMS?	13
	Indications on missing data?	3
	Are other limitations discussed?	5
	Study design clearly described?	32

4.2.1 Deviation from protocol

Literature describing fixed-wing operations only, incidents with the use of helicopters without medical capacity and use of HEMS in later recovery phase were excluded as the aim of the article was the use of HEMS in the immediate response to sudden-onset major incidents. Articles regarding HEMS use in military conflicts were also excluded as systems and settings are less applicable to civilian incidents.

The review included commentaries as the search revealed that the quality of commentaries was similar to some of the included case reports.(175)

4.3 Paper II – Cross-sectional survey

The cross-sectional survey identified 329 crewmembers representing all doctors, rescue paramedics and pilots working in the 11 HEMS and seven SAR bases in Norway as of January 1st, 2015. All were invited to participate in the survey and 229 (70%) responded. The responding crew members were experienced with more than 40% of the doctors, 50% of the pilots and 70% of the rescue paramedics having more than 10 years operational experience. They had experience from a median of two (IQR

0-6) major incidents and 56% (n = 128) had attended a major incident within the past five years.

Table 8 – Main incident characteristics in cross-sectional study

Incident characteristics		
	Road traffic incident	61 (48%)
	Fire	31 (24%)
	On-going violence	26 (20%)
Location	Rural	80 (63%)
	Urban	24 (19%)
Environment	Daylight	90 (71%)
	Darkness	53 (42%)
Season	Summer	50 (40%)
	Winter	36 (29%)
N = 126, multiple answers allowed, except season.		

Blunt trauma was the dominating type of injury (59%, n = 51). All main rescue agencies were present on-scene in most of the incidents.

Table 9 – Main tasks for crew reported in the cross-sectional study

Doctor	Treatment	42 (84%)
	Transport	29 (58%)
	Triage	25 (50%)
	Medical command physician	23 (46%)
Pilot	Transport	26 (70%)
	Coordination of other HEMS units	19 (51%)
	Organizing landing site	12 (32%)
Rescue paramedic	Treatment	34 (92%)
	Transport	18 (51%)
	Triage	12 (34%)
Note: Doctors: n = 50, Pilots: n = 37, Rescue Paramedic: n = 35. Multiple answers allowed		

Several HEMS/SAR units were present in 83% (n = 98) of the incidents. In 75% (n = 43) EMCC or JRCC informed the pilot of the additional HEMS/SAR units, but in 19% (n = 11) the crew was informed by other HEMS/SAR units. Own or other HEMS/SAR unit coordinated the HEMS units on-scene in 71% (n = 41) and in only 12% (n = 9) the EMCC or JRCC coordinated the helicopter traffic. Guidelines for coordination were available for 41% (n = 24) of the pilots. Of the SAR pilots, 80% (n = 20) reported lack of situational awareness equipment compared to 9% (n = 3) of the HEMS pilots. The crew reported the key aspects of major incident management, on-scene management, cooperation, triage and equipment as "good" (4) (IQR 3-4 and 4-5) on a Likert scale from 1-5, except from communication aids that were rated 2 (IQR 2-4).

Extra personnel and equipment were brought to the scene in 32% (n = 40) and 52% (n = 64) of the incidents, respectively. When missing equipment was reported, it was mainly communication aids (38%, n =

75) but 46% (n = 90) of the respondents indicated that they did not lack any extra equipment.

The training for major incidents was to a large extent inter-disciplinary with the main rescue services, EMS (90%, n = 177), police (n = 169, 86%) and fire services (n = 169 86%). Respondents reported that further training in major incident management is needed with focus on overall major incident management (n = 75, 36%), communication (n = 66, 32%), coordination (n = 65, 31%) and leadership (n = 60, 29%).

4.4 Paper III – Delphi study

The Delphi study developed a consensus-based template for reporting HEMS response to major incidents. From the EUPHOREA network, 28 critical care physicians with HEMS experience from nine European countries were invited to the study, 19 accepted the invitation and 17 completed the process. In the first round 98 variables were suggested. After five rounds with e-mail correspondence, consensus was achieved on 21 data variables in four categories:

– HEMS background
– Major incident characteristics relevant for HEMS
– HEMS response to major incidents
– Key lessons

The online template was made available as a separate reporting template at majorincidentreporting.net when the paper was published. The website is managed by the regional centre for emergency medical research and development in western Norway, RAKOS, a department of Stavanger Health Trust. The website is expected to be operational when RAKOS receives access to sufficient server hardware. (Personal communication from Jan Sigurd Moy, webmaster for majorincidentreporting, June 24th 2020 and February 26th 2021.)

4.5 Paper IV – Retrospective observational study

In the retrospective observational study, from a total of 31 803 HEMS missions, the authors achieved consensus in including 50 major incidents in south - east Norway in the period 2000 - 2016.

Table 10 – Main incident characteristics in the retrospective observational study

Incident characteristics	Road traffic incident	28 (56%)
	Bus	11 (22%)
	Fire	5 (10%)
Location	Rural	35 (70%)
	Urban	4 (8%)
Environment	Daylight	35 (70%)
	Darkness	15 (30%)
Season	Summer	23 (46%)
	Winter	13 (26%)
N = 50. Multiple answers allowed, except season.		

All main rescue agencies were present in most of the incidents (n = 41, 82%). Other HEMS/SAR participated in 37* (74%) with a median of three (1-3) helicopters. The Kruskal–Wallis test detected no significant differences between urban and non-urban incidents regarding response times and number of patients. Blunt injuries was the dominating injury (n = 37, 74%). HEMS treated patients with high NACA-score (median six) and treated more patients (median five) than they transported to hospital (median one).

* In the original article, this number was reported 27 (74%). The correct number is 37.

Table 11 – Main tasks for crew reported in the retrospective observational study

Treatment	49 (98%)
Transport to regional trauma centre	26 (52%)
Transport to trauma unit	12 (24%)
Coordination	10 (20%)
Transport from trauma unit to regional trauma centre	5 (10%)
Search and rescue	5 (10%)
Transport of extra equipment or personnel to scene	4 (8%)
Multiple answers allowed	

Extra personnel transported to the scene included doctors (n = 4, 8%), rescue paramedic (n = 1, 2%) and rescue dog with handler (n = 1, 2%). Extra equipment were stretchers (n = 3, 6%) triage equipment (n = 1, 2%) and extra medical equipment (n = 1, 2%). In the only incident reported with lack of equipment, it was navigational aids.

Weather and on-going fires were considered the most common hazards (n = 7, 14% and n = 6, 12% respectively) and difficult landing site the most common challenge (n = 5, 10%). A majority of the incidents reported no or unknown hazards or challenges (n = 34, 68% and n = 42, 84%). Communication was reported problematic in six (12%) incidents.

We also investigated the feasibility of collecting uniform data from the incident reports. The quality of the collected variables varied as most information were found in the free-text area where the anaesthesiologist reported a description of the incident and the HEMS response. Of the variables collected, 13 of the 28 variables were rated “Good”; almost always available, 12 were rated “Medium”; available in some degree and three were rated “Poor”; not available without a degree of speculation from the authors or not reported at all.

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5 Discussion

5.1 Discussion of the results

This thesis focused on the use of HEMS during sudden-onset major incidents with attention to the added benefits and challenges HEMS bring to the scene. With the systematic review, we identified and described published literature, the cross-sectional study and the retrospective observational study described experiences of the use of HEMS in Norway. The Delphi study invites to future data collection in a uniform way using a pre-defined template.

High quality observational studies describe epidemiology, uncover associations and generate hypotheses.(176) The current results may aid policy makers and clinicians in developing improved guidelines for use of HEMS and SAR in major incident medical management. It remains important that the resources HEMS and SAR bring to major incidents become integrated in plans and regulations and are regularly rehearsed with cooperating rescue agencies. In decompensated phases of such incidents, functional systems including HEMS may be pivotal in achieving optimal use of limited resources.

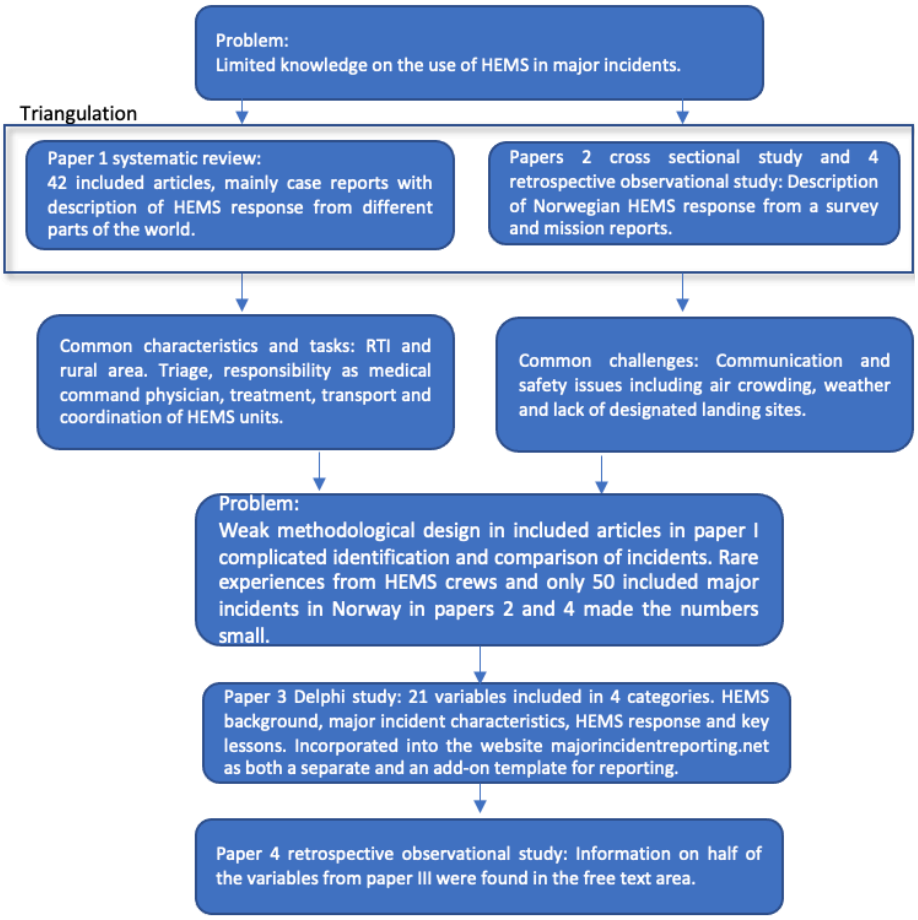

Figure 23 – Link between the studies and triangulation of research question

The systematic review identified a lack of systematic reporting and structured research. Although the case reports were heterogenous in format, they described valuable major incident experiences and contributions of HEMS in the immediate management of sudden-onset major incidents. The cross-sectional study described the major incident experiences of HEMS/SAR crew members in Norway and identified a call for additional exercises and training with other rescue agencies. The retrospective observational study characterized experiences from written reports of the HEMS/SAR crews, confirmed some of the characteristics described in the cross-sectional study and demonstrated the complexity of structured, retrospective data collection for data variables developed in the HEMS major incident template.

The template from the Delphi study is incorporated into the website majorincidentreporting.net as an independent option for submitting reports or as an add-on to the existing major incident report developed by Fattah et al.(32) It is freely available but implementation remain a challenge and the website is currently not fully operational due to technical reasons.

5.1.1 Major incident characteristics

Most of the articles in paper I included detailed descriptions of the incidents, but background information on HEMS was often missing, thereby complicating transferability of data. Paper I provided information of major incident characteristics that was later reproduced in Paper II and Paper IV.

The world map depicted in figure five indicates that Europe is less exposed to disasters compared to other areas in the world.(50) Well-established HEMS are located mainly in countries with few major incidents and not necessarily incorporated into major incident plans. The majority of incidents happen in countries with less resources and perhaps less HEMS resources available. Both paper II and IV found that major incidents are rare in Norway. Paper II demonstrated that HEMS crew members were experienced but only a little more than half of them had attended a major incident the past five years. The 16-year span of the retrospective observational study revealed only 50 incidents. Although major incidents are rare, it remains relevant to have good systems and incorporated guidelines to ensure a functioning system when a major incident strike.

The Norwegian population has, in principle, equal rights to health care services. This may be difficult to achieve in a country with a scattered population and potentially long distances to definite care.(177) As pointed out in paper II and IV, most major incidents occurred in rural areas. In paper IV, a difference in number of patients in rural vs. urban areas was identified although not significant due to the low number of urban incidents. Rural areas are more prone to declare a major incident, which may be explained by the scattered pre-hospital resources where fewer severely injured patients potentially will overwhelm the system.(178) HEMS may then play a crucial role in bringing more resources and experienced clinicians to the scene. When major incidents occur in wilderness settings or a complex disaster has damaged the infrastructure, helicopter services may be the main vehicle for rescue, as previously described in articles included in the review and also shown in two of the incidents included in paper IV. Examples of such incidents in Scandinavia are the loss of the ferries Sleipner and Estonia, and the plane crash at the Operafjell at Svalbard.(4, 69, 74)

RTI were most frequent in all the descriptive papers, I, II and IV, echoing studies of trauma epidemiology and WHO statistics of death rates where RTI are currently estimated to be the eight-leading cause of death across all age groups and the leading cause of death among people aged 15-29 years.(64, 65, 68, 179-182) On-going violence was among the most common major incidents reported in the cross-sectional study. The Utøya incident may be a strong contributor to the reported major incident experiences reported by crew members in Study II. Summer was the busiest season and daylight the busiest time of the day potentially increasing availability of HEMS as the challenges of ice, harsh weather and darkness are avoided. Previous research has shown that variation in season and weather are predictors of increased trauma admissions.(183, 184) This is important factors when planning for in-hospital resource allocation and remain equally relevant for pre-hospital planning and availability of HEMS. Norways long coastal line makes planning for major incidents at sea important. The Alexander Kielland oilrig incident and Sleipner ferry incident showed that bad weather at sea creates a challenging environment for rescue work where HEMS/SAR are an important part.(71)

5.1.2 The roles of HEMS in major incidents

The responsibilities of HEMS are not specifically described in the Scandinavian major incident guidelines. However, the principles of sector-responsibility, cooperation and similarity are outlined in all the guidelines and accordingly, HEMS will have the same responsibilities and tasks in a major incident as in everyday missions.(38, 40, 84)

The cross-sectional survey found that HEMS personnel are experienced with the potential to bring increased operational and strategical capacity to the scene. HEMS may deploy extra staff and equipment when needed and bring specialized resources like alpine rescue equipment and personnel.(27, 28, 75) The HEMS doctor may take the clinical leadership in cooperation with the medical incident commander and be responsible for mass casualty triage and treatment as approximately half of the respondents had experienced in the cross-sectional study.(28, 40, 85)

The patients managed during major incidents and disasters are heterogenous and vary according to type of incident. Paper IV showed that HEMS treated patients with high NACA score as showed in previous research.(30) They treated more patients on-scene in addition to provide rapid transport to definite trauma care. The recurring dilemma for the HEMS crew is whether to stay and claim clinical leadership, take an active role in treating the most severely injured patients or transport them quickly to the hospital. All abovementioned tasks are important but also not possible to handle by only one crew in a MI. One solution is to deploy extra HEMS units to manage the different tasks, as was done in the response to the terror attack in Norway 2011.(2) Equally important is to scale down when less resources are needed to avoid exhaustion of a limited resource and maintain resilience. Other HEMS contributions may be search and rescue operations, avalanche search, and airborne surveillance.(5, 185)

HEMS also offer the possibility of advanced medical treatment when severely injured patients are transferred to secondary specialized units, such as a burns unit or decompression chamber and is another potential benefit.(167)

5.1.3 Challenges for HEMS in major incidents

Restrictions in flying due to bad weather are highlighted as a challenge for HEMS.(105) The systematic review included only papers describing HEMS in major incidents and the retrospective observational study included only major incidents where HEMS were present. The magnitude of incidents without participation of HEMS e.g. because of bad weather was not studied in this thesis. Bad weather in the Alexander Kielland oilrig incident delayed HEMS participation with several hours, as HEMS had to withdraw from the initial rescue work.(71)

Paper II described several HEMS units on-scene in 83% of the answers, paper IV described a median of three helicopters participating in each incident. In paper II pilots reported that on-scene coordination most often was coordinated by local HEMS-units on-scene instead of EMCC/JRCC. Multiple HEMS units and insufficient air traffic control should be addressed with specific procedures with clear rules for communication and command to ensure aviation safety.(2, 88) The enhanced use of drones for surveillance of incident sites may increase operational awareness, but also represent a risk of collisions with other aircrafts.(186) Approximately half of the pilots in the survey coordinated other HEMS units, a contribution that probably will grow in importance as the use of drones makes air-crowding a greater challenge.

In three of the included articles in the systematic review, the receiving hospitals lacked helipads. Lack of designated landing sites has been recommended included in major incident plans.(102, 158, 173) In Norway, the Civil Aviation Authority regulates for designs of hospital helipads and the Norwegian Hospital Construction Agency is responsible for customizing the helipads for the new SAR AugustaWestland AW101.(187, 188) Rotor-downwash accompanying take-off and landing should be taken into consideration.(5)

Communication during major incidents remain challenging when agencies cooperate in a chaotic environment.(189) Inter-disciplinary cooperation is pivotal for an efficient incident response.(190) Communication aids were the only equipment rated as low in paper II (2 on Likert scale 1-5) highlighting an equipment improvement potential and focus for future exercises. Complex communication with multiple agencies highlights the importance of clear recognition of other agencies and their responsibilities. HEMS may also provide an additional information line to the receiving hospitals with frontline updates from the incident site.(5)

Some incidents may involve an increased risk e.g. CBRNe incidents, on-going violence or extreme weather. Such incidents represent not only safety issues for HEMS personnel, but all rescue professionals involved and may be considered a major incident although the number of involved is low due to the complicated response.(2, 191, 192)

5.1.4 Major incident exercises

Inter-disciplinary major incident exercises remain an important and uncovered need, as depicted in Paper II. In major incidents, several agencies, including HEMS, are involved that not necessarily work together on a daily basis. The respondents in paper II called for training in overall major incident management, communication, especially with other agencies, coordination and leadership. Well-functioning cooperation and coordination in both resilience planning and response should be rehearsed.(193)

Training and sharing of experiences with other agencies create technical competences and trust in each other's abilities.(81) National guidelines where the responsibilities of HEMS are incorporated are important and the crews need to be trained in their tasks prior to managing a real incident. Updated major incident plans should be implemented in all services involved and rehearsed in interdisciplinary exercises to enhance knowledge of other services and their responsibilities. Resource mobilisation should be thoroughly described in these guidelines and rehearsed to be fully functioning when a major incident strike.

Two training systems are developed and validated in Sweden, 3 level collaboration and MacSim, both containing methods of training decision-making.(194) The Norwegian Air Ambulance Foundation offers courses (Tverretatlig Akuttmedisinsk Samhandling / Interdiciplinary Emergency Service Cooperation) for all the emergency services that focus on inter-agency cooperation, communication and management of complex incident sites and major incidents.(195) In 2019 they carried out 49 courses for approximately 1 500 personnel from the emergency services. (Personal communication from Knut Styrkson, June 19th 2020). The Norwegian Air Ambulance Foundation also facilitates annual national training camps for all Norwegian HEMS personnel.

Standardised exercises with evaluation allow for comparison of responses. If the number of reports from such exercises increases, opportunities to draw valid conclusions and lessons learnt may arise and be relevant in real major incidents.(196) Submitting reports from exercises is an option on majorincidentreporting.net. So far, two airplane crash exercises in Finland are published, providing a channel for shared experiences.

The SARS CoV-2 pandemic has fast-forwarded the systems for e-learning, forcing educational institutions to adapt to societies in lockdown.(197) This opens new possibilities for virtual learning programmes and online simulation training for the agencies participating in major incident management. Nevertheless, it is still important with joint exercises and courses for the emergency services to be familiar with other agencies skills and experiences.

5.1.5 Major incident case reports

Grynszman et al. argues for three main advantages of case studies in disaster medicine research; i.e. they help capture the complexity of the incident, they appeal to a broad audience and lastly that disaster risk reduction needs an approach that can maximize the lessons learnt from each incident. Further, illustrative and investigative case studies may give answers to the impact of a given hazard and how the guidelines and preparedness worked out in an actual incident instead of exercises.(198)

Apart from a few case reports derived from the DISAST-CIR methodology, the articles included in the systematic review were heterogenous.(131, 169) Still, they provided valuable overviews and insight in the incidents and described important lessons learnt.(152) Three Swedish KAMEDO reports were included in the systematic review, all maritime incidents; Sleipner (1999), Estonia (1994) and Scandinavian Star (2004).(4, 199, 200) Data capture may improve with systematic reporting in the future if the EMS community agree on a common template for reporting.

5.2 Strengths and limitations

Table 12 – Summary of main strengths and limitations

Paper	Main strengths	Main limitations
1	Systematic inclusion following PRISMA guidelines.	Weak methodological design of included articles. Authors selected data extraction and appraisal.
2	Inter-disciplinary. Acceptable response-rate (70%).	Recall bias. Unvalidated questionnaire.
3	Systematic development of an online open access template. E-mail anonymity ensured in the process.	Homogenous expert group, only European countries recruited from EUPHOREA network.
4	Covered both rural and urban areas. Incidents included by consensus in author group.	No space for major incidents in database. Recall bias. Rejected/ aborted missions not included.

5.2.1 General strengths and limitations

The main strength of this thesis is the triangulation of methods used in the effort to answer the research question “What are HEMS roles in sudden-onset major incidents”.

All papers were published in PubMed indexed, scientific peer-reviewed journals. Peer-review is a screening method of the quality of the submitted papers and the peer-reviewers are researchers with a critical view of the manuscript that consider validity and quality of the methods used, evaluate the significance of the work and detect errors, scientific, references or language.(201)

A language limitation was noted in paper I that only included articles in English and Scandinavian languages. In paper II the communication was carried out in Norwegian and in paper III all communication was in English only. As major incidents frequently occur in non-English speaking countries, valuable information may have been lost in the literature search. However, the Delphi study included non-English speaking experts and may have profited from that.

The data extraction and quality appraisal in paper I were designed through consensus in the author group by including items assumed to be relevant, thereby reducing transportability of results. The lack of a validated questionnaire is also a limitation in Paper II where the questions were constructed by the authors. The questions were piloted on colleagues, but no structured validation was performed. In both paper I and II this does not represent reference standards as, to our knowledge, no such standard exists. This makes it even more important to follow guidelines like PRISMA to enhance transparency. Further, assessments tools like CASP (Critical Appraisal Skills Programme) are useful to systematically assess systematic reviews and cohort studies.(202, 203)

5.2.2 Reliability and validity

Reliability indicates whether results are replicable for other researchers. Validity describes whether results are accurate and measure what they are intended to measure (internal validity) and are generalizable to environments outside the studied setting (external validity).(204, 205) A study should optimally produce the same results if conducted by others (inter-rater reliability) or at different times (test-retest reliability).(206)

In this thesis, all studies had protocols and methods chapters aiming to describe the research process to enhance the reliability and enable other researchers to conduct similar studies. Both internal and external validity of the included studies in the systematic review was depicted in the quality appraisal, although the questions regarding the internal validity were less answered than the external validity. As significant information relevant for quality appraisal were lacking in a majority of the articles it was hard to give conclusive remarks.

Test-retest reliability; repeated administration of the questionnaire to the respondents would have allowed us to evaluate consistency in responses in both paper II and III.(207) Such time-consuming tests remained outside the scope of this thesis, but repeated studies are called upon to possibly strengthen the results presented.

The inter-rater reliability can be calculated with a Kappa value as the observed proportion of observations where the two raters agree.(207) A Kappa value closer to 1 means good agreement. This was impossible to calculate correctly in paper IV as the disagreement would represent reports and not unique incidents. Study III was a qualitative study aiming for consensus in the final round, hence Kappa values were not a part of the study.

Content validity concerns whether measured data include the most relevant items.(207) This was ensured to some extent by reusing selected variables throughout the different papers (Table 4: Main data variables in Methods section).

The questionnaire in paper II was thoroughly discussed in the author group to increase the chance that questions were interpreted in a similar manner for all participants and then distributed to a small sample of experienced in-hospital colleagues as a pilot test as there was no relevant validated questionnaire available. To avoid the problems of construct validity, when questions are measuring something not directly observable (207), most questions of experiences were on specific observations (e.g. incident characteristics) and only a few questions reflected subjective opinions, such as rating of cooperation and communication.

The Delphi technique may be criticised for a lack of reliability as two different panels may give different opinions.(208) The technique only offers a snapshot of the groups opinion at that time. The use of participants with a special knowledge and interest in the questions may increase content validity and a high response rate is important for the validity of the results.(138, 209) The measures of rigour in qualitative research may be measured with trustworthiness, consisting of four elements: credibility, dependability, confirmability and transferability. Credibility may be explained by how data can be trusted based on the ability of the expert panel. Dependability reflects on the reproducibility of the collected data. Confirmability refers to the neutrality of the collected data from the expert panel. Transferability relates to whether the data may be applied to other settings (external validity).(209, 210).

5.2.3 Paper I – Systematic review

The PRISMA guidelines were followed in the systematic review process (135), but only one author made the initial screening due to lack of resources thereby deviating from the Cochrane handbook.(136) Accordingly, we may have missed to identify relevant studies.

There was no specific definition of what constitutes a major incident in the inclusion criteria. With an aim of including all literature describing HEMS in major incidents, articles where the authors defined or mentioned their incident as major were included.

The methodological designs of the included articles were weak and dominated by retrospective case reports. Selection bias, performance bias and detection bias may be present in the included trials.(211) Some incidents were described in several reports indicating a possible skewness towards high-profile incidents.

5.2.4 Paper II – Cross-sectional study

A strength of paper II was that the survey managed to invite all eligible pilots, doctors and rescue paramedics working in HEMS and SAR crews in Norway, thereby minimizing selection bias.

Limited control over data collection and response rate was a weakness in the cross-sectional survey design.(176) HEMS in Norway are uniform considering professions and qualifications in the crews, the variations in answers would be related to the individual experiences. Although there is no agreed-upon standard for response rate, 70% was considered acceptable. However, non-respondents represent a potential bias as non-responders may differ from the respondents.(212, 213) Non-response bias assessment remained outside the scope of this study given its anonymous survey design.(214) Recall bias was minimized by asking for reporting of major incidents in the previous five years, but given the chaotic nature of such incidents, recall bias may still be relevant.

Cross-sectional studies are limited as they only give an indication of experiences at one point in time, and causality cannot be established.(141) Representing a national survey, the prevalence estimations made could be considered a valuable asset in major incident planning.

5.2.5 Paper III – Delphi Study

The main strength of the template was that it was developed through a structured process previously used in major incident management research.(215) As the process was solely conducted through e-mail communication, it allowed including experts without the time restriction and cost of travelling. Although complete anonymity could not be guaranteed as the researchers knew the identity of the participants, the anonymity between the participants provided them with an opportunity of presenting ideas and judgements without influence by dominating individuals in the group.(208)

Anonymity may encourage quick judgements as the respondents were not accountable for their judgements, but as they were recruited based on their knowledge and participation was voluntary, this was less likely to occur.(216)

Including experts in a non-random order makes it important to justify the selection process.(216) The Delphi process only allows for inclusion of the items suggested by the participants; hence items may be missed. We only included items that reached full consensus, relevant items may accordingly have been excluded due to lack of agreement in the group.

5.2.6 Paper IV – Retrospective observational study

In the published version, Paper IV was named retrospective cohort study. In hindsight this was not precise, and in this thesis it has been redefined as a retrospective observational study.

Retrospective observational design is effective in studying rare exposures, such as major incidents, compared to prospective design.(176) In the retrospective observational study, data had been documented prior to the study hypothesis being placed and data collection was limited to variables already implemented in the system. The HEMS template from study III was not incorporated into the LABAS system prior to study IV was initiated and is still not implemented. Selection bias was minimised by including all missions from the period 2000 through 2016 from selected HEMS and SAR bases. Inclusion of incidents was made through consensus from the authors. There is no thick box for major incidents in the LABAS system, relevant incidents might have been wrongfully excluded as the major incident definition applied takes into account magnitude of event and resources available. The authors only read mission reports that might not capture all relevant operational information.

By including bases with different locations, we aimed to capture the major incident incidence in south - east Norway, but as aborted HEMS missions were excluded, major incidents without HEMS participation were not analysed.

The HEMS doctor documented the mission retrospectively, thereby increasing the risk for recall bias and inter-personal variation.(140) As the HEMS medical records are not designed for collecting major incident data, the records varied in length and detail.

There is a knowledge gap on the exact number of patients involved as these numbers are not always reported, a limitation also recognised in other studies.(217) In the National EMS Database in the United States of America, the EMS personnel must document whether or not the incident was a mass casualty incident. Although there is a difference between mass casualty incidents and major incidents, this makes it easier to collect retrospective data.(64)

As the study was retrospective, the problem of loss to follow up in prospective studies was avoided, but retrospective bias was potentially introduced. Patterns found may be random findings and should only be treated as hypothesis generating.(218)

5.3 Challenges in this thesis

As stated in the introduction, the clear definition of a major incident remains a challenge as both incidents and health care systems around the world vary. The importance of clear definitions remains pivotal to produce studies with high reliability and validity.

In this thesis and three of the papers the definition from majorincidentreporting.net was used as an inclusive definition that allowed for individual interpretation of what constitutes a major incident. Although the definition states *"mobilization of extraordinary EMS* *resources"* there will almost always routinely be other rescue agencies present during incident management.

In the cross-sectional survey, modifications to the definition of a major incident were made and was defined as «*an incident reported to EMCC or JRCC from pre-hospital resources as extensive enough to require extra personnel or resources from neighbouring districts and the activation of the emergency plans in involved hospitals. The magnitude of what constitutes a major incident would vary according to resources available in the regions*».(28) The change was made because of feedback from the pilot-testing of the survey that the definition was unclear. It is a limitation that this thesis did not use the same definition throughout.

The General Data Protection Regulation (EU) 2016/679 provided a new set of data protection and privacy protection rules and was introduced in Norway in 2018.(219) With these changes a data protection impact assessment (DPIA) was warranted as we collected information regarding dominating injuries in the incidents and the patient characteristics age and gender in Paper IV. This increased the waiting time for approval from the Norwegian Social Science Data Services as there was insecurity on how the new regulations were to be interpreted. Hopefully, these regulations will provide a clear set of regulations for future research where participants are confident that their information are not misused.

5.3.1 Implementation of the major incident HEMS template and analysis of published reports

The need for standardized reporting is a recognized problem and several major incident reporting templates exists.(32, 220, 221) In the majorincidentreporting.net website there are eight reports from major incidents and two reports from exercises. RAKOS is now responsible for the website and it was rebuilt into an updated version in the spring of 2020. Some technical challenges still remain, and the website currently awaits official approval from Stavanger Health Trust to set the database into further production. (Personal communication from Jan Sigurd Moy, July 24th 2020 and February 26th 2021)

It has proven challenging to implement the HEMS template into an operational context, a challenge also recognised in the thesis by Fattah.(128) Recruiting clinicians with major incident experiences to submit incident reports has proven to be difficult. If more reports are submitted there will be opportunities to look for similarities, main challenges and areas for improvements to build more resilient systems in future major incident responses.(129)

6 Conclusion

By summarizing existing literature in a review combined with a cross-sectional study and a retrospective observational study on major incident management, this thesis provides a picture of present use of HEMS in major incidents and a foundation of knowledge for future research. It highlights the lack of systematic reporting, especially with background information for enhanced validity and transferability of the reports. The HEMS template and major incident reporting website need to collect standardized reports to further enhance the knowledge on how to optimize the use of HEMS in future major incident management.

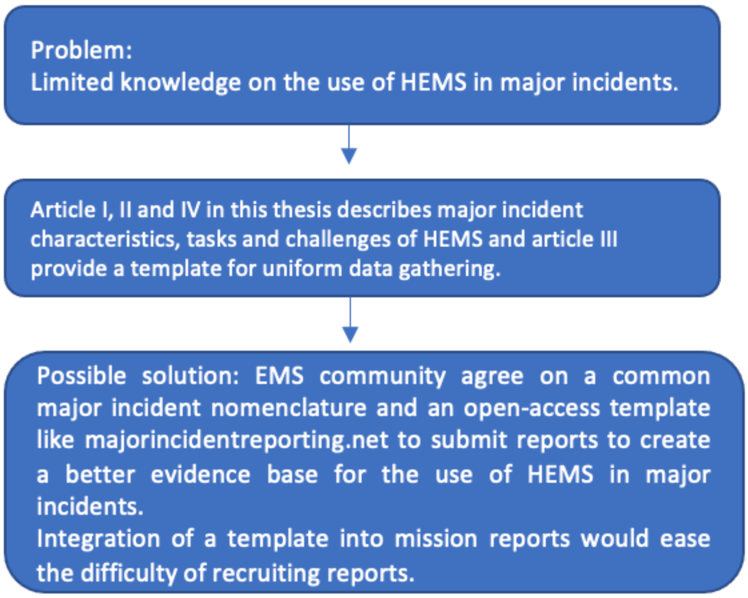

Figure 24 – Flow from the problem of limited knowledge on HEMS in major incidents to a suggested solution to enhance the knowledge and optimize the use

HEMS are inter-regional resources that benefit from national standards in major incident management, but the role of HEMS remain mostly undescribed in preparedness plans. HEMS and SAR operations in major incidents are valuable assets in bringing specialized crews and additional personnel and equipment to the incident site. They do not only transport the severely injured patients to hospitals but also treat additional patients on-site. The operations are demanding, where inter-disciplinary communication and cooperation on-scene are highlighted as challenges on which to focus future exercises and to be described in national and regional guidelines.

This thesis adds to the amount of research on benefits and challenges of HEMS in major incident management but the optimal use remains unanswered. It is important to build resilient systems and focus on systematic data reporting to enhance the quality of future major incident response and research.

7 Future perspectives

The lack of universally accepted major incident definition and nomenclature make major incident research complicated to conduct in a standardized and reproducible manner. There is a need to establish a uniformly accepted nomenclature to enable easier transfer of experiences.

Conventional research designs used in this thesis suggests that systematic reporting is pivotal to describe use, challenges and lessons learnt from the utilization of HEMS and SAR in major incidents. By implementing the HEMS major incident report from majorincidentreporting.net in the rescue services, it may be possible to analyse standardized information for patterns, common lessons learnt thereby generating hypotheses for future research.

The cross-sectional and the retrospective observational studies may be repeated to look for an updated prevalence of major incident characteristics with HEMS involvement and changes in the experiences in the crews and reports. A prospective observational study may be initiated, but a long recruitment period must be expected as major incidents are rare in Norway. A multicentre, international design would shorten this period. These answers can be further explored in interviewing experienced personnel to provide deeper understanding relevant for developing systems for major incidents preparedness. Feasibility studies may test the suggested changes and bring further knowledge on how to respond when a major incident occur. In this way qualitative and quantitative methods may complement each other. The main aim will be to improve future major incident exercises and national and regional preparedness plans and guidelines for optimal incorporation of the use of HEMS in major incident management.

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9 Papers

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Paper I

Open Access Research

BMJ Open

Utilisation of helicopter emergency medical services in the early medical response to major incidents: a systematic literature review

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ABSTRACT

Objective: This systematic review identifies, describes and appraises the literature describing the utilisation of helicopter emergency medical services (HEMS) in the early medical response to major incidents.
Setting: Early prehospital phase of a major incident.
Design: Systematic literature review performed according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials, the Web of Science, PsycINFO, Scopus, Cinahl, Bibsys Ask, Norart, Svemed and UpToDate were searched using phrases that combined HEMS and 'major incidents' to identify when and how HEMS was utilised. The identified studies were subjected to data extraction and appraisal.
Results: The database search identified 4948 articles. Based on the title and abstract, the full text of 96 articles was obtained; of these, 37 articles were included in the review, and an additional five were identified by searching the reference lists of the 37 articles. HEMS was used to transport medical and rescue personnel to the incident and to transport patients to the hospital, especially when the infrastructure was damaged. Insufficient air traffic control, weather conditions, inadequate landing sites and failing communication were described as challenging in some incidents.
Conclusions: HEMS was used mainly for patient treatment and to transport patients, personnel and equipment in the early medical management of major incidents, but the optimal utilisation of this specialised resource remains unclear. This review identified operational areas with improvement potential. A lack of systematic indexing, heterogeneous data reporting and weak methodological design, complicated the identification and comparison of incidents, and more systematic reporting is needed.
Trial registration number: CRD42013004473.

Strengths and limitations of this study

- This is a systematic literature review that follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.
- The protocol was published before conducting the study to avoid data-driven decisions; deviations from the protocol are noted in the article.
- Only literature in English and in Scandinavian languages is included.

INTRODUCTION

Major incidents remain a major global health challenge. In 2013, natural-triggered disasters killed more than 20 000 people, created almost 100 million victims and caused enormous economic damage worldwide.[1] These numbers are only for natural disasters and do not take into account other types of major incidents. Major incidents are characterised by the need for an extraordinary medical response. They are heterogeneous by nature and their unexpectedness remains a challenge for emergency medical services (EMS). Fundamental for an effective major incident response is a robust and resilient EMS system.[2] These systems can provide rapid access to advanced major incident management to improve patient outcome[3] and optimise resource allocation as demand often exceeds capacity.[4]

Helicopters are obvious resources in major incident management through their capacity to bring specialised teams and equipment to incident scenes. They can also transport patients, provide search and rescue services, and perform overhead surveillance. When a site is remote or difficult to access, helicopters may be the only way to transport personnel, equipment and patients in and out of it.[5–9] Following the first organised use of helicopters for military medevac during the Korean War,[10] the use of helicopters for civilian patient transportation was introduced in the USA in the early 1970s.[11] It was later integrated as helicopter EMS (HEMS) in most high-income countries.[12–14] Although HEMS is embedded in most emergency response plans, the optimal use of this limited resource in the early medical management of major incidents remains unclear.

We aimed to systematically identify, describe and appraise the literature that describes the utilisation of HEMS in the early medical response to major incidents, to better address common challenges and to facilitate future research.

METHODS

Study identification

The protocol was published prior to conducting the literature search[15] and registered in PROSPERO (CRD42013004473). A comprehensive literature search was performed to identify all relevant articles available as of 19 March 2015. The following databases were searched: MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials, the Web of Science, PsycINFO, Scopus, Cinahl, Bibsys Ask, Norart, Svemed and UpToDate. An additional search was performed in PubMed in order to retrieve articles that had not yet been entered into MEDLINE. The search was designed using Medical Subject Headings and related terms as keywords. This search was then adapted for use in the other databases (see online supplementary additional file I). In the absence of universally accepted nomenclature, literature that defined their incident as a major incident or disaster was included.

Study eligibility and selection

Inclusion criteria:

Articles that describe the use of HEMS in the early medical management of a major incident.

Exclusion criteria:

- Articles in languages other than English and Scandinavian
- Articles without abstracts
- Book chapters, conference abstracts, letters to the editor and editorials

Deviations from the protocol on inclusion and exclusion criteria.[15]

- Inclusion of commentaries
- Exclusion of literature where:
  - Only fixed-wing aircraft were used
  - Helicopters without dedicated medical capacity were used
  - Incidents were considered to be part of military conflicts
  - HEMS was used in the later recovery phase of the response.

The reason for the inclusion of commentaries was that these did not provide less relevant information than case reports. Exclusion criteria were adjusted to better target civilian medical helicopter response to major incidents in the acute phase.

Search findings

All studies were collected in an Endnote bibliographic database (2011; Thomson Reuters, USA). One author (ASJ) scanned the titles and abstracts, and excluded articles that clearly did not meet the inclusion criteria. Full-text versions of the remaining articles were obtained and divided among pairs of authors (ie, ASJ and MR, SF and SJMS) for further screening, using the criteria listed above. Excluded articles were listed with the reason(s) for exclusion. If there was any uncertainty about whether a study should be included, there was a discussion until a consensus was reached among all of the authors. The reference lists of the studies that were included initially were examined individually to identify the additional relevant literature.

Data extraction and appraisal

ASJ appraised the quality of the included studies and extracted predefined data from the included articles into an Excel spreadsheet (2010; Microsoft, USA). Data extraction included the demography of incident area and characteristics regarding HEMS, major incident, incident response and patient characteristics. The data extraction variables were pilot-tested on four randomly selected articles before the protocol was published.[15] The appraisal items were selected by the authors, and aimed to describe the internal and external validity of the included studies. All data extraction and appraisal results were agreed on by another co-author.

RESULTS

Literature search

The search identified 4948 records (2763 after duplicates were removed), and the full-text versions of 96 articles were obtained. Of these, 37 articles[6–9 16–48] were included in the study, and an additional 5[49–53] were identified by searching through the reference lists of the 37 articles. Thus, the review included a total of 42 articles (table 1), with 59 articles excluded for various reasons (see online supplementary additional file II). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram (figure 1) shows the inclusion and exclusion of articles in the different phases of this review.[54]

Data extraction

None of the included articles contained all of the items on the data extraction list (figure 2). Basic information about the affected area was described in 12 articles (29%), information about the affected population in 24 (57%) and scene access in 29 articles (69%). Most papers described the characteristics of the incident. A timeline for the incident response was present in 25 articles (59%) and a description of personnel in 35 (83%) articles. In 12 (29%) of the articles, there was a lack of resources, prehospital surge capacity was reported in 2 (5%), and the response time was documented in 19 articles (45%). Communications and coordination were described in 34 articles (81%), and were in most cases failing. Scene safety was reported to

Table 1 Study methods and use of HEMS

	Method	Described use of HEMS
Afzali *et al*[16]	Prospective observational study	Brought extra equipment for advanced life support. HEMS doctor was Medical Incident Officer in three major incidents
Almersjø *et al*[49]	Case report	Performed search and rescue and secondary transfers
Ammons *et al*[17]	Case report	Evacuated the most severely injured patients to hospitals and brought extra equipment to the scene
Assa *et al*[7]	Case report	Brought extra personnel and equipment to the scene. Air-medical crews assisted ground units in triage and treatment. Transportation of casualties from the remotely located scene to trauma centres. Allowed distribution of patients between various centres in the region
Bland[18]	Case report	Command, triage, treatment and transport. Author was Forward Medical Incident Officer at Kings Cross scene
Bovender and Carey[19]	Case report	Used for more than 200 helicopter sorties from flooded hospital
Brandsjø *et al*[50]	Case report	Rescued main proportion of survivors, because nearby ships could not perform sea rescue
Brandstrom *et al*[20]	Case report	Search and Rescue
Buerk *et al*[21]	Case report, design not clearly described	Evacuated severely injured patients. Caused disruption of radio communication and destroyed an aid station. The possibility of collision was a concern
Buhrer and Tilney[22]	Case report	Patient transport with advanced life support and a secondary transfer to a burn centre
Carlascio *et al*[23]	Case report, design not clearly described	Secondary transfers and rescued one patient. Brought extra crew and blood products
Cassuto and Tarnow[24]	Case report, design not clearly described	Secondary transfers from urban fire disaster
Cocanour *et al*[25]	Case report, describing same type of incident as Bovender and Nates	Evacuated patients from a flooded hospital. Used for longer distance transport
Eckstein and Cowen[26]	Case report	Not clearly described
Felix Jr [27]	Summarizes HEMS in USA in the early1970s with a major incident case report	Flew equipment to two damaged hospitals and transferred patients to other hospitals
Franklin *et al*[28]	Case report	Patient transport from flooded areas to hospital and brought health personnel to places where they were needed
Furukawa[28]	Case report	Transported personnel to the remote site of an airplane crash and airlifted survivors and dead from the scene
Iselius[29]	Case report describing the same incident as Oestern	Evacuation of injured passengers from railway accident. Brought extra crew and equipment to the site
Jacobs *et al*[30]	Review of seven major incidents in one HEMS service describing the same inci- dents as Stohler	Used for evacuation and transport of the most critically injured patients to trauma centres. Distributed them to different centres, so not to overwhelm the closest one
Lavery and Horan[31]	Case report	Primary and secondary transport of injured patients
Lavon *et al*[32]	Two case reports	Brought extra personnel, equipment and command team to the local hospital. Participated in secondary transfer with advanced trauma life support to larger trauma centre
Leiba *et al*[33]	Case report describing the same incident as Lavon	Brought extra personnel and blood products to the closest hospital and evacuated patients

Continued

Table 1 Continued

	Method	Described use of HEMS
Leiba *et al*[34]	Case report describing the same incident as Assa. The DISAST-CIR methodology of reporting also used by Schwartz	Primary transport of injured to different hospitals ensuring that the closest hospital did not reach surge capacity
Lockey *et al*[35]	Case report describing the same incident as Bland	Deployed staff and equipment to the scenes and staff from home to the hospitals. Allowed rapid deployment in difficult traffic conditions
Lyon and Sanders[36]	Commentary of a case report	Brought pre-hospital doctors to the scene for medical incident command and advanced interventions. Transported the patients directly to specialist paediatric trauma centres
Malik *et al*[37]	Observational study of scoring systems in a major incident in remote area	Transported personnel to the incident. Secondary transport of priority I patients to trauma centre
Martchenke *et al*[38]	Case report, interviewing all participating HEMS members involved	Triage, treatment and transport of patients from earthquake
Martin[51]	Case report	Helicopter and personnel present at event. Tasks not specified
Matsumoto *et al*[39]	Case report	Mainly used for patient transportation and evacuation. Also transported food, water and generators to destroyed hospitals
Nates[40]	Case report and review of literature. Describing same type of incident as Bovender and Cocanour	Transport of patients from damaged hospital, vital in evacuation because of damaged roads
Nia *et al*[53]	Case report and survey of survivor's opinions about health response	Evacuated injured from the earthquake zone and brought resources and equipment to affected area
Nicholas and Oberheide[52]	Case report describing the same incident as Ammons	Transport from primary to secondary health care facility. Brought supplies to scene
Nocera and Dalton[41]	Two case reports	Transport of experienced crew to the scene. Performed advanced life-saving procedures in one of the incidents
Oestern *et al*[42]	Case report describing the same incident as Iselius	Transported patients to more remote hospitals
Pokorny[43]	Case report	Evacuation of victims in flooded area, otherwise not specified.
Romundstad *et al*[44]	Case report	Arriving HEMS doctor was appointed Medical Incident Commander and organized medical resources in teams. Transported some of the patients to more remote hospitals
Schwartz and Bar-Dayan[45]	Case report presented in DISAST-CIR met-hodology for uniform presentation. Leiba 2009 used same methodology	Patient transport of the most seriously injured patients
Sollid *et al*[46]	Case report	Flew out extra personnel and stretchers. Triaged and treated patients acted as medical incident commander and transported the most severely injured from one of the incident sites
Spano *et al*[9]	Case report	Brought personnel and equipment to site and evacuated the patients when weather allowed
Stohler *et al*[8]	Retrospective review of four major incidents. Same incidents as Jacobs	The responses included bringing extra personnel and equipment to scene, triage, medical treatment, air surveillance and transport
Urquieta and Varon[47]	Case report	Triage and transport of severely injured victims
Yi-Szu *et al*[48]	Case report, analysing patterns and outcomes of patients with chest injuries	Secondary transport of patients from field hospitals in earthquake zone.

be an issue in 18 reports (43%), and this was related to issues such as inadequate air traffic control, active shooters, inadequate landing sites and bad weather. HEMS tasks included patient evacuation and transport from scene as well as transport of supplies, personnel and equipment to the scene. The literature also described HEMS being used for secondary transport, treatment, leadership and on-scene triage. In addition, HEMS was

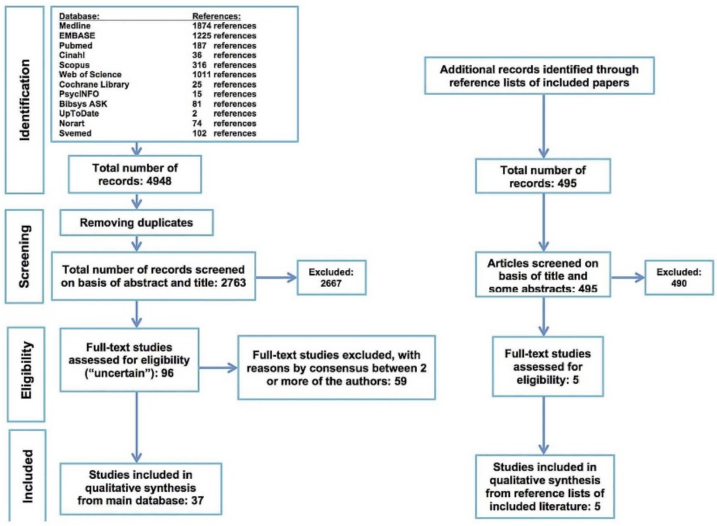

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

in some incidents utilised for search and rescue, and for air surveillance (table 1).

Appraisal

We sought to identify data items related to internal and external validity. Of the included articles, 19 (45%) contained references to where the data were obtained. We found 5 articles (12%) that reported no conflicts of interests and 1 (2%) that reported a conflict of interests. No articles reported they had ethical approval, although 1 (2%) stated that such approval was not needed. The description of both the HEMS and EMS structure before the incident was described in 12 (29%), whereas 7 articles (17%) described HEMS alone. The incident itself was clearly described in 40 articles (95%). Study limitations were discussed in 5 (12%), and the study design was described in 32 articles (76%). The quality appraisal findings are shown in figure 3. The study methodology was as follows: Of the 42 included studies, 37 (88%) were case reports, 2 (5%) observational studies, 2 (5%) reviews and 1 (2%) was a summary of the use of HEMS combined with a case report (table 1).

DISCUSSION

This systematic literature review found little or no systematic reporting of the utilisation of HEMS in the early medical management of major incidents. HEMS were most often reported to be used in patient evacuation and transport from the scene, and in transport of supplies and personnel to the incident scene (table 1). Data relevant to depict internal and external validity, such as reference to data source and handling of missing data, were lacking (figure 3). Further, the heterogeneity of the literature and the overall weak methodological design made it difficult to evaluate the contribution of HEMS to the management of major incidents.

The included incidents had various logistical and geographical challenges. In the 7/7 London terrorist bombings in 2005, a helicopter was used to deploy staff and equipment to urban scenes when road access was difficult.[35] Use of a helicopter also allowed the deployment of staff from home at a time when public transportation was inaccessible in the city. In the 22/7 Utøya terrorist shootings in 2011, additional medical personnel were brought to the scene, which this time was a rural area with overloaded provincial roads.[46] Other studies described how HEMS facilitated the transport of victims to the hospital, especially when the scene of the incident was difficult to access.[49 25] HEMS also helped in secondary transfers of patients with particular needs, such as transporting patients to dedicated burns units.[24] Although scene safety remains a foremost priority in major incident management, this was discussed in less than half of the studies. The inability to fly due to bad weather[8] and the lack of designated landing sites[19 31 47] were described as operational hazards. Further, HEMS involvement in major incident management often

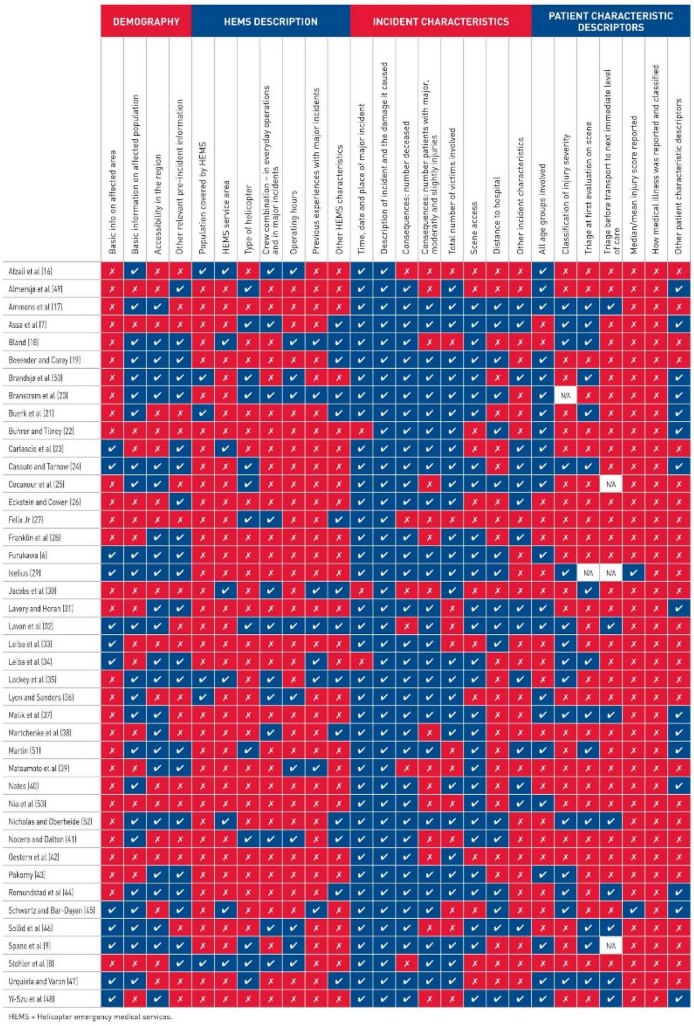

Figure 2 Data extraction.

involved multiple aircraft operating in uncontrolled air space, indicating insufficient air traffic control.[21 23 27 38 46] Future improvements in aviation traffic awareness systems, navigation and communication may mitigate the aviation risks. However, the emphasis should be on implementing procedures for multiple aircraft operations in uncontrolled air space. Crew training may also reduce the

Figure 2 Continued

	INCIDENT RESPONSE																		
	How was the major incident declared?	The timeline for the medical response	Who participated – personnel (health, fire, police, military, voluntary organizations)	Who participated – transport	What tasks did they perform?	Which prehospital resources were lacking?	Prehospital surge capacity	HEMS: number of crews	Estimated arrival time from alarm	Information recieved	Bring extra crew	Extra equipment	Number of patients transported by HEMS	Which hospitals recieved patients?	Did HEMS have other responisibilities?	Did HEMS have other tasks?	Communication and coordination described	Scene safety described	Other incident response data described
Afzali et al (16)	✗	✗	✗	✗	✗	✗	✗	✔	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Almersjø et al (49)	✔	✔	✔	✔	✔	✗	✗	✔	✔	✗	✔	✗	✗	✔	✔	✗	✔	✗	✗
Ammons et al (17)	✔	✔	✔	✔	✔	✗	✗	✔	✗	✔	✗	✔	✔	✔	✗	✗	✔	✗	✔
Assa et al (7)	✔	✔	✔	✔	✔	✔	✗	✔	✔	✔	✔	✗	✔	✔	✔	✗	✔	✗	✗
Bland (18)	✔	✗	✗	✔	✔	✗	✗	✔	✗	✗	✔	✗	✗	✗	✔	✗	✔	✔	✔
Bovender and Carey (19)	✔	✔	✔	✔	✔	✔	✗	✗	✗	✗	✗	✔	✗	✔	✗	✗	✔	✔	✔
Brandsjø et al (50)	✔	✔	✔	✔	✔	✔	✗	✔	✔	✔	✔	✗	✔	✔	✗	✗	✔	✔	✔
Branstrom et al (20)	✔	✔	✔	✔	✔	✔	✗	✔	✔	✔	✔	✗	✔	✔	✔	✗	✔	✔	✔
Buerk et al (21)	✗	✔	✗	✔	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✔	✔	✔
Buhrer and Tilney (22)	✗	✗	✔	✔	✔	✔	✗	✔	✗	✔	✗	✗	✔	✔	✗	✗	✗	✗	✗
Carlascio et al (23)	✗	✗	✔	✔	✔	✗	✗	✔	✗	✔	✔	✔	✗	✗	✗	✗	✔	✗	✗
Cassuto and Tarnow (24)	✔	✔	✔	✔	✔	✔	✗	✗	✔	✔	✗	✔	✔	✔	✔	✔	✔	✔	✔
Cocanour et al (25)	✗	✔	✔	✔	✔	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✔	✗	✗
Eckstein and Cowen (26)	✗	✗	✔	✔	✔	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✔	✔	✗
Felix Jr (27)	✗	✗	✔	✗	✔	✗	✗	✗	✗	✗	✗	✗	✗	✔	✗	✗	✔	✔	✗
Franklin et al (28)	✔	✔	✔	✔	✔	✗	✗	✔	✗	✗	✔	✗	✔	✗	✗	✗	✔	✗	✔
Furukawa (6)	✗	✔	✔	✗	✔	✗	✗	✗	✔	✗	✗	✗	✔	✗	✗	✗	✗	✗	✔
Iselius (29)	✗	✔	✔	✔	✔	✔	✔	✗	✔	✔	✔	✔	✔	✔	✗	✗	✔	✗	✔
Jacobs et al (30)	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✔	✗	✗
Lavery and Horan (31)	✗	✔	✔	✗	✔	✗	✗	✗	✔	✔	✗	✗	✗	✔	✔	✔	✔	✗	✔
Lavon et al (32)	✔	✔	✔	✔	✔	✗	✗	✔	✔	✗	✔	✗	✔	✔	✔	✗	✔	✔	✗
Leiba et al (33)	✗	✔	✔	✔	✔	✗	✗	✗	✔	✗	✔	✔	✗	✔	✗	✗	✗	✗	✗
Leiba et al (34)	✔	✔	✔	✔	✔	✗	✗	✔	✗	✗	✗	✗	✔	✔	✗	✗	✔	✗	✗
Lockey et al (35)	✗	✔	✔	✔	✔	✗	✗	✔	✔	✔	✔	✔	✔	✗	✔	✗	✔	✔	✗
Lyon and Sanders (36)	✗	✗	✔	✔	✔	✗	✗	✔	✗	✗	✗	✗	✗	✔	✔	✗	✗	✗	✗
Malik et al (37)	✗	✗	✔	✔	✔	✗	✗	✗	✔	✔	✗	✗	✔	✔	✔	✗	✔	✔	✗
Martchenke et al (38)	✗	✗	✔	✗	✔	✗	✗	✔	✗	✗	✔	✗	✔	✗	✗	✔	✔	✔	✔
Martin (51)	✔	✔	✔	✔	✔	✔	✗	✔	✔	✗	✗	✗	✗	✔	✗	✗	✔	✔	✗
Matsumoto et al (39)	✗	✔	✔	✔	✔	✗	✗	✔	✔	✗	✗	✔	✔	✗	✔	✗	✔	✗	✗
Nates (40)	✗	✗	✔	✔	✔	✗	✗	✔	✗	✗	✔	✔	✗	✗	✗	✗	✔	✗	✗
Nia et al (53)	✗	✗	✔	✔	✔	✔	✗	✗	✗	✗	✔	✔	✔	✗	✔	✗	✗	✗	✗
Nicholas and Oberheide (52)	✗	✔	✔	✔	✔	✗	✗	✗	✔	✗	✔	✔	✔	✔	✔	✔	✔	✗	✔
Nocera and Dalton (41)	✗	✗	✗	✗	✔	✗	✗	✔	✗	✗	✔	✔	✔	✔	✔	✗	✗	✗	✗
Oestern et al (42)	✗	✔	✔	✔	✔	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✔	✗	✔
Pokorny (43)	✗	✗	✔	✔	✔	✗	✗	✔	✗	✗	✔	✔	✗	✗	✗	✗	✔	✗	✔
Romundstad et al (44)	✗	✔	✔	✔	✔	✔	✔	✗	✔	✗	✗	✗	✔	✔	✗	✗	✔	✔	✔
Schwartz and Bar-Dayan (45)	✔	✗	✔	✔	✔	✗	✗	✗	✗	✗	✗	✗	✔	✔	✗	✗	✔	✔	✗
Sollid et al (46)	✔	✔	✔	✔	✔	✗	✗	✔	✔	✗	✔	✔	✔	✔	✔	✗	✔	✔	✗
Spano et al (9)	✗	✔	✔	✔	✔	✔	✗	✔	✔	✗	✔	✔	✗	✗	✗	✗	✔	✔	✗
Stohler et al (8)	✗	✗	✗	✗	✔	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✔
Urquieta and Varon (47)	✗	✔	✔	✗	✔	✗	✗	✔	✔	✗	✗	✗	✔	✔	✗	✗	✔	✔	✗
Yi-Szu et al (48)	✗	✗	✗	✔	✗	✔	✗	✗	✗	✗	✗	✗	✗	✔	✗	✗	✔	✗	✗

HEMS = Helicopter emergency medical services.

risks associated with confined area landings and bad weather flight operations.

The heterogeneous nature of major incidents is reflected by the lack of a common nomenclature.[55] Several definitions of a major incident have been proposed that differ slightly from each other.[56–58] To avoid excluding relevant articles, literature that defined their incident as a major incident or disaster was included.

	INTERNAL VALIDITY					EXTERNAL VALIDITY						
	Is the author a person directly involved in the major incident medical response?	Does the literature provide reference to where the data were obtained?	Does the literature provide reference to how the data were obtained?	Do the authors have conflicts of interest?	Has an ethics committee approved the reporting?	Describe the local EMS and HEMS structure before the incident?	Is the major incident clearly described?	Are the medical resources used in the major incident response clearly described?	Does the literature report the type, number and capacity of HEMS?	Are there indications on missing data?	Are other limitations discussed?	Is the study design clearly explained?
Afzali et al [16]	?	✔	✔	✗	✗	✔	✗	✗	✔	✗	✗	✔
Almersjø et al [49]	✗	✔	✔	?	?	✔	✔	✗	✔	✗	✗	✔
Ammons et al [17]	?	✗	✗	?	?	✔	✔	✔	✗	✗	✗	✔
Assa et al [7]	?	✔	✔	?	?	✗	✔	✔	✔	✗	✗	✔
Bland [18]	✔	N/A	N/A	?	?	✗	✔	✗	✗	✗	✗	✔
Bovender and Carey [19]	✔	✗	✗	?	?	✗	✔	✗	✗	✗	✗	✔
Brandsjø et al [50]	✗	✔	✔	?	?	✔	✔	✔	✔	✗	✗	✔
Branstrom et al [20]	✗	✔	✔	?	?	✔	✔	✔	✔	✗	✗	✔
Buerk et al [21]	?	✗	✗	?	?	✔	✔	✗	✗	✔	✗	✗
Buhrer and Tilney [22]	?	✗	✗	?	?	✗	✔	✗	✔ Not capacity	✗	✗	✔
Carlascio et al [23]	✔	✗	✗	✔	?	✔ Not EMS	✔	✔ Not EMS	✔ Not type	✗	✗	✗
Cassuto and Tarnow [24]	?	✗	✗	?	?	✗	✔	✔	✗	✗	✗	✗
Cocanour et al [25]	?	✗	✗	?	?	✗	✔	✗	✗	✗	✗	✔
Eckstein and Cowen [26]	?	✗	✗	?	?	✗	✔	✗	✗	✗	✗	✔
Felix Jr [27]	?	✔ Partly	✗	?	?	✔ Not EMS	✔	✗	✗	✗	✗	✔
Franklin et al [28]	?	✗	✗	?	✗	✗	✔	✔	✗	✗	✗	✗
Furukawa [6]	?	✗	✗	?	?	✗	✔	✔	✗	✗	✗	✗
Iselius [29]	✗	✔	✗	?	?	✗	✔	✔	✗	✗	✗	✔
Jacobs et al [30]	?	✔	✗	?	?	✔ Not EMS	✗	✗	✗	✗	✗	✔
Lavery and Horan [31]	?	✗	✗	✗	?	✗	✔	✗	✗	✗	✔	✗
Lavon et al [32]	?	✔	✔	?	?	✔	✔	✔	✔	✗	✔	✔
Leiba et al [33]	?	✔	✔	?	?	✗	✔	✗	✗	✗	✗	✔
Leiba et al [34]	?	✔	✔	?	?	✗	✔	✔	✗	✗	✗	✔
Lockey et al [35]	?	✔	✗	?	?	✔ Not EMS	✔	✗	✗	✔	✗	✔
Lyon and Sanders [36]	?	✗	✗	✗	?	✔ Not EMS	✔	✔	✗	✗	✗	✗
Malik et al [37]	?	✗	✗	?	?	✗	✔	✗	✗	✗	✔	✔
Martchenke et al [38]	?	✔	✔	?	?	✗	✔	✗	✗	✗	✗	✔
Martin [51]	✔	✗	✗	?	?	✔	✔	✔	✔ Not capacity	✗	✗	✗
Matsumoto et al [39]	?	✗	✗	?	?	✔ Only DMAT	✔	✔ Only DMAT	✗	✗	✗	✗
Nates [40]	?	✗	✗	?	?	✗	✔	✗	✗	✗	✗	✔
Nia et al [53]	?	✔	✔	?	?	✗	✔	✗	✗	✗	✗	✔
Nicholas and Oberheide [52]	✔	✗	✗	?	?	✔	✔	✗	✗	✗	✗	✗
Nocera and Dalton [41]	?	✗	✗	?	?	✔ Not EMS	✔	✗	✔ Not capacity	✗	✗	✔
Oestern et al [42]	?	✗	✗	?	?	✗	✔	✔	✗	✗	✗	✔
Pokorny [43]	?	✗	✗	?	?	✔	✔	✔	✗	✗	✗	✔
Romundstad et al [44]	✔	✔	✔	?	?	✗	✔	✔	✔ Not capacity and type	✗	✗	✔
Schwartz and Bar-Dayan [45]	✔	✔	✔	?	?	✔	✔	✔	✔ Not capacity	✗	✗	✔
Sollid et al [46]	?	✔	✔	✗	✔*	✗	✔	✔	✗	✗	✔	✔
Sparo et al [9]	?	✔	✔	✗	?	✔	✔	✔	✗	✔	✔	✔
Stohler et al [8]	?	✗	✗	?	?	✔ Not EMS	✔	✗	✗	✗	✗	✔
Urquieta and Varon [47]	?	✗	✗	?	?	✗	✔	✔	✔	✗	✗	✔
Yi-Szu et al [48]	?	✔	✗	?	?	✗	✔	✗	✗	✗	✗	✔

* Applied, Committee concidered approval not neccessary. DMAT = Disaster medical assistance teams. EMS = Emergency medical services. HEMS = Helicopter emergency medical services.

Figure 3 Appraisal.

Our findings emphasise that a universally accepted definition of major incident is needed to facilitate comparative studies and to improve the accuracy of database indexing.

Our appraisal found that the majority of the included articles provided detailed descriptions of the incidents but that there was a tendency towards inadequate descriptions of the everyday HEMS system. The lack of baseline data made it difficult to evaluate the deployment and utilisation of extraordinary resources during major incidents. The methodological designs were generally weak and dominated by retrospective observational case reports. This is not surprising considering the difficulties in planning and executing prospective studies on major incidents. With an established template of standardised variables, a prospective study design can, however, be established to collect data from major incidents. If similar data are collected from major incident exercises in similar systems, a case–control design can even be applied to future studies. Such studies can be further strengthened by including other data sources such as focus group interviews from involved personnel in the sense of method triangulation.[59 60] We also found that some incidents were described by several reports, indicating possible skewedness in the literature regarding high-profile incidents. As with all unstructured reporting, establishing a denominator for HEMS involvement proved difficult, again highlighting that future research should build on systematically collected data with uniform variable definitions to allow better comparisons.[61]

Limitations

The authors selected items for use in data extraction and appraisal that they assumed were relevant. However, these items do not represent a reference standard, since such a standard does not exist, to our knowledge.

Many major incidents occur in non-English-speaking countries; accordingly, it is a weakness that only articles in English and the Nordic languages were included. However, the included articles described incidents on different continents, which improve the generalisability of the findings. Further, we may have failed to identify some relevant studies, since articles without abstracts were not included, and a single author performed the initial screening.

Conclusion

This systematic literature review identified, described and appraised the literature on the utilisation of HEMS in the early medical management of major incidents. Heterogeneous data reporting complicated our efforts to identify and evaluate the overall utilisation of HEMS in such incidents. To address such shortcomings, systematic uniform reporting of HEMS in major incidents is called for.

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Paper II

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RESEARCH ARTICLE

Helicopter emergency medical services in major incident management: A national Norwegian cross-sectional survey

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Abstract

Objective

Helicopter Emergency Medical Services (HEMS) aim to bring a highly specialised crew to the scene of major incidents for triage, treatment and transport. We aim to describe experiences made by HEMS in Norway in the management of major incidents.

Design

Doctors, rescue paramedics and pilots working in Norwegian HEMS and Search and Rescue Helicopters (SAR) January 1st 2015 were invited to a cross-sectional study on experiences, preparedness and training in major incident management.

Results

We identified a total of 329 Norwegian crewmembers of which 229 (70%) responded; doctors 101/150, (67%), rescue paramedics 64/78 (82%), pilots 64/101, (63%). HEMS and SAR crewmembers had experience from a median of 2 (interquartile range 0–6) major incidents. Road traffic incidents were the most frequent mechanism and blunt trauma the dominating injury. HEMS mainly contributed with triage, treatment and transport. Communication with other emergency services prior to arrival was described as bad, but good to excellent when cooperating on scene. The respondents called for more interdisciplinary exercises.

Conclusion

HEMS and SAR crewmembers have limited exposure to major incident management. Interdisciplinary training on frequent scenarios with focus on cooperation and communication is called for.

adherence to all the PLOS ONE policies on sharing data and materials.

Abbreviations: CBRNe, Chemical, Biological, Radioactive, Nuclear and Explosive; EMCC, emergency medical communications centre; EMS, emergency medical services; GP, General practitioner; HEMS, helicopter emergency medical services; IQR, inter quartile range; JRCC, joint rescue coordination centre; MI, major incident; NGO, Non-Governmental Organization; RTI, Road traffic incident; SAR, search and rescue; TETRA, terrestrial trunked radio; VHF, very high frequency.

Introduction

Major incidents (MI) constitutes a major global public health problem affecting both urban and rural areas. [1–3] The definition of MI in the literature is heterogeneous, but has been referred to as an incident that requires mobilization of extraordinary emergency medical service (EMS) resources and that has been identified as a MI in that system. [4] The capacity to manage MI varies depending on type of incidents, local resources and systems. Normally, MI triggers the activation of the local health systems emergency plans. Even in high income countries where the health systems are normally robust, MI can constitute a challenge beyond the system capacity. [5] In the period between 1970–2003 a total of 80 MIs claimed 1174 lives in Norway. The incidents mainly pertained to transportation, industry, offshore activity as well as major avalanches. [6]

Helicopter emergency medical service (HEMS) and search and rescue (SAR) helicopters contribute to major incident management with transportation of equipment, personnel, and patients as well as providing overhead surveillance and perform search and rescue. [7] Although HEMS and SAR units are included in most major incident management plans, optimal utilization of this limited resource remains undecided.

Norway has a national governmentally funded air ambulance service consisting of three elements; fixed-wing air ambulance, HEMS and SAR helicopters (Fig 1). The HEMS and fixed-wing air ambulance are the responsibility of the Ministry of Health and Care Services and are provided by the four government-owned regional health enterprises. The flight operation is contracted to commercial companies that operate on a strictly regulated contract and as an integral part of the national health care system. The SAR helicopters are the responsibility of the Ministry of Justice and Public Security. They are operated by the Royal Norwegian Air Force, but are per se a civilian resource and not subject to a military command structure in SAR or HEMS operations. The HEMS units are dispatched by the local medical communications centre (EMCC) responsible for the region where the HEMS is situated, while the SAR units are dispatched by one of two joint rescue coordination centres (JRCC). The SAR units are primarily used for SAR missions, but can be released for air ambulance missions by the JRCC on request from an EMCC and are therefore regarded as an integral part of the national air ambulance system. Similarly, HEMS can be released for SAR missions by the EMCC on request from the regional JRCC. Depending on the nature of the mission, EMCC or JRCC will have the main responsibility for coordinating resources. Medical staffing is similar in both HEMS and SAR with an anaesthesiologist and a rescue paramedic, but HEMS is only equipped for light SAR missions.

By the means of a cross-sectional survey we aimed to describe experiences with major incident management, preparedness and training among all Norwegian HEMS and SAR crewmembers to identify areas of improvement for major incident response and training programmes.

Methods

Study population

Norwegian HEMS crew configuration encompasses one pilot, one rescue paramedic and one consultant anaesthesiologist. This is the normal crew configuration, however at one HEMS base, a flight nurse supplements the crew. HEMS pilots are involved in on-scene medical care as long as it does not interfere with flight operations. All SAR units are staffed with two pilots, one flight-technician, one navigator, one rescue paramedic and one consultant anaesthesiologist. The national air ambulance service consisted of seven fixed-wing bases, 11 HEMS bases and seven SAR bases at the time of the study. All HEMS and SAR bases are equipped with a

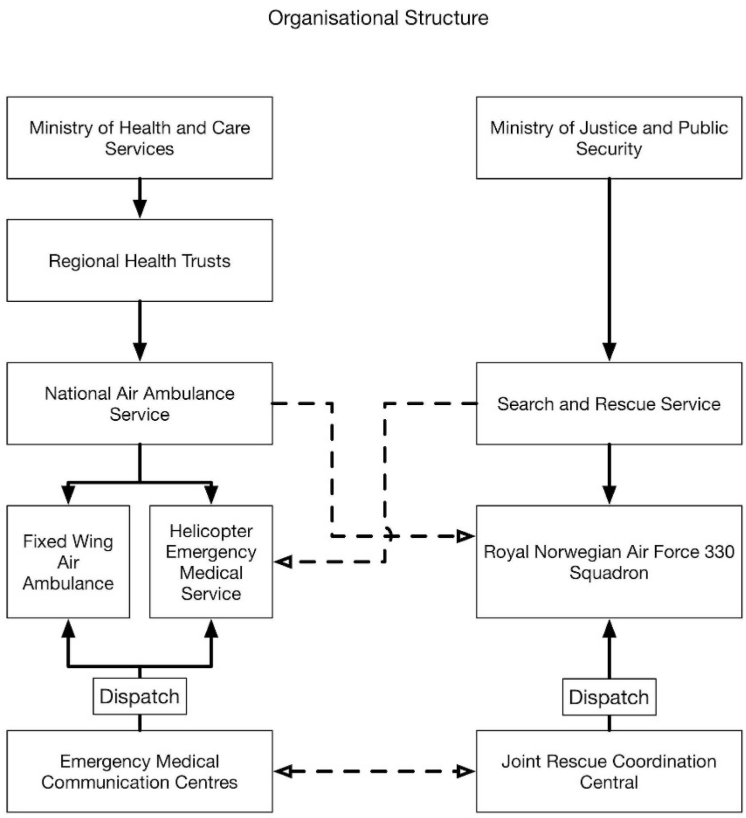

Fig 1. Organisational structure of Norwegian HEMS and SAR.

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rapid response car for missions in the proximity of the base, or as a backup when weather or technical issues do not allow for the use of helicopters. Pilots, rescue paramedics and doctors working at HEMS and SAR bases as of January 1st 2015 were invited to participate in the study. Fixed-wing operations were excluded.

Study design

A major incident was defined as an incident reported to EMCC or JRCC from pre-hospital resources as extensive enough to require extra personnel or resources from neighbouring districts and the activation of the emergency plans in involved hospitals. The magnitude of what constitutes a MI would vary according to resources available in the regions. This definition was included in the beginning of the survey to ensure that respondents understood what constituted a major incident. SAR helicopters are embedded in the air ambulance service and were defined as HEMS units.

We conducted a web-based (SurveyXact, (c) 2013–2015 Rambøll Management Consulting, Denmark) cross-sectional survey. Data was de-identified and collected in the period of the beginning of January 2015 to the end of June 2015. Eligible participants were invited individually via an e-mail describing the study. Non-responders received two reminders before they were excluded from the study. The program allowed only one answer per respondent and only sent reminders to non-responders.

In the absence of a validated questionnaire, our questions were constructed after inter-disciplinary consensus between HEMS pilot, rescue paramedic, doctor and researchers. Follow-up questions were designed to explore responder experiences in detail and to collapse irrelevant sections to avoid response fatigue. Some questions were profession specific (e.g. only for doctors), thereby changing the response nominator and denominator throughout the study.

The survey included three sections with questions pertaining to basic demographic data, experience from real incidents and training and equipment. The respondents were asked to relate questions regarding MI experiences to the latest MI they had attended within the last five years. If they had not attended any MIs within that period they only answered the training and equipment section.

Data were analyzed within SurveyXact and described by counts, median and inter quartile range (IQR). Being an anonymous survey, written consent to participate was not obtained. Responders agreed to participate in the study by answering the questionnaire. A disclaimer on personal privacy and ethical approval was presented to all potential responders in the first email that also described the authors and funding from Norwegian Air Ambulance Foundation. SurveyXact sent two reminders to non-responders before they were excluded from the study. Data was aggregated before analysis to avoid recognition of individual answers. The Regional Committee for Ethics in Medical Research concluded that ethical approval was not needed (2014/720/REK sør-øst D) and the Norwegian Social Science Data Services approved the study (38408).

Results

Study population

A total of 329 crewmembers were invited to participate in the survey and 229 (70%) responded. Rescue paramedics had the highest response rate (82%) followed by doctors (67%) and pilots (63%). Most respondents had more than 10 years HEMS or SAR experience (Fig 2).

The doctors had experience from a median of 1 (n = 101, IQR 0–5) MI, whereas rescue paramedics and pilots had experience from a median of 3 (n = 64, IQR 0–8 or more) and 2 (n = 64, IQR 0–6) MIs respectively. Further, more than half of the respondents (n = 52, (51%) doctors, n = 38, (59%) rescue paramedics and n = 38, (59%) pilots) had attended a MI within the last 5 years.

Incident description

Road traffic incident was the most common cause of incident (n = 61, 48%). Rural area (n = 80, 63%) was the most frequent location and summer (n = 50, 40%) the busiest season.

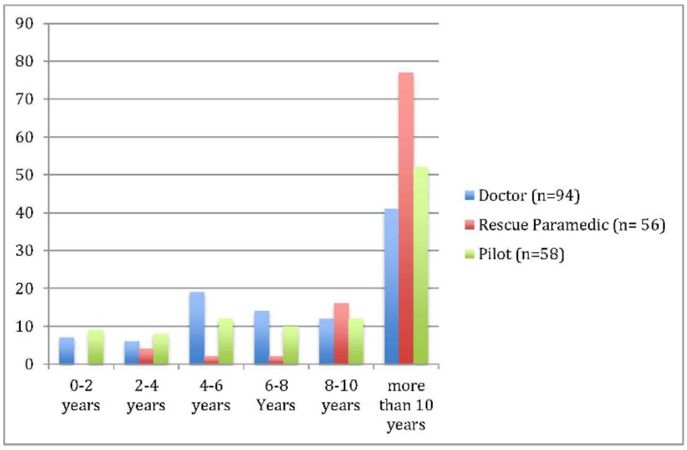

Fig 2. Years of experience working in HEMS/SAR and % of total respondents.

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Blunt trauma was the dominating type of injury in 59% (n = 51) followed by penetrating trauma (n = 14, 16%), hypothermia (n = 14, 16%) and burns (n = 13, 15%) as other frequent injuries. Further incidents descriptors are found in Table 1.

Resources on-scene

The main tasks performed by the HEMS and SAR crews were patient treatment (n = 94, 76%), triage (n = 61, 49%) and transport to local hospital (n = 46, 37%) or directly to a trauma centre (n = 37, 30%). Overview over participating agencies and individual tasks of personnel are depicted in Tables 2 and 3.

In 32% (n = 40) of the incidents, HEMS and SAR transported extra personnel and extra equipment to scene in 52% (n = 64) of the incidents.

Coordination and cooperation

The coordination and cooperation of multiple HEMS/SAR units on-scene are shown in Table 4.

Guidelines for coordination of multiple units were available for 41% (n = 24) of the pilots. Among SAR pilots, 80% (n = 20) reported they lacked enough equipment for situational awareness, compared to 9% (n = 3) among the HEMS pilots.

Table 5 depict crew rating of key aspects of major incident management.

Equipment and training

Equipment available for major incident management include extra communication aids (n = 79, 38%), extra rescue technical kit (n = 156, 75%), triage tags (n = 177, 85%), stretchers (n = 204, 98%), anti-hypothermia kits (n = 175, 84%) and extra medical equipment (n = 166,

Table 1. Description of the last incident attended by the responders.

Incident characteristics	RTI	61 (48%)
	Fire	31 (24%)
	On going violence	26(20%)
	Bus	21 (17%)
	Avalanche	21 (17%)
	Industrial accident	19 (15%)
	Tunnel	16(13%)
	Boat	16(13%)
	Airplane/Helicopter	13 (10%)
	Large crowd	11 (9%)
	Train	9 (7%)
	Explosives	9 (7%)
	Weather-related	7 (6%)
	Dangerous goods	3 (2%)
	Tram	2 (2%)
	CBRNe	1 (1%)
Location	Rural	80 (63%)
	Mixed	37 (29%)
	Alpine	25 (20%)
	Urban	24 (19%)
	Maritime	17 (13%)
Environment	Daylight	90 (71%)
	Darkness	53 (42%)
	Rain	29 (23%)
	Fog	26 (21%)
	Snow	22 (17%)
	Storm	20 (16%)
Season	Summer	50 (40%)
	Winter	36 (29%)
	Autumn	31 (25%)
	Spring	8 (6%)

Note: n = 126, multiple answers allowed
RTI = Road traffic incidents, CBRNe = Chemical, Biological, Radioactive, Nuclear and Explosive

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Table 2. Participating agencies in major incident management.

Police	118 (95%)
Ambulance	116 (94%)
Fire	110 (89%)
Other HEMS/SAR	95 (77%)
Rapid response car with GP	53 (43%)
Non-governmental organizations	49 (40%)
Military	42 (34%)
Rapid response car with anaesthesiologist	38 (31%)
Civil protection agencies	33 (27%)

Note: n = 125, multiple answers allowed. GP = General practitioner

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Table 3. HEMS/SAR tasks.

Doctor	Treatment	42 (84%)
	Transport	29 (58%)
	Triage	25 (50%)
	Medical incident commander	23 (46%)
	Other leadership tasks	8 (16%)
Pilot	Transport	26 (70%)
	Coordination of other HEMS units	19 (51%)
	Organizing landing site	12 (32%)
	SAR	9 (24%)
	Secure scene	5 (14%)
Rescue paramedic	Treatment	34 (92%)
	Transport	18 (51%)
	Triage	12 (34%)
	Securing scene	8 (23%)
	Ambulance Incident Commander	4(11%)
	Casualty clearing officer	2 (6%)

Note: Doctors: n = 50, Pilots: n = 37, Rescue Paramedic: n = 35. Multiple answers allowed.

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80%). When reporting on missing equipment, 38% (n = 75) reported communication aids, 16% (n = 31) extra medical equipment whereas 46% (n = 90) reported that they did not lack any extra equipment. Training for major incident management is depicted in Table 6.

Discussion

This national cross-sectional survey found that approximately half of Norwegian HEMS and SAR crewmembers attended a MI during the last five years. Rescue paramedics and pilots had attended more MIs than doctors. The contribution of HEMS in MI management was typically patient treatment, triage and transport of patients and personnel. This echoes the findings from a recent systematic review on the use of HEMS in major incident management. [7] Inter-disciplinary training on frequent scenarios with focus on cooperation and communication was called for by most respondents.

Incident description and resources on-scene

Road traffic incidents were reported to be the most frequent cause of MI. More than half of the incidents took place in autumn and winter when daylight is limited. A recent study of Norwegian HEMS found that cancellations were more frequent at night-time and during autumn and winter. [8] Sub-arctic weather conditions and seasonal darkness makes flight conditions in Norway challenging. Requirements for visibility and cloud base are strict for HEMS missions during darkness and thereby causes more cancelling of missions when light is low. The Norwegian All weather SAR project aims to improve the bad weather capacity for the next generation SAR helicopters. [9] In addition the Norwegian Air Ambulance"Points IN Space" project with pre-fixed routes and the Norwegian Air Ambulance"Weather Camera project" aims to improve the regularity of the HEMS missions during darkness and austere weather. [10]

Most operations were conducted in rural areas, which coincide well with Norway being a sparsely populated country with vast distances and a sub-arctic climate. [11,12]

Table 4. Coordination and cooperation.

How many EMCCs did you contact from start to end of mission? Median (IQR)		**1 (1–2)**
Several HEMS/SAR units on-scene?	Yes	98 (83%)
	No	16 (14%)
	Do not know	4 (3%)
Who informed you of the other units?	EMCC	27 (47%)
	JRCC	16 (28%)
	Other HEMS/SAR units	11 (19%)
	No information	3 (5%)
	Do not know	1 (2%)
Who coordinated HEMS units on scene	Own aircraft	34(59%)
	Other HEMS/SAR units	7 (12%)
	EMCC	5 (9%)
	Other	5 (9%)
	JRCC	2 (3%)
	Do not know	5 (9%)
What type of communication was used to communicate with other units	VHF	81 (45%)
(more than one option possible)	Norwegian public safety radio	53 (29%)
	Mobile phone	33 (18%)
	Annet	14 (7%)

Note: n = 118; IQR = Inter Quartile Range, EMCC = emergency medical communications centre, JRCC = joint rescue coordination centre, VHF = very high frequency

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Coordination and communication

The majority of incidents mobilised an interdisciplinary response. Close cooperation across hierarchical levels and knowledge of the skills of professionals and participating agencies is important in an emergency response with limited resources. [13–15] Critical decisions are made in early stages of the emergency response when resources are not meeting the demand and are made under time pressure. [16]

Table 5. Crew rating of selected key aspects of major incident management.

How would you rate	Median	IQR
On-scene management	4	(3–4)
Inter-disciplinary cooperation	4	(3–4)
Scene-safety	4	(4–5)
Personnel identification (tabards)	4	(3–4)
Personal protective equipment	4	(4–5)
Communication aids	2	(2–4)
Triage	4	(3–4)
Medical equipment	4	(4–5)

Note: n = 118, Rated on Likert scale 1–5. (1 = Very bad, 5 = Very good); IQR = Inter Quartile Range

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Table 6. Training for major incident management and extra equipment available for handling major incidents (n = 209).

How many times / year do you train for Major Incident management? Median (IQR)	1 (0–2)
How often do you train with other emergency services?	
Always	44 (21%)
Sometimes	148 (71%)
Never	10 (5%)
Do not know	6 (3%)
If yes, with who (n = 197, multiple answers allowed)	
EMS	177 (90%)
Police	169 (86%)
Fire service	169 (86%)
NGO	143 (73%)
Other HEMS/SAR units	86 (44%)
Military	67 (34%)
Primary health care	60 (30%)
What do you want more training for in the future: (n = 208, multiple answers allowed)	
Management	75 (36%)
Communication	66 (32%)
Coordination	65 (31%)
Leadership	60 (29%)
Decision-making	50 (24%)
Triage	39 (19%)
Rescue technical procedures	22 (11%)
Medical procedures / knowledge	21 (10%)

Note: IQR = Inter Quartile Range; EMS = Emergency Medical Services; NGO = Non-Governmental Organization

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The HEMS and SAR crewmembers considered communication a challenge, echoing previous descriptions of overloaded networks. [13] In the 2011, Utøya incident communication was done on both the new Terrestrial Trunked Radio (TETRA) system and on the old analogue system, thereby complicating communication. [17] The pilots reported that they had to contact a median of two different ERCCs, but only in half of the incidents did ERCC inform of other aircraft involved thereby potentially increasing the risk for adverse aviation events. This indicates insufficient coordination procedures among ERCCs regarding resources involved. At the time of the survey, 11 ERCCs were involved in dispatching 11 HEMS. Fewer and larger ERCCs or fewer ERCCs involved in dispatching neighbouring HEMS units might be a solution. The pilots reported communication with other aircraft prior to arrival as bad, but good to very good on-scene. This might reflect limitations in the radio transmission range, but it may also reflect insufficient coordinating procedures by the ERCCs on a MI with multiple HEMS/SAR helicopters. The TETRA system was fully implemented in 2016 hopefully contributing to more secure and efficient communication. [18] Rapid access to essential information reduces risk during MIs. [19] Among the SAR pilots, 80% reported a lack of equipment for situational awareness while only 9% of the HEMS pilots answered that they lacked equipment for situational awareness. This discrepancy indicates clearly an improvement potential regarding the equipment on the SAR helicopters. The acquisition of the new all weather SAR helicopters may improve equipment status considerably. [9]

Equipment and training

The extra equipment HEMS brought to scene was considered sufficient by 46% of the respondents, whereas 38% wanted more communication equipment. Although the crews train regularly, they call for more inter-disciplinary exercises that should focus on coordination, communication and cooperation. This study emphasise the importance of training on prevalent scenarios, such as road traffic incidents and austere weather conditions.

Strengths and limitations

This study aimed to depict the inter-disciplinary cooperation by including all HEMS/SAR doctors, rescue paramedics and pilots in Norway. The study achieved a response rate of 70%, which is considered acceptable. [20] Although the study population only constituted 329 potential respondents, it depicts the entire Norwegian HEMS crewmember cohort. Approximately half of the respondents had attended a major incident the last five years. The lack of a uniformly accepted definition of a major incident remains a challenge. [4,21] The present definition was constructed to increase understanding of what constitutes a major incident from the respondents. Cross-sectional study design only depicts present state of major incident preparedness and experience; causal correlations cannot be made. We also cannot exclude a certain recall bias since some of the experiences reported took place up until five years ago. We think however that the potential risk of recall bias is outweighed by the number of incidents and amount of survey data this five-year period includes. A degree of selection bias can also not be excluded. Potential respondents who have never experienced a major incident may have neglected the survey causing a skewness in the material. We hope however that the relatively high response rate of 70% makes the results representative. Few studies on major incident management in Norway have been made and no validated questionnaire existed. The present questionnaire was designed after inter-disciplinary consensus.

Conclusion

Norwegian HEMS and SAR crewmembers attend major incidents infrequently. Road traffic incidents constitute the majority of incidents and most operations are conducted in rural areas with blunt trauma as the dominating injury. HEMS predominately contribute with treatment, triage and transport of patients, equipment and personnel. Failing communication and inadequate air traffic control remains a challenge in the immediate inter-disciplinary response phase. More training with focus on coordination, communication and cooperation is called for.

Supporting information

S1 File. Survey. Original (Norwegian) version.
(DOC)

S2 File. Survey. English version.
(DOC)

S3 File. Data in Excel. Original (Norwegian) version.
(XLSX)

S4 File. Data in Excel. English (translated) version.
(XLSX)

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Paper III

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Original Research

Reporting Helicopter Emergency Medical Services in Major Incidents: A Delphi Study

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A B S T R A C T

Objective: Research on helicopter emergency medical services (HEMS) in major incidents is predominately based on case descriptions reported in a heterogeneous fashion. Uniform data reported with a consensus-based template could facilitate the collection, analysis, and exchange of experiences. This type of database presently exists for major incident reporting at www.majorincidentreporting.net. This study aimed to develop a HEMS-specific major incident template.

Methods: This Delphi study included 17 prehospital critical care physicians with current or previous HEMS experience. All participants interacted through e-mail. We asked these experts to define data variables and rank which were most important to report during an immediate prehospital medical response to a major incident. Five rounds were conducted.

Results: In the first round, the experts suggested 98 variables. After 5 rounds, 21 variables were determined by consensus. These variables were formatted in a template with 4 main categories: HEMS background information, the major incident characteristics relevant to HEMS, the HEMS response to the major incident, and the key lessons learned.

Conclusion: Based on opinions from European experts, we established a consensus-based template for reporting on HEMS responses to major incidents. This template will facilitate uniformity in the collection, analysis, and exchange of experience.

By nature, major incidents do not readily lend themselves to a prospective interventional study design. Predominately, research on major incidents is based on case reports. Although these studies can depict the challenges involved in major incident management, they are notoriously heterogeneous in format. Data reports for major incidents should be standardized to allow researchers to compare data sets and generate transportable recommendations.[1,2]

A previous systematic literature review identified 10 templates that currently existed for reporting prehospital major incident medical management.[3] However, those templates were heterogeneous and limited by incomplete implementation and a lack of feasibility testing. Subsequently, a template was created with a particular focus on the immediate prehospital phase of major incident medical management.[4] This template specified information on preincident data, background on emergency medical services (EMS), incident characteristics, EMS response data, patient characteristics, and key lessons. The template was deployed through an open-access webpage[5] that allowed peer-reviewed reporting and access to previously published reports.[6] It allows researchers and planners to collect data systematically, with the aim of improving preparedness for major incidents. However, no data set is currently available that is dedicated to the use of helicopter EMS (HEMS).

A recent systematic literature review on the use of HEMS in major incidents found that reporting was scarce and nonsystematic.[7] The review identified case reports that mainly described the use of HEMS to transport personnel and equipment, provide patient treatment, and transport patients to medical facilities.[7] HEMS is a limited, costly resource that demands highly trained, skilled personnel. Therefore, it is imperative to conduct a thorough scientific evaluation of HEMS use and potential benefit in major incident management. Reporting prospective uniform data with a consensus-based template could facilitate the collection, analysis, and exchange of experiences. We conducted a Delphi study with physicians who had HEMS experience. This study aimed to develop a consensus-based template for reporting on HEMS use in major incidents to provide uniform data for evaluations.

Methods

We used a Delphi approach with experts who interacted by e-mail.[8] The Delphi technique is a method for systematically collecting opinions from a group of respondents on a specific issue. Questionnaires are administered in repeated rounds, with adjustments in each round, until a consensus is reached.[8-10] The consensus requires general agreement or "a consensus of opinion among judges."[11]

We recruited prehospital critical care physicians with current or previous HEMS experience to participate in the consensus group. This group was drawn from the European prehospital research alliance (EUPHOREA),[12] defined as an informal European research network, which is composed of clinicians and researchers who aim to promote research in prehospital critical care. The recruited experts were from the Nordic countries and Eastern and Central Europe. They were asked to identify which data variables were most important to report during an immediate HEMS response to a major incident. A major incident was defined as an incident that required the mobilization of extraordinary EMS resources and was identified as a major incident in that system.[4]

The objectives for each round of the Delphi process are listed in Table 1. The primary aims were to provide systematic collection of standardized data and a means for freely disseminating these data to other practitioners and managers. Gradually, with each individual assessment and reassessment of synthesized responses, a consensus was reached. As a feedback control, in each round, we provided a summary of the previous rounds and offered the participants an opportunity to add thoughts and clarifications.[8] All data were summarized and presented anonymously in Excel spreadsheets (Microsoft Corp, Redmond, WA).

Ethics

Norwegian law dictated that this project did not fall within the mandate of the Health Research Act, and it did not require approval by the Regional Committee for Medical and Health Research because it did not involve research on humans, biological material, or confidential information.[13] Furthermore, this study was exempt from the Data Protection for Research restrictions because we did not collect personal or sensitive data.[14]

Results

The Consensus Process

Of the 28 individuals invited to participate in the consensus process, 19 accepted (67.9%). Fifteen participated throughout the entire process, and 2 responded to 4 out of 5 rounds. The remaining two participants did not respond after round 1 and were excluded from the research process, leaving a total of 17 participating experts. In the first round, we received a total of 98 suggested variables from the experts. Based on the comments and the average

Table 1
Objectives for Each Round of the Delphi Process

Round 1	In an open-ended question, participants in the expert group were asked to suggest the 10 variables that they thought were most important to report during a HEMS response to a major incident.
Round 2	The results from the first round were structured in a spreadsheet, and duplicate suggestions were removed before they were returned to the experts. They were asked to review and rate all variables from 1 (totally disagree) to 5 (totally agree) based on how relevant they found each item.
Round 3	Variables with an average score of 4 or more continued to the third round. In this round, the experts received a number of questions to answer regarding wording of questions, consent to delete some questions because of overlap, relevance of alternatives under a main question, and if there should be a free-text field for addressing key lessons. Furthermore, they were instructed to provide comments and grade the variables as either compulsory or optional.
Round 4	After summarizing the feedback from round 3, the list of variables that received a consensus, the accompanying comments, and further questions were distributed to the experts. This round provided an opportunity for participants to revise their judgments and combine similar variables.
Round 5	The feedback from round 4 was summarized into a final version of the template and sent to the experts to elicit any objections and/or to give final approval of the HEMS major incident-reporting template.

HEMS = helicopter emergency medical service.

variable scores in round 2, 29 variables were selected for round 3. In round 3, the experts had to agree on the wording of questions, and they rated the questions as compulsory or optional. In round 4, the participants clarified uncertainties and merged similar variables to obtain 21 variables. In round 5, all 17 members of the group gave their final approval of the HEMS major incident reporting template. These 5 rounds resulted in a template that covered 4 main categories (Supplementary Material): HEMS background information, major incident characteristics relevant to HEMS, the HEMS response to major incident, and key lessons.

HEMS Background

The variables in this category (questions 1-4, Supplementary Material) provided information regarding HEMS deployment details. It specified the number of HEMS sent to the affected area, whether HEMS was staffed by a doctor, and the preplanned role of HEMS in a major incident.

Major Incident Characteristics Relevant to HEMS

These variables (questions 5-7, Supplementary Material) described how accessible the scene was to HEMS and hazards that specifically affected HEMS in the incident.

HEMS Response to the Major Incident

The variables in this category (questions 8-19, Supplementary Material) were divided into 2 subcategories: dispatch and tasks. Data collected in the dispatch subcategory (questions 8-13) described the time line for dispatch, the number of HEMS requested, and how many actually responded. Furthermore, this category recorded the reasons for the request and the reasons for not responding (when applicable). The tasks subcategory (questions 14-19) recorded the tasks performed by the HEMS crew, the individual members transported to respond to the scene, and patient descriptors.

Key Lessons

This category contained 2 questions (questions 20 and 21). The first listed several safety challenges (question 20), and the second (question 21) allowed free-text descriptions of key lessons learned.

Implementation

This template for reporting data on the use of HEMS in immediate prehospital medical responses to major incidents can be used as a stand-alone document, but it will also be embedded in the established major incident reporting database.[5] Upon accessing the template, the recorder must provide a short summary before proceeding to question 1. The summary will consist of relevant pre-incident data and information about the time, mechanism, location, and accessibility of the incident. Completion of the full major incident-reporting template will be optional.

Discussion

This study developed a template for reporting on the use of HEMS for an immediate prehospital medical response to a major incident. We achieved a consensus among 17 clinicians with HEMS experience. The template included 21 variables in a stand-alone format. We implemented this template in an existing database (majorincidentreporting.net) to allow global open access for reporting on the use of HEMS in major incidents.[4]

In most countries, HEMS is an integral part of major incident management and planning, but uniformity is lacking in reports on the use of HEMS.[7] Major incidents are infrequent events that often have devastating impacts on regional infrastructures and people's lives. Optimized major incident management has been shown to improve outcome[15]; however, planners must strive for efficient use of limited resources. By obtaining a consensus on data reporting, we may be able to generate a body of experiences from previous incidents that can inform our responses to future challenges. Furthermore, the template categories can be used to structure manuscripts and to guide editorial reviews of case reports. The data recorded on the HEMS background and major incident characteristics relevant to HEMS allow readers to assess whether the findings might be valid in other settings. The HEMS response to the major incident section contains data useful for establishing a time line, for determining the number and types of resources to dispatch, and for estimating how these resources could be used on scene. Finally, the key lessons section can offer personnel the ability to describe in their own words the challenges and successes encountered during a major incident. The free-text sections may provide data for future qualitative studies.

Several definitions of a major incident exist. In the current template, we applied the definition used in a previous template for continuity.[4] The presence of multiple definitions for a major incident[4,16-18] and more or less synonymous wording, such as mass casualty incidents or disasters, may be sources of confusion. Therefore, uniform nomenclature is called for.

We chose the Delphi method because it is useful for gaining information in the absence of sufficient research on the topic,[8] which was the case for the use of HEMS in major incidents. E-mail correspondence provided a cost- and time-effective alternative to physical attendance to consensus meetings. Additionally, e-mail anonymity reduced the possibility that dominant individuals might influence opinions, which may be a concern in physical meetings.[10] Although all the experts were recruited from the EUPHOREA network, they were not aware of the identities of other participants until after the concensus process was completed. After each of the 5 rounds, the study authors summarized results, merged very similar questions, and suggested subheadings for the template. In this work, the study authors attempted to maintain objectivity to minimize their influence on the process.[9]

This study had some limitations. First, the expert group may have been overly homogenous; thus, it may not have covered the entire spectrum of opinions.[19] Also, the consensus group consisted only of clinicians from European countries; this potential bias may limit the global application of the template. However, because most HEMS services are currently available only in high-income countries, we believe that the results from the current expert group are generalizable. Finally, during the final rounds, 2 experts withdrew from the process. As described previously, a poor response rate can present a challenge; however, our small dropout rate (2/17) was not expected to compromise the study results.[20]

Conclusion

We developed a consensus-based template for reporting on HEMS responses to major incidents based on the opinions of a group of European HEMS physicians. This template was designed to supplement an existing template for reporting on prehospital medical management in major incidents. Uniform data on the HEMS response to major incidents can facilitate the collection, analysis, and exchange of valuable experiences. In addition, it may provide a basis for scientific evaluations on the use of this scarce, resource-demanding service in such situations. The implementation of systematic, structured reports on HEMS use in major incidents represents an important step in making vital data available for conducting comparative analyses and drawing valid conclusions. We urge global HEMS systems to implement and disseminate this template.

Author contributions

SF conceived the idea. All authors took part in study design. SF and ASJ collected and analyzed the data. Decisions in all the rounds were based on consensus between all the authors and suggestions from the consensus group. All authors took part in writing the manuscript and provided final approval.

Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.amj.2016.08.003.

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Paper IV

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ORIGINAL ARTICLE

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Major incident management by helicopter emergency medical services in south-east Norway from 2000 to 2016: Retrospective cohort study

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Background: Helicopter emergency medical services (HEMS) and search and rescue helicopters (SAR) aim to bring specialized personnel to major incidents and transport patients to definite care, but their operational pattern remains poorly described. We aim to describe the use of HEMS and SAR in major incidents in Norway and investigate the feasibility of retrospectively collecting uniform data from incident reports.

Methods: We searched HEMS medical databases from three HEMS and one SAR base in south-east Norway for the written reports of incidents from 2000 to 2016. After incidents were included through consensus in the author group, we collected data as described in majorincidentreporting.org and a previous cross-sectional study and rated availability of the variables.

Results: From a total of 31 803 missions, we identified 50 (0.16%) major incidents with HEMS/SAR involvement where road traffic accidents were the most common type of incident (n = 28, 56%), and rural area was the most prevalent location (n = 35, 70%). Inter-agency cooperation was common and HEMS contributed most often with treatment and transport. The majority of information was found in the free-text area in the medical records hereby increasing the risk for rater variability.

Conclusion: Major incidents are rare in Norway. HEMS and SAR play an important role in incident logistics, cooperation with other agencies, treatment and transport of patients and should be included in major incident plans. Retrospective data collection is challenging as data variables are not systematically integrated into the database. Future research should focus on systematic data gathering and a system for sharing lessons learned.

1 | INTRODUCTION

Major incidents, like natural disasters, terrorist attacks and complex road traffic accidents are variously defined in the literature. A definition by Fattah et al[1] refers to a major incident as an incident that requires mobilization of extraordinary emergency medical services (EMS) resources and is identified as a major incident in that system. Major incidents remain a major societal problem, inflicting great human suffering and financial loss. An analysis found that a total of 80 major incidents relating to transportation, industry, offshore activity as well as avalanches claimed 1174 lives in the period between 1970 and 2003 in Norway.[2]

Helicopter emergency medical services (HEMS) and search and rescue helicopters (SAR) have the potential to contribute to major incident management with transportation of equipment, personnel and patients as well as providing overhead surveillance and scene search.[3,4] A previous cross-sectional survey of all Norwegian HEMS and SAR crew members found that they seldom attended major incidents, the doctors had attended on average one whereas the rescue paramedic and pilot had attended three incidents.[5]

Norway is a subarctic country, with scattered population where transport distances may be long and challenged by fjords and mountains. There is a publicly funded health care system where HEMS and fixed-wing air ambulance are part of a national air ambulance system. SAR are integrated in the air ambulance system and operated by the Royal Norwegian Air Force, but used primarily as a civilian resource. There are 12 HEMS and seven SAR bases in Norway, all staffed with a consultant anaesthesiologist, a rescue paramedic and pilot(s) and with similar medical equipment set-up. In addition, SAR are staffed with a flight mechanic and a navigator. Dispatch is subject to unitary coordination causing great overlap in catchment/operating areas. When required, the services have additional equipment on-base for use in incidents with special needs, for example avalanche. HEMS/SAR can provide advanced pre-hospital treatment and often has senior competence to make medical and tactical decisions. Ambulance, police and fire services are in close inter-disciplinary cooperation in most incidents in Norway. The personnel on-scene informs the emergency medical command centre what resources are needed for coordination and allocation of additional rescue services.

In an attempt to collect uniform data on HEMS/SAR use in major incidents, a consensus-based template for the use of HEMS and SAR in major incidents was developed in 2016.[6] The aim of the present study was to conduct a retrospective cohort study of Norwegian HEMS and SAR major incident management describing how HEMS and SAR are used in major incidents, their tasks and challenges to improve future management and preparedness. Furthermore, we aimed to investigate the feasibility of retrospectively collecting uniform data from incident reports.

2 | METHODS

2.1 | Setting

In this retrospective cohort study, we searched the medical database LabasNG (Normann IT) from three HEMS bases and one SAR base, for reports covering major incidents in the period from 2000 through 2016 (inclusive). The HEMS bases Lørenskog, Ål and Arendal together cover urban, mountain and coastal terrains and were thus assumed to be representative of the Norwegian HEMS. Lørenskog has two helicopters at disposal. Arendal, Ål and Rygge have one helicopter each. The SAR base at Rygge is considered a good representative of the SAR service in Norway with a mission profile of both ambulance- and SAR missions.

Editorial Comment

This report describes recent major incidents in a region where there are physician-manned helicopter ambulances. Major incidents appear to be rare in South-East Norway according to this retrospective study. HEMS units also appear to play a major role in their management in that region.

2.2 | Eligibility criteria

A major incident was defined as "an incident that requires the mobilization of extraordinary EMS resources and is identified as a major incident in that system."[1] In Norway, this means that the extent will vary according to resources available in the district were the incident occurs. Urban areas have more resources available; hence, they can potentially handle more patients than rural districts before extraordinary EMS resources are mobilized. Rural was defined as "characteristic of the countryside rather than the town" and urban was defined as "relating to, or characteristic of a town or city."[7]

2.3 | Incident selection

LabasNG is a proprietary relational database management system. No data fields, tick-boxes or other descriptors denote a major incident. Identification of major incidents can only be processed via free text searches. Initial mapping by International Classification of Diseases (ICD) diagnosis (Data S1) removed the incidents that clearly did not fit the description. Aborted and rejected missions were excluded as they cannot be identified as major incidents in the current registry. One author (ASJ) manually searched the remaining reports for possible eligibility. MR and MS evaluated the free text sections of all potentially eligible reports for inclusion. In cases with divergent opinions, SJS was consulted and consensus was sought through group discussion.

2.4 | Data collection

When a major incident was identified, we collected data according to variables defined in majorincidentreporting.org[6] and a previous cross-sectional survey[5] (Data S2). There are 28 questions in the HEMS template in majorincidentreporting.net and 62 questions in the cross-sectional study, many of which are overlapping. In total, information on 28 variables was collected, including incident characteristics, resources on scene, HEMS/SAR tasks, response times, challenges for HEMS/SAR and patients' characteristics. For cross-reference, we also searched the mission database AMIS (CSAM Health AS) of the emergency medical communication centre in Oslo and information available in the public domain for information regarding number of patients involved and injured. The time of incident was checked against local sunrise and sunset. The availability of the variables was rated "Good": almost always information available in free-text area or tick-boxes; "Medium": information available in both free-text areas or tick-boxes; but more vulnerable to rater variability and "Poor": not possible to find information without a degree of speculation from the authors or not found at all.

2.5 | Statistical analysis

Data were entered into a Microsoft Excel (Microsoft Corporation) spread sheet and was analysed using IBM SPSS Statistics version 25 (IBM). Categorical data are presented as counts (n) and proportions (%). Continuous data are presented as medians with quartiles and missing data are presented in brackets. The Kruskal-Wallis nonparametric test are used when assessing the differences in response times, the number of persons involved, the number of persons injured, the number of persons declared dead on-scene and the number of persons treated by HEMS/SAR and between urban and non-urban (semi-rural, rural, maritime and alpine) incidents.

2.6 | Ethics

The Regional Committee for Ethics in Medical Research concluded that ethical approval was not needed and gave exemption from the duty of confidentiality with the condition that no person would be recognizable (2017/2175-3 and 2017/2148-3 REKSør-Øst, approval date December 20, 2017) The Norwegian Social Science Data Services approved the study (60670/3/HJP/LR, approval date November 9, 2018) and the data protection officers from the three local health enterprises responsible for the respective HEMS/SAR services gave permissions.

The STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) checklist for cohort studies was consulted when conducting this study.[8]

3 | RESULTS

The search produced a total of 31 803 missions for the study period. ASJ initially included 265 missions for further screening. MR and MS disagreed in 162 of the 265. This did not represent 162 individual major incidents, as HEMS/SAR submit reports on unique patients, not missions. It represented 109 separate incident reports, but the exact number of major incidents was lower as the four HEMS/SAR bases often attended the same incidents. The majority of the incidents with disagreement were road traffic accidents (RTAs) (76 of 109). After achieving consensus, a total of 50 incidents were defined as major incidents and included in further statistical analyses, see Figure 1.

3.1 | Major incident characteristics

RTAs were the most common incidents (n = 28, 56%), and rural area the most prevalent location (n = 35, 70%). Most incidents occurred during daylight (n = 35, 70%) and in summer season (n = 23, 46%).

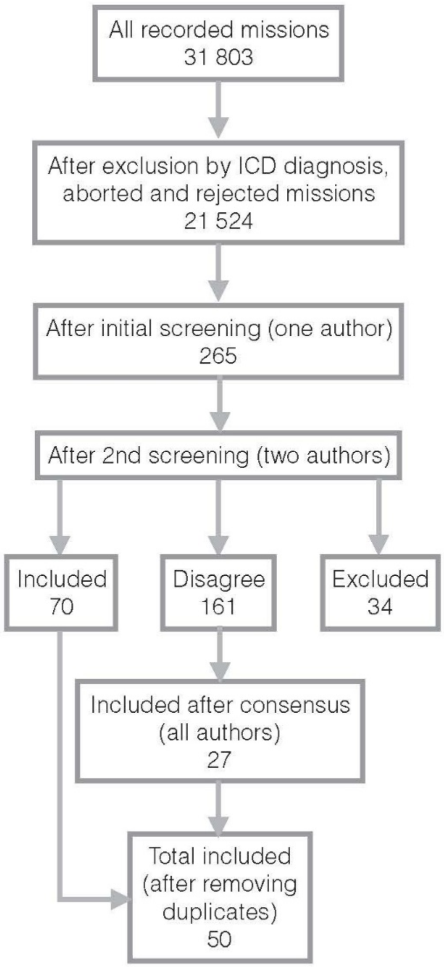

FIGURE 1 Mission flowchart

3.2 | HEMS/SAR characteristics

In the 50 incidents included, a median of three (1-3) helicopters participated. The median response time for the first helicopter on scene was 36.5 (24-50) minutes, 25 (16-36) minutes for urban and 37 (24-51) minutes for non-urban incidents (P = .147).

TABLE 1 Major incident characteristics (n = 50) (Selecting multiple alternatives possible with incident characteristics, location and environment)

Incident characteristics	
RTA	28 (56%)
Bus	11 (22%)
Fire	5 (10%)
Avalanche	4 (8%)
Tunnel	4 (8%)
Boat	4 (8%)
Train	3 (6%)
Helicopter	2 (4%)
On-going violence	2 (4%)
CBRNe	1 (2%)
Other	2 (4%)
Location	
Urban	4 (8%)
Semi-rural	7 (14%)
Rural	35 (70%)
Maritime	4 (8%)
Alpine	6 (10%)
Environment	
Daylight	35 (70%)
Darkness	15 (30%)
Snow	3 (6%)
Fog	2 (4%)
Rain	2 (4%)
Storm	2 (4%)
Season	
Winter	13 (26%)
Spring	8 (16%)
Summer	23 (46%)
Autumn	6 (12%)

Abbreviations: CBRNe, chemical, biological, radioactive, nuclear and explosive; RTA, road traffic accident.

We identified only three incidents (6%) where HEMS/SAR was the first medical resource on scene, but in 33 incidents (66%) they brought the first (or only) doctor. In two of the incidents (4%), HEMS/SAR was the only resource in the acute phase, a train accident in a mountainous area not accessible by road and a helicopter crash in a mountainous region.

3.3 | Resources on-scene and HEMS/SAR tasks

Participating agencies are depicted in Table 2 and HEMS/SAR crew tasks in Table 3. The main tasks were treatment (n = 49, 98%) and transport directly to the regional trauma centre (n = 26, 52%). In six incidents HEMS/SAR transported extra personnel to the scene, doctor (n = 4, 8%), rescue-paramedic (n = 1, 2%) and rescue-dog with handler (n = 1, 2%). In four incidents, they carried extra equipment that is stretchers (n = 3, 6%), triage equipment (n = 1, 2%) and extra medical equipment (n = 1, 2%). HEMS/SAR crew indicated that they lacked necessary equipment in only one incident (2%), in this case a navigational aid.

3.4 | Challenges for HEMS/SAR

Weather was considered a hazard on-scene in 7 (14%) and on-going fires in 6 (12%) incidents. Difficult landing site was the most common challenge (n = 5, 10%), but in the majority of incidents there were no reported hazards. Communication problems were reported in 6 (12%) incidents (see Table 4 for a summary reported challenges).

3.5 | Patient characteristics

A total of 2422 persons were involved in the incidents. Median persons involved was 11 (7-36), with 43 (6-93) for urban and 11 (7-34) for non-urban incidents (P = .590). A total of 615 persons were injured. Median number of persons injured was 7 (5-11), with 9 (6-18) for urban and 7 (4-11) for non-urban incidents (P = .389). Twenty incidents (40%) resulted in human fatalities, where a total of 114 persons were declared dead on-scene.

HEMS/SAR crew treated a total of 425 patients. Median patients treated were 5 (3-7), 6 (1-17) for urban incidents and 5 (3-7) (P = .692) for non-urban incidents. HEMS/SAR crew transported a total of 101 patients, all from non-urban incidents. Median patients transported by HEMS/SAR were 1 (1-3).

The median age of persons involved was 25 (18-45) years (missing 291), 168 males and 168 females (missing 279). The median NACA score was 6 (4-7) (missing 386). Patient characteristics with age, sex and NACA have a high number of missing as HEMS crew only report data on the patients they treat.

TABLE 2 Participating agencies in major incident management in Norway 2000-2016. (n = 50) (Selecting multiple alternatives possible)

Ambulance	48 (96%)
Fire	41 (82%)
Police	41 (82%)
Other HEMS/SAR	27 (74%)
Rapid response car with anaesthesiologist	8 (16%)
Non-governmental organizations	7 (14%)
Rapid response car with general practitioner	6 (12%)
Foreign units	4 (8%)
Civil protection agencies	1 (2%)
Military	1 (2%)
Other	8 (16%)

TABLE 3 HEMS/SAR tasks (n = 50) (Selecting multiple alternatives possible)

Transport of extra equipment or personnel to scene	4 (8%)
Coordination	10 (20%)
Treatment	49 (98%)
Transportation from scene to casualty clearing station	2 (4%)
Transportation from scene to trauma unit	12 (24%)
Transportation from scene to regional trauma centre	26 (52%)
Transportation from casualty clearing station to trauma unit	3 (6%)
Transportation from casualty clearing station to regional trauma centre	3 (6%)
Transportation from trauma unit to regional trauma centre	5 (10%)
Search and rescue	5 (10%)
Other	4 (8%)

TABLE 4 Challenges for HEMS/SAR (n = 50) (Selecting multiple alternatives possible)

Hazards on-scene that affected HEMS/SAR	
Weather	7 (14%)
Fire	6 (12%)
Visibility	2 (4%)
Weapon	1 (2%)
CBRNe	1 (2%)
Other	1 (2%)
No or unknown hazards	34 (68%)
Safety challenges for HEMS/SAR	
Aircraft crowding—air	1 (2%)
Aircraft crowding—ground	1 (2%)
Drones/press helicopter	1 (2%)
"Hot zone"	2 (4%)
Difficult landing site	5 (10%)
No or unknown challenges	42 (84%)
Challenges with communication	
Yes	6 (12%)
No/unknown	43 (86%)

Blunt injuries were the most dominating injuries (n = 37, 74%). Hypothermia (n = 8, 16%) and burn injuries (n = 6, 12%) were also seen.

3.6 | Inclusion of reported, unreported and missing data

Multiple questions from the template and the survey were overlapping (6 from the template and 12 from the survey) and others were general background information (8 and 34, respectively). The majority of information was found in the free-text area where the anaesthesiologist reported a description of the incident, response and patient treatment. This is subject to rater variability. The availability ratio "Good":"Medium":"Poor" was 13:12:3 (Data S2, column D-F).

Data depicting coordinating roles and triage remain unreported, as this was not systematically recorded in LABAS.

4 | DISCUSSION

Major incidents are rare in South-East Norway. In this retrospective cohort study of Norwegian HEMS/SAR in major incident management, we identified 50 major incidents in the period 2000-2016. Our study shows that HEMS/SAR play a diverse role with the capacity of bringing a highly specialized crew and extra personnel and equipment to the scene. The operations are characterized by extensive inter-disciplinary cooperation with other HEMS/SAR bases and rescue agencies. Furthermore, HEMS/SAR have capability for providing advanced treatment and quick transport to designated trauma care for patients with high severity as depicted by their high NACA-score (median 6). In this study they treated more patients than they transported to definite care. They should be included in major incident management plans and train regularly with other agencies.

Road traffic accidents (RTAs) were the most common type of incident and summer the busiest season, echoing findings from other studies.[9-11] Norway is a country dominated by rural areas in a sub-arctic environment with potential for decompensated scenes given the austerity of the environment. The capacity to manage a major incident varies with local resources and is why we differentiated urban and rural incidents. A majority of incidents occurred in rural areas as these resources are more easily overwhelmed. Other countries will have different profile of distances, HEMS/EMS coverage and crew combination, but RTAs will probably be a leading cause of trauma and a warm climate may make them more prone to major incidents.[12] Arguments for a more widespread use of ground units may be wise in some countries, but considered not so relevant in Norway. The Norwegian population is scattered and transport distances are long and challenged by fjords and mountain areas, making HEMS/SAR effective in reducing transportation time for severely injured patients in rural areas. HEMS/SAR are vulnerable to weather[13-15] but in most incidents there were no recorded hazards or safety challenges. Aircraft crowding and "Hot zone" hazard were all related to the twin-terrorist attack in the governmental building and Utøya island.[16] This was the largest incident in this material both regarding resources and persons involved, injured and dead thereby being an outlier in our data.[16,17]

Although HEMS/SAR are seldomly the first crew on-scene, they often bring the first doctor.[18,19] The first crew on scene will often have a role in keeping overview, triage and perform logistical and tactical communication with the other agencies. Furthermore, the other crews will focus on the most severely injured patients identified by first crew on-scene.[19] The median number of helicopters participating in major incidents was three, showing that cooperation between the different HEMS/SAR bases is frequent. The median response time was 36.5 (24-50) minutes. Østeras et al reported response times of 24 minutes and Samdal et al reported 47 minutes for HEMS and 47 minutes for SAR.[18,20,21] Norway has no official policy on "Stay and Play" vs "Scope and Run." This depends on the condition of the patient, provider competence and transport time to hospital. All HEMS/SAR transports to hospital were from rural incidents. HEMS/SAR may contribute with transport of personnel and equipment to scene, although this study shows that HEMS/SAR rarely bring additional equipment. When needed, this may be brought by civil protection services and non-governmental organizations. In the majority of included major incidents, other rescue agencies were present. When a major incident occurs, multiple agencies with different roles operate in parallel in chaotic environments.[22,23] Therefore, it is important to have implemented major incident management plans and ensure that inter-agency training frequently occur.

In this study, we wanted to investigate the feasibility of retrospectively collecting uniform data from the incident reports. We originally planned to include information regarding triage and coordinating roles. We interpreted from free text field annotations that informal major incident triage has been performed, but the application of formal triage standards was not described. The Norwegian standard for mass-casualty triage was developed during the study period and was published in 2013.[24]

The complexity of defining a major incident remains a controversy in the field of disaster medicine research where several definitions exist and no definition is uniformly accepted.[1,25,26] We applied the definition used in the previous cross-sectional study and Delphi study in which the variables in the current study originated.[1,5] The definition focus on medical major incidents but as this study shows, all rescue services work together in the complexity of a major incident. We have not been able to quantify other rescue services participating as the current registry provides no information on this. There is no exact space that mentions major incidents. The prehospital experience and knowledge of Norwegian geography in the author group were used to achieve consensus on which incidents to include.

There are multiple reporting templates available.[27] The EMS society should agree on a common template to enable more homogenous data reporting as major incidents are rare and prospective studies will be hard to conduct.

The current study does not include all Norwegian HEMS and SAR bases, thereby lacking full national representation. Nevertheless, we included services covering both rural and central areas to improve generalizability of results to other settings as well. The data extracted in this study did not cover all the data from the majorincidentreporting.org template,[6] mainly because the template is not incorporated into LABAS, but underlining a need for implementing common templates for data collection. The doctor writes his report after the incident. This may inflict recall bias and the quality of the entered data varies. HEMS/SAR will naturally record data on patients they treat and transport, but not patients handled by other rescue organizations. Median NACA of all patients involved in major incident will probably be lower as missing data most likely occur in patients with lower NACA score. The score was set by the doctor reporting in LABAS and is a subjective score for patient severity. Although it may be subject for rater variability, it has shown to reliably predict mortality and the need for advanced interventions.[28] This was a retrospective study and we may have missed incidents, thereby underestimating our reported major incident incidence. Unfortunately, the current data system does not allow analysis of aborted or rejected mission requests and incidents where helicopters did not participate because of weather, technical issues etc remain unknown. The total number of patients involved in the major incidents included is difficult to establish, as the exact number not always was reported.

5 | CONCLUSION

Major incidents are rare and operations are characterized by extensive inter-disciplinary cooperation. HEMS play a central role in medical management and should be included in major incident plans. Future research should focus on systematic data gathering and a system for sharing lessons learned for major incident planners to make resilient plans that include HEMS/SAR involvement and help HEMS/SAR crews identify important areas of training.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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Appendices

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Appendix 1 – Survey, English version

To those working in Helicopter Emergency Medical Services (HEMS) and Search and Rescue (SAR) services in Norway. We appreciate that you take the time to respond to the present survey.

Definition:
Major incident:
An incident reported to Emergency Medical Communication Centrals (EMCC) or Joint Rescue Coordination Centres (JRCC) from pre-hospital resources as extensive enough to require extra personnel or resources from neighbouring districts and the activation of the emergency plans in involved hospitals.
The magnitude of what constitutes a major incident will vary according to resources available in the regions.

Survey:

What is your profession?
(1) ❑ Doctor
(2) ❑ Rescue paramedic
(3) ❑ Pilot

In how many major incidents have you been involved as rescue personnel?
(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4
(6) ❑ 5
(7) ❑ 6
(8) ❑ 7
(9) ❑ 8
(10) ❑ 9
(11) ❑ 10 or more

Have you been involved in the management of a major incident the last 5 years?
(1) ❑ Yes
(2) ❑ No

Characteristics with the major incident:

-Please reply to the following questions based on the last major incident you attended.

In which service did you work?

(1) ❑ SAR/Recue helicopter service
(2) ❑ HEMS

Describe the incident: (Multiple alternatives allowed)

(1) ❑ Large road traffic incident
(2) ❑ Bus
(3) ❑ Train
(4) ❑ Tram/Underground
(5) ❑ Plane/Helicopter
(6) ❑ Tunnel
(7) ❑ Boat
(8) ❑ Extreme weather
(9) ❑ Avalanche
(10) ❑ Work related incident/Industrial incident
(12) ❑ Fire
(13) ❑ Large crowd
(14) ❑ Explosives
(15) ❑ Ongoing life-threatening violence - Active shooter
(16) ❑ Chemical/Biological/Radioactive/Nuclear
(17) ❑ Dangerous goods
(18) ❑ Unknown
(19) ❑ Other _____

Where was the incident? (Multiple alternatives allowed)

(1) ❑ City
(2) ❑ Urban area
(3) ❑ Rural area
(4) ❑ Maritime
(5) ❑ Alpine
(6) ❑ Other _____

Weather / conditions at incident start: (Multiple alternatives allowed)

(1) ❑ Daylight
(2) ❑ Darkness
(3) ❑ Snow

(4) ❑ Fog
(5) ❑ Rain
(6) ❑ Strong winds/storm
(7) ❑ Other _____

Season:
(1) ❑ Summer
(2) ❑ Autumn
(3) ❑ Winter
(4) ❑ Spring

Dominating type of injury? (Multiple alternatives allowed)
(1) ❑ Blunt
(2) ❑ Penetrating
(3) ❑ Hypothermia
(4) ❑ Burns
(5) ❑ Other __________

Which other services participated in the rescue work? (Multiple alternatives allowed)
(1) ❑ Ambulance
(2) ❑ Rapid response car with General Practitioner on-call
(3) ❑ Rapid response car with Anaesthesiologist
(5) ❑ Fire services
(6) ❑ Police
(7) ❑ Other HEMS/SAR services
(8) ❑ Voluntary organizations
(9) ❑ Civil defense
(13) ❑ Defense
(10) ❑ Industry protection services
(11) ❑ Foreign services
(12) ❑ Other _____

On-scene management:
What was your crew and aircraft used for? (Multiple alternatives allowed)
(1) ❑ Transport to scene with extra resources/rescue personnel
(2) ❑ Securing scene
(3) ❑ Leadership/Coordination

(4) ❑ Triage
(5) ❑ Patient treatment
(6) ❑ Transport from scene to casualty clearing station
(7) ❑ Transport from scene to trauma unit
(8) ❑ Transport from scene to regional trauma center
(9) ❑ Transport from casualty clearing station to trauma unit
(10) ❑ Transport from casualty clearing station to regional trauma center
(11) ❑ Transport from trauma unit to regional trauma center
(12) ❑ Search
(13) ❑ Other _____

What was your role on-scene? (Multiple alternatives allowed)
(1) ❑ Medical incident officer (Fagleder helse)
(2) ❑ Other leadership
(3) ❑ Triage
(4) ❑ Patient treatment
(5) ❑ Transport
(6) ❑ Other __________

What was your duties on-scene? (Multiple alternatives allowed)
(1) ❑ Securing scene
(2) ❑ Leadership
(3) ❑ Coordination of other aircrafts
(9) ❑ Organization/Preparation of landing site
(4) ❑ Triage
(5) ❑ Treatment
(6) ❑ Transport
(7) ❑ Search
(8) ❑ Other __________

What was your duties on-scene? (Multiple alternatives allowed)
(1) ❑ Rescue paramedic (assisting the Doctor)
(2) ❑ Medical on-scene commander (Operativ leder helse)
(3) ❑ Leader casualty clearing station
(4) ❑ Leader incident scene
(5) ❑ Leader patient transport
(6) ❑ Triage

(7) ❑ Patient treatment
(8) ❑ Transport
(9) ❑ Securing scene
(10) ❑ Search
(11) ❑ Other __________

Did you bring extra personnel in addition to ordinary crew?
(1) ❑ Yes
(2) ❑ No

What professional category? (Multiple alternatives allowed)
(1) ❑ Doctor
(2) ❑ Nurse
(3) ❑ Rescue paramedic
(4) ❑ Pilot
(5) ❑ Ambulance personnel
(6) ❑ Observer
(7) ❑ Other __________

Did you bring extra equipment?
(1) ❑ Yes
(2) ❑ No
(3) ❑ Unknown

What type of equipment did you bring? (Multiple alternatives allowed)
(1) ❑ Communication equipment
(2) ❑ Rescue technical equipment
(3) ❑ Triage equipment
(4) ❑ Stretchers
(5) ❑ Drugs
(6) ❑ Hypothermia preventive equipment
(7) ❑ Medical supply
(8) ❑ Other __________

Did you have sufficient equipment to handle the situation?
(1) ❑ Yes
(2) ❑ No

What equipment was missing? (Multiple alternatives allowed)
(1) ❑ Communication equipment
(2) ❑ Rescue technical equipment
(3) ❑ Triage equipment
(4) ❑ Stretchers
(5) ❑ Drugs
(6) ❑ Hypothermia preventive equipment
(7) ❑ Medical supply
(8) ❑ Other __________

Where the patients systematically triaged?
(1) ❑ Yes
(2) ❑ No
(3) ❑ Unknown

What system for triage was used?
(1) ❑ TAS triage
(2) ❑ SALT
(3) ❑ National guidelines for major incident triage
(4) ❑ No formal system for triage was used
(5) ❑ Other _____

How did this work?

	Very bad	**Bad**	**Neither good nor bad**	**Good**	**Very good**	**Unknown**
Scene management	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Common understanding of scene organization	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Own safety	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Personnel tabards	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
PPE	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Communication	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

	Very bad	Bad	Neither good nor bad	Good	Very good	Unknown
Triage	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Medical supply	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Extra stretchers	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Other preparedness equipment	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Safety, cooperation and logistics:

How many EMCCs did you communicate with from activation until mission was completed and you had returned back to base?

(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4
(6) ❑ 5
(7) ❑ 6 or more

Where multiple helicopters activated to the incident?

(1) ❑ Yes
(2) ❑ No
(3) ❑ Unknown

How many helicopters were involved?

____

Who informed that these helicopters were activated? (Multiple alternatives allowed)

(1) ❑ EMCC
(2) ❑ JRCC
(3) ❑ ATC
(4) ❑ Other HEMS/SAR helicopters
(5) ❑ Other rescue services

(6) ❑ No information given
(7) ❑ Unknown

Who coordinated cooperation between different helicopters on-scene?
(1) ❑ EMCC
(2) ❑ JRCC
(3) ❑ ATC
(4) ❑ Other helicopters
(5) ❑ Own helicopter/Captain
(6) ❑ Other __________
(7) ❑ Unknown / Not applicable

What mode of communication was used between the different helicopters? (Multiple alternatives allowed)
(1) ❑ Health radio/Digital emergency radio
(2) ❑ VHF flight radio
(3) ❑ Mobile telephone
(4) ❑ Other __________

How did communication with other helicopters prior to arrival to scene work?
(1) ❑ Very bad
(2) ❑ Bad
(3) ❑ Neither bad nor good
(4) ❑ Good
(5) ❑ Very good
(6) ❑ Unknown / not applicable

How did on-scene *cooperation and communication* work with:

	Very bad	**Bad**	**Neither good nor bad**	**Good**	**Very good**	**Unknown**
Pilots	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Rescue paramedic	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
HEMS Doctors	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Other Doctors	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

	Very bad	Bad	Neither good nor bad	Good	Very good	Unknown
Own crew	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
EMCC in-charge	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
JRCC in-charge	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Responsible ATC	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Local rescue coordinating central	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ambulance services	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Police on-scene	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Fire services	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Defense	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Voluntary organizations	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Civil defense	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Receiving hospital	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Delivering hospital during Inter-hospital transfer	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Industry protection services	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Describe what was good / challenging with the cooperation:

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____

In the incident area, how will you describe your knowledge about:

	Very bad	**Bad**	**Neither good nor bad**	**Good**	**Very good**	**Unknown**
Hospital	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Casualty clinic	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ambulance service	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Cooperation and logistics:

Who should, in your opinion, coordinate air traffic in uncontrolled airspace with several helicopters during a major incident?

(1) ❑ EMCC
(2) ❑ ATC
(3) ❑ JRCC
(4) ❑ First HEMS or SAR helicopter on-scene
(5) ❑ Other _____
(6) ❑ Unknown

Does guidelines for coordination/cooperation between multiple helicopters on scene in uncontrolled airspace exist in your Company/Squadron?

(1) ❑ Yes
(2) ❑ No
(3) ❑ Unknown

Is the helicopter you operate, in your opinion, equipped with sufficient equipment to allow "situational awareness" in flight safety and other aircrafts?

(1) ❑ Yes
(2) ❑ No
(3) ❑ Unknown

What type of equipment do you miss?

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Do you know what VHF flight frequency that is normally used during rescue operations?

(1) ❑ Yes

(2) ❑ No

How do you consider your knowledge about:

	Very bad	Bad	Neither good nor bad	Good	Very good	Unknown
Other rescue services in your	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

	Very bad	Bad	Neither good nor bad	Good	Very good	Unknown
catchment area						
Treatment options at hospitals in your catchment area	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Other rescue services outside your catchment area	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Hospital organization outside your catchment area	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Competence and procedures:

Do you have experience in being Medical incident officer (Fagleder helse)?

(1) ❑ Yes
(2) ❑ No

Have you attended a major incident where you, in your opinion, should have been Medical incident officer (Fagleder helse)?

(1) ❑ Yes
(2) ❑ No

Have you attended a major incident where you were Medical incident officer (Fagleder helse), where this was unnecessary?

(1) ❑ Yes
(2) ❑ No

Do you have experience with being Medical on-scene commander (Operativ leder helse)?

(1) ❑ Yes
(2) ❑ No

Have you attended a major incident where you, in your opinion, should have been Medical on-scene commander (Operativ leder helse)?

(1) ❑ Yes
(2) ❑ No

Have you attended a major incident where you were Medical on-scene commander (Operativ leder helse), where this was unnecessary?

(1) ❑ Yes
(2) ❑ No

How do you consider:

	Very bad	**Bad**	**Neither good nor bad**	**Good**	**Very good**	**Unknown**
Your competence in organizing a major incident scene?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Training you have received in organizing a major incident scene?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Your competence in taking the role of Medical incident officer?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Training you have received in in taking the role of Medical incident officer?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Your competence in taking the role of Medical on-scene commander?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Training you have received in in taking the role of Medical on-scene commander?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Have you participated in the course "Cooperation on-scene" ("Samvirke på skadested")?

(1) ❑ Yes
(2) ❑ No

How many years have gone since you participated on the course?

(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4 or more

How will you consider your training in handling your allocated tasks in managing a major incident?

(1) ❑ Very bad/Non existent
(2) ❑ Bad
(3) ❑ Neither bad nor good
(4) ❑ Good
(5) ❑ Very good

How many times per year do you train on managing major incidents? (If you work on several bases, please list total amount of training)

(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4 or more

How often does your service participate in large exercises with other services?

(1) ❑ Every time
(2) ❑ Now and then
(3) ❑ Never
(4) ❑ Unknown

With whom? (Multiple alternatives allowed)

(1) ❑ Police
(2) ❑ Fire
(3) ❑ Ambulance
(4) ❑ Other HEMS/SAR helicopters
(5) ❑ Primary health care
(6) ❑ Rapid response in-hospital teams
(7) ❑ Defense

(8) ❑ Voluntary organizations
(9) ❑ Other _____

On a scale from 1 to 5 where 1 is to little and 5 is to a large extent, will more knowledge and training make you better prepared to manage future major incidents?

(1) ❑ 1
(2) ❑ 2
(3) ❑ 3
(4) ❑ 4
(5) ❑ 5

What do you want more knowledge about/competence in? (Multiple alternatives allowed)

(1) ❑ Leadership
(2) ❑ Decision-making
(3) ❑ Organization
(4) ❑ Communication
(5) ❑ Cooperation with own and other services
(6) ❑ Rescue technical procedures
(7) ❑ Medical procedures/Knowledge
(8) ❑ Triage
(9) ❑ Other _____
(10) ❑ Nothing

Have you been trained in the new guidelines for major incident triage?

(1) ❑ Yes
(2) ❑ No
(3) ❑ Unknown

Have your service available tagging equipment adapted to the new guidelines for major incident triage?

(1) ❑ Yes
(2) ❑ No
(3) ❑ Unknown

What extra equipment for major incident management exists in your service? (Multiple alternatives allowed)

(1) ❑ Communication equipment
(2) ❑ Rescue technical equipment
(3) ❑ Triage equipment
(4) ❑ Stretcher
(6) ❑ Hypothermia preventive equipment
(7) ❑ Medical extra equipment
(8) ❑ Other _____
(9) ❑ Nothing

What extra equipment for major incident management do you miss in your service? (Multiple alternatives allowed)

(1) ❑ Communication equipment
(2) ❑ Rescue technical equipment
(3) ❑ Triage equipment
(4) ❑ Stretcher
(6) ❑ Hypothermia preventive equipment
(7) ❑ Medical extra equipment
(8) ❑ Other _____
(9) ❑ Nothing

Finally:

How many years have you been working in pre-hospital service?

(1) ❑ 0-2
(2) ❑ 2-4
(3) ❑ 4-6
(4) ❑ 6-8
(5) ❑ 8-10
(6) ❑ more than 10 years

Where do you work?

(1) ❑ SAR/Rescue helicopter service
(2) ❑ HEMS

Do you have any suggested improvements in major incident management? What works well/bad?

____

____

____

____

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Thank you for taking the time to respond to the survey

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Appendix 2 – Survey, Norwegian version

Til deg som jobber i luftambulansetjenesten / redningstjenesten i Norge.
Tusen takk for at du tar deg tid til å besvare undersøkelsen.

Stor hendelse:
En hendelse/ulykke som er så omfattende ut i fra melding til AMK at stedlige ressurser (ambulanse, politi og brann) må tilkalle mannskaper på ekstravakt eller hente inn ressurser fra nabodistrikt. Den er så stor at det slås katastrofealarm på nærmeste sykehus. Hendelsens størrelse og hva man kan håndtere vil variere ut i fra de ressurser man har til rådighet i sin region.

Hva er ditt yrke?

(1) ❑ Lege
(2) ❑ Redningsmann
(3) ❑ Pilot

I hvor mange store hendelser har du som innsatspersonell vært innvolvert i redningsarbeid?

(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4
(6) ❑ 5
(7) ❑ 6
(8) ❑ 7
(9) ❑ 8
(10) ❑ 9
(11) ❑ 10 eller flere

Har du vært innvolvert som innsatspersonell i en stor hendelse siste 5 år?

(1) ❑ Ja
(2) ❑ Nei

Generelle kjennetegn ved hendelsen.
Svar på de neste spørsmålene ut i fra den siste store hendelsen du var på.

Hvilken tjeneste jobbet du i ved den aktuelle hendelsen?

(1) ❑ SAR / redningshelikoptertjenesten

(2) ❑ Rotorwing luftambulansetjenesten

Beskriv hendelsen (sett gjerne flere kryss).

(1) ❑ Stor trafikkulykke

(2) ❑ Buss

(3) ❑ Tog

(4) ❑ Trikk

(5) ❑ Fly / Helikopter

(6) ❑ Tunnel

(7) ❑ Båt

(8) ❑ Ekstremvær

(9) ❑ Skred

(10) ❑ Arbeidsulykke / Industriulykke

(12) ❑ Brann

(13) ❑ Stor folkemengde

(14) ❑ Eksplosiver

(15) ❑ Skarp situasjon / skyting pågår

(16) ❑ Kjemisk / Biologisk / Radioaktiv / Nukleær

(17) ❑ Farlig gods

(18) ❑ Ukjent

(19) ❑ Annet _____

Hvor var hendelsen? (Sett gjerne flere kryss)

(1) ❑ By

(2) ❑ Tettbygd strøk

(3) ❑ Grisgrendt strøk

(4) ❑ Maritim

(5) ❑ Fjell

(6) ❑ Annet _____

Værforhold ved hendelsens start. (Sett gjerne flere kryss)

(1) ❑ Dagslys
(2) ❑ Mørke
(3) ❑ Snøvær
(4) ❑ Tåke
(5) ❑ Regn
(6) ❑ Sterk vind / storm
(7) ❑ Annet _____

Årstid.

(1) ❑ Sommer
(2) ❑ Høst
(3) ❑ Vinter
(4) ❑ Vår

Hvilke pasientskader dominerte? (Sett gjerne flere kryss)

(1) ❑ Stumpe skader
(2) ❑ Spisse skader
(3) ❑ Hypotermi
(4) ❑ Brannskader
(5) ❑ Andre __________

Hvilke andre etater deltok i redningsarbeidet? (Sett gjerne flere kryss)

(1) ❑ Ambulanse
(2) ❑ Legebil med legevaktslege
(3) ❑ Legebil med anestesilege
(5) ❑ Brannvesen
(6) ❑ Politi
(7) ❑ Andre luftambulansetjenester / redningshelikoptre
(8) ❑ Frivillige organisasjoner
(9) ❑ Sivilforsvaret
(13) ❑ Forsvaret
(10) ❑ Industrivern
(11) ❑ Utenlandske enheter

(12) ❑ Andre_____

Arbeid på skadested.

Hva ble *ditt crew og fartøy* brukt til? (sett gjerne flere kryss)

(1) ❑ Transport til skadested med ekstra ressurser / innsatspersonell
(2) ❑ Sikring av skadested
(3) ❑ Ledelsesoppgaver / koordinering
(4) ❑ Triage
(5) ❑ Pasientbehandling
(6) ❑ Transport fra skadested til samleplass
(7) ❑ Transport fra skadested til akuttsykehus
(8) ❑ Transport fra skadested til regionalt traumesenter
(9) ❑ Transport fra samleplass til akuttsykehus
(10) ❑ Transport fra samleplass til regionalt traumesenter
(11) ❑ Transport fra akuttsykehus til regionalt traumesenter
(12) ❑ Søk
(13) ❑ Annet_____

Hva ble *du* brukt til? (Sett gjerne flere kryss)

(1) ❑ Fagleder helse
(2) ❑ Annen ledelse
(3) ❑ Triage
(4) ❑ Pasientbehandling
(5) ❑ Transport
(6) ❑ Annet__________

Hva ble *du* brukt til? (Sett gjerne flere kryss)

(1) ❑ Sikring av skadested
(2) ❑ Ledelsesoppgaver

(3) ❑ Koordinering av andre luftfartøy
(9) ❑ Organisering / tilrettelegging av landingsplass
(4) ❑ Triage
(5) ❑ Behandling
(6) ❑ Transport
(7) ❑ Søk
(8) ❑ Annet __________

Hva ble *du* brukt til? (Sett gjerne flere kryss)
(1) ❑ Redningsmann(assistent til legen)
(2) ❑ Operativ leder helse
(3) ❑ Leder samleplass
(4) ❑ Leder skadested
(5) ❑ Leder innbringertjeneste
(6) ❑ Triage
(7) ❑ Pasientbehandling
(8) ❑ Transport
(9) ❑ Sikring av skadested
(10) ❑ Søk
(11) ❑ Annet __________

Tok dere med ekstra personell utover vanlig crew?
(1) ❑ Ja
(2) ❑ Nei

Hvilke yrkeskategorier? (Sett gjerne flere kryss)
(1) ❑ Lege
(2) ❑ Sykepleier
(3) ❑ Redningsmann
(4) ❑ Pilot
(5) ❑ Ambulansepersonell
(6) ❑ Hospitant
(7) ❑ Andre __________

Tok dere med ekstra utstyr?

(1) ❑ Ja
(2) ❑ Nei
(3) ❑ Vet ikke

Hvilket utstyr tok dere med? (Sett gjerne flere kryss)

(1) ❑ Sambandsutstyr
(2) ❑ Redningsteknisk utstyr
(3) ❑ Triageutstyr
(4) ❑ Bårer
(5) ❑ Medikamenter
(6) ❑ Hypotermiforebyggende utstyr
(7) ❑ Medisinsk ekstrautstyr
(8) ❑ Annet __________

Hadde dere tilstrekkelig utstyr for å håndtere situasjonen?

(1) ❑ Ja
(2) ❑ Nei

Hvilket utstyr manglet? (Sett gjerne flere kryss)

(1) ❑ Sambandsutstyr
(2) ❑ Redningsteknisk utstyr
(3) ❑ Triageutstyr
(4) ❑ Bårer
(5) ❑ Medikamenter
(6) ❑ Hypotermiforebyggende utstyr
(7) ❑ Medisinsk ekstrautstyr
(8) ❑ Annet __________

Ble pasienter triagert på en systematisk måte?

(1) ❑ Ja

(2) ❑ Nei

(3) ❑ Vet ikke

Hvilken type triage ble brukt?

(1) ❑ TAS triage

(2) ❑ SALT

(3) ❑ Nasjonal veileder for masseskadetriage

(4) ❑ Ingen formell triage ble benyttet

(5) ❑ Annen ______

Hvordan fungerte:

	Svært dårlig	**Dårlig**	**Hverken dårlig eller bra**	**Bra**	**Svært bra**	**Vet ikke**
Skadestedsledelse	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Felles forståelse for organisering av skadested	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Egensikkerhet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Merking av personell	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Personlig bekledning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Samband	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Triage	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Medisinsk utstyr	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ekstra båremateriell	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Annet beredskapsutstyr	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Sikkerhet, samarbeid og logistikk.

Hvor mange AMK sentraler var dere i kontakt med fra alarmering til oppdraget var gjennomført og dere var tilbake på basen?

(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4
(6) ❑ 5
(7) ❑ 6 eller flere

Ble det rekvirert flere helikoptre til hendelsen?

(1) ❑ Ja
(2) ❑ Nei
(3) ❑ Vet ikke

Hvor mange helikoptre var innvolvert?

____

Hvem informerte om at disse var involvert / rekvirert? (Sett gjerne flere kryss)

(1) ❑ AMK
(2) ❑ HRS
(3) ❑ ATC
(4) ❑ Andre luftambulanser / redningshelikoptre
(5) ❑ Andre nødetater
(6) ❑ Fikk ingen informasjon
(7) ❑ Vet ikke

Hvem påtok seg den koordinerende rollen for samvirke med øvrige helikoptre på skadested?

(1) ❑ AMK
(2) ❑ HRS
(3) ❑ ATC
(4) ❑ Andre helikoptre
(5) ❑ Eget helikopter / fartøysjef
(6) ❑ Andre __________
(7) ❑ Vet ikke / ikke aktuelt

På hvilket samband foregikk kommunikasjon med øvrige helikoptre? (Sett gjerne flere kryss)

(1) ❑ Helseradio / digitalt nødnett
(2) ❑ VHF flyradio
(3) ❑ Mobiltelefon
(4) ❑ Annet __________

Hvordan vil du vurdere kommunikasjon med øvrige helikoptre før ankomst skadested?

(1) ❑ Svært dårlig
(2) ❑ Dårlig
(3) ❑ Hverken dårlig eller god
(4) ❑ God
(5) ❑ Svært god
(6) ❑ Vet ikke / ikke aktuelt

Hvordan vil du vurdere *samarbeid og kommunikasjon* under innsatsen med:

	Svært dårlig	**Dårlig**	**Hverken eller**	**Bra**	**Svært bra**	**Vet ikke / Ikke aktuelt**
Piloter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Redningsmenn	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
LAT leger	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

	Svært dårlig	Dårlig	Hverken eller	Bra	Svært bra	Vet ikke / Ikke aktuelt
Andre leger	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Eget crew	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ansvarlig AMK	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ansvarlig HRS	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ansvarlig ATC	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ansvarlig lokal redningssentral (LRS)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ambulansetjenesten	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Politi på skadested	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Brannvesen	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Forsvaret	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Frivillige organisasjoner	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Sivilforsvaret	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Mottagende sykehus	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Avleverende sykehus ved sekundærtransport	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Industrivern	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Evt beskriv hva som var bra / utfordrende med samhandlingen.

____

____

____

____

____

____

____

____

I det aktuelle området for hendelsen, hvordan vil du vurdere din oversikt over:

	Svært dårlig	Dårlig	Hverken dårlig eller god	God	Svært god	Vet ikke / ikke aktuelt
Sykehus	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Legevakt	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Ambulansetjeneste	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Generelt vedr samarbeid / logistikk.

Hvem bør, etter din mening, koordinere lufttrafikken i ukontrollert luftrom med flere deltagende helikoptre ved en stor hendelse?

(1) ❑ AMK
(2) ❑ ATC
(3) ❑ HRS
(4) ❑ Første ambulanse/redningshelikopter på stedet
(5) ❑ Andre_____
(6) ❑ Vet ikke

Finnes det retningslinjer for hvordan koordinering / samvirke mellom flere helikoptre på skadested i ukontrollert luftrom skal foregå i ditt operatørselskap / skvadron?

(1) ❑ Ja
(2) ❑ Nei
(3) ❑ Vet ikke

Er helikopteret du opererer, etter din mening, utstyrt med tilstrekkelig med nødvendig teknisk utstyr for å gi "situational awareness" i forhold til flysikkerhet og andre helikoptre?

(1) ❑ Ja

(2) ❑ Nei
(3) ❑ Vet ikke

Hvilket utstyr savner du?

Kjenner du til hvilken nasjonal VHF flyfrekvens som vanligvis benyttes under redningsoperasjoner?

(1) ❑ Ja

(2) ❑ Nei

Hvordan vil du vurdere din oversikt over:

	Svært dårlig	**Dårlig**	**Hverken dårlig eller god**	**God**	**Svært god**	**Vet ikke**
Andre redningsressurser i din bases primærområde	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Behandlingstilbud ved sykehus i din bases primærområde	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Andre redningsressurser utenfor din bases primærområde	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Sykehusstrukturen utenfor din bases primærområde	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Kompetanse og prosedyrer.

Har du erfaring i å være Fagleder Helse?

(1) ❑ Ja

(2) ❑ Nei

Har du vært på en stor hendelse hvor du, etter din mening, burde ha vært Fagleder Helse?

(1) ❑ Ja

(2) ❑ Nei

Har du vært på en stor hendelse hvor du var Fagleder Helse, hvor dette var unødvendig?

(1) ❑ Ja
(2) ❑ Nei

Har du erfaring i å være Operativ Leder Helse?

(1) ❑ Ja
(2) ❑ Nei

Har du vært på en stor hendelse hvor du, etter din mening, burde ha vært Operativ Leder Helse?

(1) ❑ Ja
(2) ❑ Nei

Har du vært på en stor hendelse hvor du var Operativ Leder Helse, hvor dette var unødvendig?

(1) ❑ Ja
(2) ❑ Nei

Hvordan vurderer du:

	Svært dårlig	**Dårlig**	**Hverken dårlig eller god**	**God**	**Svært god**	**Vet ikke**
Din egen kompetanse til å organisere et skadested i forbindelse med en stor hendelse?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Opplæringen du har fått i å organisere et skadested ved	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

	Svært dårlig	Dårlig	Hverken dårlig eller god	God	Svært god	Vet ikke
en stor hendelse?						
Din egen kompetanse for å ivareta rollen som Fagleder Helse?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Opplæringen du har fått for å ivareta rollen som Fagleder Helse?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Din egen kompetanse for å ivareta rollen som Operativ Leder Helse?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Opplæringen du har fått for å ivareta rollen som Operativ Leder Helse?	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Har du gjennomført kurset "Samvirke på skadested"?

(1) ❑ Ja
(2) ❑ Nei

Hvor mange år er det siden du gjennomførte kurset?

(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4 eller mer

Hvordan vil du vurdere din utdanning i å håndtere dine arbeidsoppgaver i en stor hendelse?

(1) ❑ Svært dårlig / manglende
(2) ❑ Dårlig

(3) ❑ Hverken dårlig eller god
(4) ❑ God
(5) ❑ Svært god

Hvor mange ganger per år trener du på store hendelser? (Er du tilknyttet flere baser, svar på totalt antall trening)

(1) ❑ 0
(2) ❑ 1
(3) ❑ 2
(4) ❑ 3
(5) ❑ 4 eller flere

Hvor ofte trener *din tjeneste* med andre etater ved større øvelser?

(1) ❑ Hver gang
(2) ❑ Av og til
(3) ❑ Aldri
(4) ❑ Vet ikke

Med hvem?

(1) ❑ Politi
(2) ❑ Brann
(3) ❑ Ambulanse
(4) ❑ Andre luftambulanser / redningshelikoptre
(5) ❑ Primærhelsetjenesten (legevakt / kommunehelsetjenesten)
(9) ❑ Utrykningspersonell fra sykehus
(6) ❑ Forsvaret
(7) ❑ Frivillige organisasjoner
(8) ❑ Andre_____

På en skala fra 1 til 5 hvor 1 er liten og 5 er stor grad, vil mer kunnskap og øvelse gjøre deg bedre forberedt ved større hendelser i fremtiden?

(1) ❑ 1
(2) ❑ 2

(3) ❑ 3
(4) ❑ 4
(5) ❑ 5

Hva ønsker du mer kunnskap / øvelse på? (Sett gjerne mer enn ett kryss)

(1) ❑ Ledelse
(2) ❑ Beslutningsprosess
(3) ❑ Organisering
(4) ❑ Kommunikasjon
(5) ❑ Samhandling med andre og egne etater
(6) ❑ Redningstekniske prosedyrer
(7) ❑ Medisinske prosedyrer / kunnskap
(8) ❑ Triage
(9) ❑ Annet _____
(10) ❑ Ingenting

Har du fått opplæring i den nye veilederen for masseskadetriage?

(1) ❑ Ja
(2) ❑ Nei
(3) ❑ Vet ikke

Har din tjeneste merkeutstyr som er tilpasset den nye veilederen for masseskadetriage?

(1) ❑ Ja
(2) ❑ Nei
(3) ❑ Vet ikke

Hva finnes av ekstrautstyr til bruk ved store hendelser i din tjeneste? (Sett gjerne mer enn ett kryss)

(1) ❑ Sambandsutstyr
(2) ❑ Redningsteknisk utstyr
(3) ❑ Triageutstyr
(4) ❑ Bårer
(6) ❑ Hypotermiforebyggende utstyr

(7) ❑ Medisinsk ekstrautstyr
(8) ❑ Annet _____
(9) ❑ Ingenting

Hva savner du av ekstrautstyr til bruk ved store hendelser i din tjeneste?

(1) ❑ Sambandsutstyr
(2) ❑ Redningsteknisk utstyr
(3) ❑ Triageutstyr
(4) ❑ Bårer
(5) ❑ Hypotermiforebyggende utstyr
(6) ❑ Medisinsk ekstrautstyr
(7) ❑ Annet _____
(8) ❑ Ingenting

Til slutt litt generelt.

Hvor mange år har du jobbet innen pre-hospitale tjenester?

(1) ❑ 0-2
(2) ❑ 2-4
(3) ❑ 4-6
(4) ❑ 6-8
(5) ❑ 8-10
(6) ❑ mer enn 10 år

Hvor jobber du?

(1) ❑ SAR / redningshelikoptertjenesten
(2) ❑ Rotorwing luftambulansetjenesten

Hvilken helseregion jobber du i?

(1) ❑ Nord

(2) ❑ Midt

(3) ❑ Vest

(4) ❑ Sør-Øst

Har du noen innspill til håndtering av store hendelser? Forbedringspotensialer eller hva som fungerer bra / dårlig?

Tusen takk for at du tok deg tid til undersøkelsen.

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Appendix 3 – A consensus based template for reporting data on the use of Helicopter Emergency Medical Services in the immediate pre-hospital medical response to a major incident

NORSK LUFTAMBULANSE
NORWEGIAN AIR AMBULANCE

A consensus based template for reporting data on the use of Helicopter Emergency Medical Services in the immediate pre-hospital medical response to a major incident

○ Indicates that only one option can be ticked
□ Indicates that several options can be ticked

HEMS BACKGROUND INFORMATION

1a	**Number of units available 24/7?**
1b	**Number of units with restricted working hours?**
1c	**Do the available units have rapid response cars as well?**
	○ Yes
	○ No

2a	**Is the HEMS unit staffed by a doctor?**
	○ Yes
	○ No
2b	*If yes:* **Is the HEMS service manned by physician with special training in pre-hospital critical care?**
	○ Yes
	○ No

3	**What, if any, is the pre-planned role of HEMS physician during major incidents? Please tick all options that apply**
	□ Medical commander
	□ Treatment leadership
	□ Triage
	□ Provide medical care
	□ Transportation of patient
	□ Other

4	**What, if any, is the pre-planned role of the HEMS unit? Please tick all options that apply**
	□ Provide medical care
	□ Search and rescue
	□ Transportation. If yes: personnel? Equipment? Patients?
	□ Command
	□ Reconnaissance flights
	□ Scene of accident only accessible by helicopter
	□ Other (please specify)

MAJOR INCIDENT CHARACTERISTICS RELEVANT FOR HEMS

5	**Was the site accessible for helicopters only, within a timeframe considered reasonable according to incident and local resources?**
	○ Yes
	○ No
	If possible, please explain

6	**Could lack of HEMS resources have changed the major incident operation adversely?**
	○ Yes
	○ No
	If possible, please elaborate

7	**Were there any hazards at the scene that specifically affected HEMS approach or access to the incident site? Please tick all options that apply**
	□ Weather
	□ Visibility
	□ Weapons
	□ Explosives
	□ Fire
	□ CBRN (chemical, biological, radiological, nuclear)
	□ No hazards
	□ Other (please specify)

HEMS RESPONSE TO MAJOR INCIDENT

DISPATCH

8a	**Time of activation of first HEMS (DD:MM:YY and hh:min)**
8b	**Time first HEMS arrived on-scene (DD:MM:YY and hh:mm)**

9	**How was HEMS alerted to respond to major incident?**
	□ By responsible emergency medical dispatch center immediately after receiving emergency call from bystanders
	□ Request from the ground EMS team(s) already at the scene
	□ Request from other rescue organization or institution (e.g. fire brigade, mountain rescue etc.)
	□ Other (please specify)

10	**Was HEMS activated as a part of local/regional/national major incident algorithm?**
	○ Yes
	○ No

11a	**How many HEMS units were requested?**
11b	**How many HEMS units responded?**
11c	**During the response, how many flights in total were performed?**

12	**What were the reasons for HEMS response? Please tick all options that apply**
	□ Provide medical care
	□ Search and rescue
	□ Transportation. If yes: personnel? Equipment? Patients?
	□ Command
	□ Reconnaissance flights
	□ Scene of incident only accessible by helicopter
	□ Other (please specify)

13	**If HEMS was unavailable or inoperable, what was the reason(s)? Please tick all options that apply**
	□ Weather conditions *
	□ Other mission
	□ Distance*
	□ Personal decision*
	□ Communication issues
	□ Technical failure *
	□ Medical team unavailable
	□ Helicopter unavailable *
	□ Pilot unavailable *
	□ No landing site *
	□ Other* (please specify)
	□ Unknown

*If question marked * is ticked a follow up question will appear: did HEMS crew respond by ground vehicle instead of helicopter*

TASKS

14	**Was HEMS the first medical response team on scene?**
	○ Yes
	○ No
	○ Unknown

15	**Did HEMS deliver the first physician on scene?**
	○ Yes
	○ No
	○ Not applicable (HEMS was not staffed with a physician)
	○ Unknown

16	**What was the HEMS role on scene during the major incident? Please tick all options that apply**
	□ Purely medical treatment of patients
	□ Search and rescue
	□ Patient treatment
	□ Transportation. If yes: personnel? Equipment? Patients?
	□ Command
	□ Other (please specify)

17	**Which tasks did the HEMS medical crew perform? Please tick all options that apply**
	□ Medical incident commander □ Triage officer □ Treating patients on scene □ Treating patients in a designated treatment area □ Treatment area organisation / leadership □ Patient transportation to nearest facility □ Patient transport to secondary / tertiary facilities □ RSI (rapid sequence induction) □ Blood products □ Thoracotomies □ Amputation □ Other advanced procedure(s) or treatment(s) □ Other tasks (please specify) □ None

18	**What did HEMS transport during the major incident?**
	□ Patients. If ticked: total number of patients (% of all casualties) □ EMS physicians. If ticked: total number inclusive own crew □ EMS personnel. If ticked: total number inclusive of own crew □ Medical supplies □ Rescue material to be used on ground □ Advanced rescue material (i.e. search dogs, technical devices i.e. infrared camera) □ Support material for rescue teams

19a	**Total number of patients treated and/or transported by HEMS**
19b	**Please describe the categories (age group, severity) of these patients. Free-text field**

KEY LESSONS

20	**What, if any, were the safety challenges during HEMS major incident response?**
	□ No challenges □ Aircraft crowding- air □ Aircraft crowding- ground □ Drones or press helicopters □ Difficult landing site □ Darkness □ Other flight hazards □ Use of protective gear □ Working in "hot zone" (please specify) □ Other challenges □ Not able to comment

21	**Please describe other key lessons. Free-text field**

Appendix 4 – Data variables, Sources and Availability in Labas

Data variables, Sources and Availability in Labas

	Data source	Availability in Labas
Incident Description (Selecting multiple alternatives possible)	Free-text field Labas	Good
Road traffic incident		
Bus		
Train		
Tram		
Helicopter /airplane		
Tunnel		
Boat		
Extreme weather		
Avalanche		
Industrial accident		
Fire		
Large Crowd		
Explosives		
On-going violence		
CBRNe		
Dangerous goods		
Unknown		
Other		
Location (Selecting multiple alternatives possible)	Free-text field Labas	Good
Urban		
Semi-Rural		
Rural		
Maritime		
Alpine		
Other		
Was incident only accessible for HEMS within a reasonable timeframe?	Free-text field Labas	Good
Yes		
No		

Weather (Selecting multiple alternatives possible)	Free-text field in Labas	Medium
Daylight	timeanddate.no	
Darkness	timeanddate.no	
Snow		
Fog		
Rain		
Storm		
Other		
Season	Activation date Labas	Good
Winter		
Spring		
Summer		
Autumn		
Time activation of first HEMS (DD:MM:YY and hh:min)	Activation time and date Labas	Good
Time first HEMS arrival at scene (DD:MM:YY and hh:min)	Response time Labas	Good
Number of HEMS involved	Free-text field Labas	Good
Did first doctor arrive with HEMS?	Free-text field Labas	Medium
Yes		
No		
Unknown		
Was HEMS first medical team on scene?	Free-text field Labas	Medium
Yes		
No		
Unknown		
Who coordinated helicopters on scene?	Free-text field Labas / system knowledge	Poor
EMCC (emergency medical coordination centre)		
JRCC (Joint rescue coordination centre)		

Other HEMS unit		
Own unit		
Other		
Do not know / NA		
Participating agencies (Selecting multiple alternatives possible)	Thick boxes Labas	Medium
Ambulance		
Fire		
Police		
Other HEMS/SAR		
Rapid response car with anaestesiologist		
Non-governmental organizations		
Rapid response car with general practitioner		
Foreign Units		
Civil protection agencies		
Military		
Other		
HEMS /SAR tasks (Selecting multiple alternatives possible)	Free-text field Labas	Good
Transport of extra equipment or personnel to scene		
Secure the scene		
Coordination		
Triage		
Treatment		
Transportation from scene to casualty clearing station		
Transportation from scene to trauma unit		
Transportation from scene to regional trauma center		
Transportation from casualty clearing station to trauma unit		
Transportation from casualty clearing station to regional trauma center		
Transportation from trauma unit to regional trauma center		
Search and rescue		
Other		
Extra personnel?	Thick boxes Labas	Good
Yes		

No		
If Yes: who? (Selecting multiple alternatives possible)	Thick boxes Labas	Good
Doctor		
Nurse		
Rescue paramedic		
Pilot		
Paramedic		
Hospitant		
Other		
Bring extra equipment?	Free-text field Labas	Medium
Yes		
No		
Unknown		
If Yes: what kind of equipment? (Selecting multiple alternatives possible)	Free-text field Labas	Medium
Communication equipment		
Rescue technical equipment		
Triage equipment		
Strechers		
Medications		
Equipment for prevention of hypothermia		
Medical extra equipment		
Other		
Sufficient equipment for the situation?	Free-text field Labas	Medium
Yes		
No		
If No: what equipment were lacking? (Selecting multiple alternatives possible)	Free-text field Labas	Medium
Communication equipment		
Rescue technical equipment		
Triage equipment		

Strechers		
Medications		
Equipment for prevention of hypothermia		
Medical extra equipment		
Other		
What injury dominated? (Selecting multiple alternatives possible)	Free-text field Labas	Good
Stumpe skader		
Spisse skader		
Hypotermi		
Brannskader		
Andre		
Were the patients systematically triaged?	Free-text field Labas	Poor
Yes		
No		
Unknown		
What kind of triage was used?	Free-text field Labas	Poor
TAS triage		
SALT		
Norwegian standard for mass-casualty triage		
No formal triage was used		
Other		
Total number of patients involved in the incident	Free-text field Labas and information in the public domain	Good
Total number of patients treated by HEMS	Free-text field Labas	Good
Age / sex	Free-text field Labas and AMIS	Medium
NACA	Thick box	Medium
Hazards on-scene affecting HEMS or availability of incident scene? (Selecting multiple alternatives possible)	Free-text field Labas	Medium
Weather		

Visibility		
Weapons		
Explosives		
Fire		
CBRN (chemical, biological, radiological, nuclear)		
No hazards		
Other (please specify)		
Safety challenges for HEMS? (Selecting multiple alternatives possible)	Free-text field Labas	Medium
No challenges		
Aircraft crowding- air		
Aircraft crowding- ground		
Drones or helicopters from other agencies than HEMS		
Difficult landing sites		
Darkness		
Other challenges		
Work in ”hot zone” (specify)		

Appendix 5 – REK approval study II

REK REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Gjøril Bergva	22845529	28.05.2014	2014/720/REK sør-øst D
			Deres dato:	**Deres referanse:**
			08.04.2014	

Vår referanse må oppgis ved alle henvendelser

Anne Siri Johnsen
Holterveien 24
1441 Drøbak

2014/720 Luftambulanse i store ulykker, tverrsnittsundersøkelse blandt luftambulansepersonell i Norge

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 07.05.2014. Vurderingen er gjort med hjemmel i helseforskningsloven § 10, jf. forskningsetikklovens § 4.

Forskningsansvarlig: Stiftelsen Norsk Luftambulanse
Prosjektleder: Anne Siri Johnsen

Prosjektomtale (revidert av REK):
Formålet med prosjektet er å systematisere erfaringer fra store ulykker i Norge, gjennom et nettbasert spørreskjema til alle leger, redningsmenn og piloter i luftambulansetjenesten i Norge, uavhengig av arbeidsgiver. Totalt dreier det seg om ca. 600 personer. Det spørres etter erfaringer fra store ulykker, trening og hva man eventuelt trenger av kompetanse i fremtiden. Prosjektet vil kartlegge kompetansen og erfaringen til luftambulansepersonell i Norge, og kan brukes til å skreddersydd undervisning og prosedyrer i tjenesten.

Vurdering
I lys av prosjektleders beskrivelse av prosjektets formål, anser komiteen at prosjektet ikke har som formål å fremskaffe ny kunnskap om helse og sykdom som sådan. Prosjektet faller dermed utenfor helseforskningslovens virkeområde. Det kreves ikke godkjenning fra REK for å gjennomføre prosjektet. Prosjektet kommer inn under de interne regler som gjelder ved forskningsansvarlig virksomhet. Det er institusjonens ansvar å sørge for at prosjektet følger gjeldende reguleringer for behandling av helseopplysninger. Ettersom prosjektet forutsettes gjennomført i samsvar med gjeldende reguleringer, vil dette ikke være til noe hinder for at resultatene kan publiseres.

Vedtak
Prosjektet faller utenfor helseforskningslovens virkeområde da det ikke oppfyller formålet, jf. § 2. Det kreves ikke godkjenning fra REK for å gjennomføre prosjektet.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst D. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst D, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Vi ber om at alle henvendelser sendes inn med korrekt skjema via vår saksportal: http://helseforskning.etikkom.no. Dersom det ikke finnes passende skjema kan henvendelsen rettes på e-post

Besøksadresse:	Telefon: 22845511	All post og e-post som inngår i	Kindly address all mail and e-mails to
Gullhaugveien 1-3, 0484 Oslo	E-post: post@helseforskning.etikkom.no Web: http://helseforskning.etikkom.no/	saksbehandlingen, bes adressert til REK sør-øst og ikke til enkelte personer	the Regional Ethics Committee, REK sør-øst, not to individual staff

til: post@helseforskning.etikkom.no.

Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen

Finn Wisløff
Professor em. dr. med.
Leder

Gjøril Bergva
Rådgiver

Kopi til: marius.rehn@norskluftambulanse.no

Appendix 6 – REK approval study IV

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Hege Cathrine Finholt, PhD	22857547	20.12.2017	2017/2175 REK sør-øst D
			Deres dato:	**Deres referanse:**
			31.10.2017	

Vår referanse må oppgis ved alle henvendelser

Anne Siri Johnsen
Stiftelsen Norsk Luftambulanse

2017/2175 Storulykkehåndtering i luftambulansen 1990-2016. Retrospektiv kohort.

Forskningsansvarlig institusjon: Stiftelsen Norsk Luftambulanse
Prosjektleder: Anne Siri Johnsen

Vi viser til søknad om dispensasjon fra taushetsplikt i ovennevnte prosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst D) i møtet 29.11.2017. Vurderingen er gjort med hjemmel i forskrift av 02.07.09 nr.989, helsepersonelloven § 29 første ledd og forvaltningsloven § 13 d første ledd.

Prosjektleders prosjektbeskrivelse
Vi vil søke gjennom rapporter i databasene som helikoptertjenesten skriver i fra år 2000-2016 for å beskrive bruk av helikoptertjenesten i store ulykker og se om tidligere mal vi har utarbeidet for rapportering egner seg til å hente ut opplysninger fra rapporter.

Vurdering
Formålet med prosjektet er å vurdere om tidligere utarbeidet mal for rapportering av bruk av helikoptertjenesten i store ulykker er velegnet som en kilde for helseopplysninger. Det skal innhentes opplysninger fra LABAS og Amis (rapporteringsstedene for Luftambulansetjenesten). Dette vil ikke være pasientopplysninger, men generelle data om ulykken, hva helikoptercrew ble brukt til, utfordringer de hadde, samarbeid med andre etater, hvilke skader som dominerte hos pasientene, farer og utfordringer ved oppdraget. Det søkes om fritak fra samtykkekravet for å gjennomføre prosjektet.

Komiteen vurderer at prosjektet ikke vil fremskaffe ny kunnskap om helse eller sykdom. Prosjektet faller derfor utenfor REKs mandat etter helseforskningsloven. Det søkes imidlertid om fritak fra samtykkekravet for pasienter som er registrert i LABAS og Amis, og prosjektet er dermed avhengig av dispensasjon fra taushetsplikt.

REK er gitt myndighet til å kunne gi dispensasjon fra taushetsplikten for tilgang til taushetsbelagte helseopplysninger fra helsepersonell eller helsetjenesten for annen forskning, jf. helsepersonelloven § 29 første ledd og forvaltningsloven § 13 d første ledd. Komiteen er av den oppfatning at de samme vurderinger skal gjøres her, som ved vurdering av fritak av lovpålagt taushetsplikt etter helseforskningsloven §§ 15, 28 og 35. Relevante skjønnsmomenter i vurderinger foretatt etter helseforskningslovens bestemmelser er anvendt i komiteens vurdering av denne saken.

Etter komiteens syn har prosjektet samfunnsnytte, og opplysningene som skal innhentes er relevante for å besvare disse spørsmålene. Det er et stort antall deltagere, der noen også vil være døde, og det vil være vanskelig å innhente samtykke. Opplysningene som skal innhentes er lite sensitive, og de blir avidentifisert,

Besøksadresse:
Gullhaugveien 1-3, 0484 Oslo

Telefon: 22845511
E-post: post@helseforskning.etikkom.no
Web: http://helseforskning.etikkom.no/

All post og e-post som inngår i saksbehandlingen, bes adressert til REK sør-øst og ikke til enkelte personer

Kindly address all mail and e-mails to the Regional Ethics Committee, REK sør-øst, not to individual staff slik at det er liten risiko for å reidentifisere personene opplysningene gjelder. Komiteen finner at vilkårene for å innvilge dispensasjon fra taushetsplikten er oppfylt.

Komiteen gjør oppmerksom på at REKs myndighet er begrenset til å vurdere om vilkårene for å gi dispensasjon fra taushetsplikt er oppfylt. Søker må ta kontakt med personvernombudet som gir behandlingsgrunnlag/konsesjon for opplysninger som inngår i forskningsprosjekter.

Vedtak
Prosjektet faller utenfor helseforskningslovens virkeområde, jf. § 2 og § 4 bokstav a).

Med hjemmel i Forskrift av 2.7.2009 nr. 989, Delegering av myndighet til den regionale komiteen for medisinsk og helsefaglig forskningsetikk etter helsepersonelloven § 29 første ledd og forvaltningsloven § 13d første ledd, har komiteen besluttet å gi fritak fra lovpålagt taushetsplikt.

Dispensasjonen fra taushetsplikt innebærer at opplysninger kan innhentes som beskrevet i søknaden uten hinder av taushetsplikt.

Følgende vilkår ligger til grunn for dispensasjonen:
• at prosjektet gjennomføres i samsvar med søknad og forskningsprotokoll
• det forutsettes at de nødvendige godkjenninger foreligger fra personvernombud eller Datatilsynet
• at eventuelle rapporter eller publikasjoner gis i en slik form at enkeltpersoner ikke kan gjenkjennes
• at personidentifiserbare opplysninger slettes, eller anonymiseres straks det ikke lenger er behov for dem og senest ved prosjektets avslutning.

Dispensasjonen fra taushetsplikt gjelder til 23.12.2018.

Klageadgang
REKs vedtak kan påklages, jf. forvaltningslovens § 28 flg. Klagen sendes til REK sør-øst D. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK sør-øst D, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

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Vennligst oppgi vårt referansenummer i korrespondansen.

Med vennlig hilsen

Finn Wisløff
Professor em. dr. med.
Leder

Hege Cathrine Finholt, PhD
Rådgiver

Kopi til: marius.rehn@norskluftambulanse.no
Stiftelsen Norsk Luftambulanse ved øverste administrative ledelse: info@norskluftambulanse.no