



ORIGINAL ARTICLE

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

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Funding information

All authors are employed by The Norwegian Air Ambulance Foundation (NAAF). However, the NAAF play no part in the study design, data collection, analysis, writing or submitting to publication.

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 al¹ 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

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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 where 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.org⁶ and a previous cross-sectional survey⁵ (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

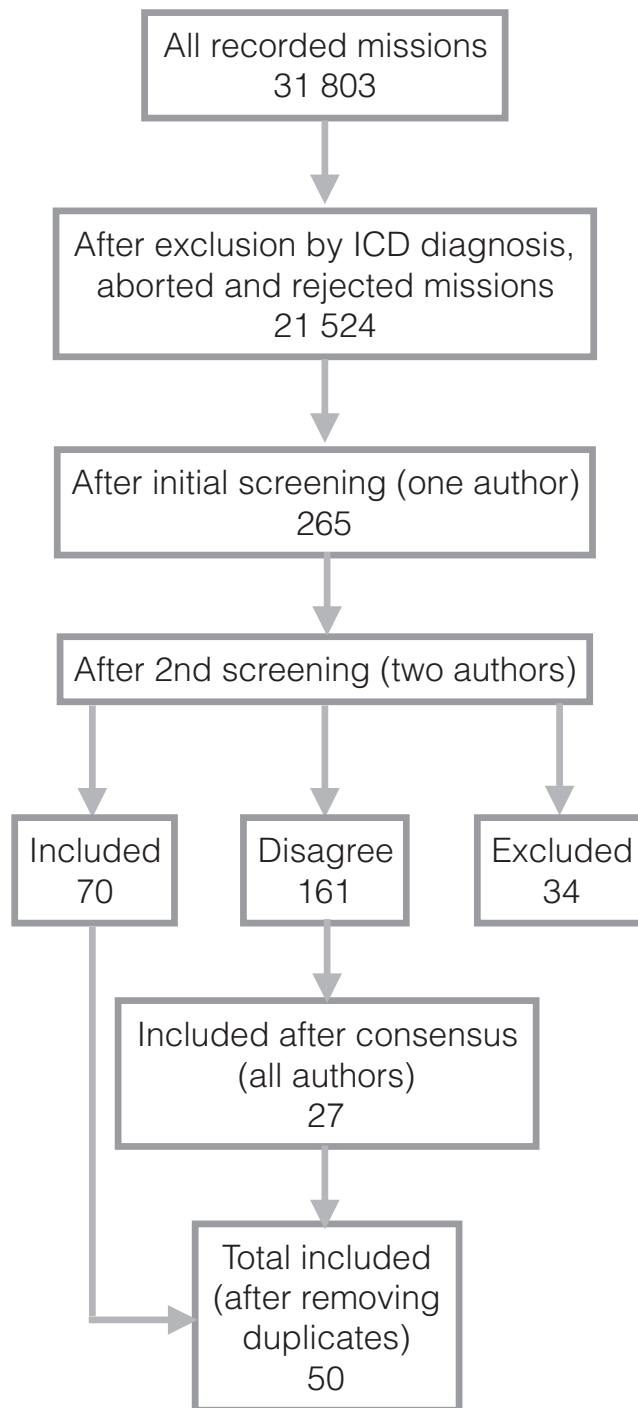


FIGURE 1 Mission flowchart

occurred during daylight (n = 35, 70%) and in summer season (n = 23, 46%).

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 weather¹³⁻¹⁵ 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 homogeneous 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.

ACKNOWLEDGEMENTS

We thank Prof. Jo Røislien for statistical quality assurance and comments on final manuscript.

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SUPPORTING INFORMATION

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

How to cite this article: 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;64:1014-1020. <https://doi.org/10.1111/aas.13583>