Interactions between the Helicopter Emergency Medical Service (HEMS) and Primary Emergency Health Care in Norway

Dag Ståle Nystøyl

Thesis for the degree of Philosophiae Doctor (PhD)
University of Bergen, Norway
2023

UNIVERSITY OF BERGEN

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Date of defense: 08.03.2023

Year: 2023

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Name: Dag Ståle Nystøyl

Print: Skipnes Kommunikasjon / University of Bergen

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1. Acknowledgements

First, I would like to express my gratitude to my main supervisor Professor Erik Zakariassen and my co-supervisor Professor Steinar Hunskår who encouraged me to start a PhD. Zakariassen and Hunskår have been important discussion partners, always available and guided me in scientific writing throughout my studies. Thank you for your patience and encouragement.

Thanks to the Norwegian Air Ambulance Foundation, which gave me a PhD fellowship and thus the opportunity to complete the project. Thanks especially for the flexibility to complete my PhD in combination with my work as a GP. And thanks to the fruitful discussions from the other PhD-candidates in the Norwegian Air Ambulance Foundation.

I would also like to thank my colleagues at the National Centre for Emergency Primary Health Care for letting me be a part of an academic environment and giving me continuous support and care.

Another thanks to Øyvind Østerås and Hans Johan Breidablik for their extensive work with data collection and access to data in **Paper I-III**, and for their contribution in the papers.

I wish to thank all my colleagues at Leirvik legekontor for their support and understanding during my work as a part-time GP together with the PhD. A special thanks to Odd Jarl Kvamme with whom I have been working together for four years, in order to make it possible to complete my PhD.

My love and thanks to my wife Hilde and my daughters Othilie, Eda and Agnes who have always believed in me and daily reminded me of the most important things in my life.

2. Scientific environment

This PhD-project was performed during my work as a general practitioner in both Bergen and Stord, as well as a 50% employment at the casualty clinic in Bergen over two years.

The study period was funded by the Norwegian Air Ambulance Foundation (SNLA), where I was given a PhD fellowship from September 2015. The SNLA had during the period over 20 PhD-candidates spread across the country, with regular mandatory gatherings for the researchers.

Throughout the whole PhD-period I have been scientifically linked to the National Centre for Emergency Primary Health, where both my supervisors have been employed.

I was accepted into the PhD programme at Group for Health Services Research, Department of Global Public Health and Primary Care, University of Bergen.

From autumn 2015 to autumn 2018 I was a part of The Norwegian Research School in General Practice.

NORCE
National Centre for Emergency Primary Health Care

NORWEGIAN AIR AMBULANCE FOUNDATION

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3. Abbreviations

Aborted HEMS mission:	When HEMS chose to abort a mission due to weather conditions, concurrencies, technical issues, or no persistent medical indication
Cancellation HEMS:	Combination of aborted and rejected HEMS missions
CI:	Confidence interval
EMCC:	Emergency Medical Communication Center (Norwegian: AMK – Akuttmedisinsk kommunikasjonssentral)
GP:	General practitioner
HEMS:	Helicopter Emergency Medical Service
HUS:	Haukeland University Hospital
ICD-10:	International Classification of Diseases code
ICPC-2:	International Classification of Primary Care
Index:	Norwegian Index for medical emergency assistance
ITS:	Interrupted time series regression
LEMC:	Local Emergency Medical Communication Centers (Norwegian: Legevaktsentral)
LEON-principle	The principle of using the lowest effective level of care

MOS:	Municipalities outside SYS-IKL
NACA score:	National Advisory Committee for Aeronautics score
NKLM:	National Centre for Emergency Primary Health (Norwegian: Nasjonalt kompetansesenter for legevaktmedisin)
NOU	White paper/Norwegian public report
OOH service:	Primary care out-of-hours service
Primary missions	Acute medical missions outside hospital
Rejected HEMS mission:	When HEMS chose to reject a mission due to weather conditions, concurrencies, technical issues or no persistent medical indication
Rural OOH-service:	OOH service in the municipalities Os and Samnanger
SAR:	Search and rescue
Secondary missions:	Interhospital transfer of patients
S&F:	County of Sogn og Fjordane
SYS-IKL:	Large inter-municipal casualty clinic in Sunnfjord and Ytre Sogn

4. Abstract

4.1 English summary

The prehospital emergency system in Norway involves out-of-hours (OOH) services with on-call primary care physicians. Together with the ground ambulance service, OOH-services constitutes the backbone of the prehospital services. The Helicopter Emergency Medical Service (hereafter HEMS) is used in cases of severe illness or trauma that require rapid transport and/or an anaesthesiologist's services. In recent years, on-call primary care physicians have been less available for callouts in Norway, and HEMS may be requested for missions that could be adequately handled by on-call physicians.

Despite the potential benefits of physician-staffed HEMS, many dispatches to primary HEMS missions in Norway are cancelled before patient encounter. Information is sparse regarding the health consequences.

Organisational changes in out-of-hour (OOH) services may have unintended consequences for other prehospital services. Reports indicate an increased use of HEMS after changes in OOH services in Norway due to greater geographical distances for on-call doctors.

The aim of this thesis is to investigate acute medical emergencies in the interaction between HEMS and the municipalities primary emergency health care. Through four studies we searched to achieve the aims, and the results are published in four papers.

In **Paper I** we aim to estimate the potential loss of life years for patients when medically indicated HEMS missions were cancelled and the patients were treated by an on-call physician and ambulance staff only. We included all HEMS requests in the period 2010–2013 from Sogn and Fjordane County that were medically indicated but subsequently cancelled. A multidisciplinary expert panel retrospectively assessed each patient's potential loss of life years due to the lack of helicopter transport and intervention by a HEMS physician. The study included 184 patients from 176

missions. Because of unavailable HEMS, seven patients (4%) were anticipated to have lost a total of 18 life years. The main contribution from HEMS care in these cases might have been rapid transport to definitive care. The probability of a patient losing life years when in need of HEMS evacuation was found to be 0.2%.

The same missions analysed in **Paper I** were used in an observational study to examine the handling of cancelled HEMS missions in **Paper II,** with a focus on primary care involvement, treatment and cooperation within the prehospital system. Our analysis included 172 missions with 180 patients. Two-thirds of the patients were from primary missions. In 95% of primary missions, on-call physicians were alerted, and they examined 62% of these patients. Among the patients examined by an on-call physician, 30% were accompanied by the physician during transport to hospital. The involvement of an on-call physician did not differ according to time of day, diagnostic group, or patient's age. In 41% of primary missions, the patients only received treatment or oxygen during transport.

In **Paper III** we investigated whether HEMS dispatches increased when nine municipalities in Sogn og Fjordane County merged into one large inter-municipal OOH district. All HEMS primary dispatches in the county between 2004 and 2013 were included. We applied an interrupted time series regression to evaluate the impact of the organisational change 1 April 2009. The nine target municipalities were compared to the rest of the municipalities in the county, which served as a control group. We included 8,751 dispatches, 5,009 (57.2%) of which were completed with a patient encounter. Overall, we found no alteration in requests for HEMS after 2009, and separate analyses of the target municipalities and control group revealed no statistically significant increase after 2009. A general increase was found in HEMS dispatches for most rural municipalities over the 10-year span, but no added increase was detected after 2009. Distance from the OOH service with regard to travel increased within the nine municipalities after 2009.

In **Paper IV** we investigated how the different availability of on-call physicians in attending emergency patients on site (callout) impacted the request and use of HEMS.

Our analysis included all acute medical missions in an urban and nearby rural OOH district, which had different approaches regarding physician callouts from the OOH service. The rates of acute medical missions in the urban and rural OOH districts were similar. The rate of HEMS requests was statistically significantly higher in the rural OOH district than in the urban district. Cardiac arrest and trauma were the major symptom categories in more than one half of HEMS-attended patients, while chest pain was the most frequent reason for an OOH callout in the rural OOH district. An NACA score of 5–7 was found in nearly half of HEMS patients from the urban district, 40.0% of HEMS patients from the rural OOH district, and only 12.8% of patients attended by an on-call physician in the rural OOH district. A majority of the patients receiving advanced interventions provided by an anaesthesiologist at HEMS had an NACA score of ≥5.

Main findings in the thesis:

- Few patients lost life years due to an unavailable HEMS. A lack of rapid HEMS transport was the primary cause of the estimated loss of life years.
- Ambulance workers and on-call primary care physicians have important roles when HEMS is unavailable.
- The majority of patients were examined by a on-call physician or cared for by ambulance workers who conferred with a physician.
- Few patients received advanced treatment, and treatment did not differ according to involvement by the on-call physician.
- Reorganising the local OOH services into one large inter-municipal OOH district did not result in an increase in HEMS dispatches.
- HEMS usage did not differ between two compared areas with different availability of callouts from the OOH-service.
- The threshold for HEMS use seems to be independent of the availability of on-call primary care physicians.

4.2 Norwegian abstract – Sammendrag

Norge har et prehospitalt system som inkluderer legevaktleger i vakt døgnet rundt. Sammen med bilambulansetjenesten utgjør legevakttjenesten ryggraden i den prehospitale beredskapen. Luftambulansetjenesten med anestesileger benyttes ved akutte medisinske problemstillinger og traumer hvor rask transport og kompetansen til en anestesilege anses nødvendig.

I senere år har legevakttjenesten endret seg slik at legevaktleger er mindre tilgjengelig for uttrykning grunnet økte avstander og ulik praksis vedrørende utrykning. Dette har medført en fare for at luftambulansetjenesten benyttes på oppdrag som legevakttjenesten normalt sett kunne håndtert.

Nytteeffekten av luftambulanse er omdiskutert, men både rask transport og tilgang på anestesilegekompetanse anses som viktige element. Tjenesten må endel ganger avbryte oppdrag, spesielt grunnet dårlige værforhold. Likevel er konsekvensene for pasientene som ikke får hjelp av luftambulansen lite undersøkt.

Endringer i legevakttjenesten med flere interkommunale legevakter har medført lengre avstander mellom pasient og legevaktlege. Det har vært en nedgang i antall utrykninger fra legevaktene, og flere rapporter har uttrykt bekymring for at luftambulanse brukes oftere i områder hvor avstandene er store. Endringer i legevakttjenesten kan også ha utilsiktede konsekvenser for andre prehospitale tjenester.

Formålet med denne avhandlingen var å undersøke akuttmedisinske hendelser i grenseoppgangen mellom luftambulansetjenesten og legevakttjenesten. Gjennom fire studier har vi undersøkt hvilke konsekvenser det har for pasientene når luftambulansen ikke kommer frem, hva som gjøres når luftambulansen ikke kommer samt undersøkt om organisatoriske endringer i legevakttjenesten har medført at luftambulansetjenesten benyttes i større grad enn tidligere. Resultatene er publisert i fire artikler.

I **artikkel I** undersøkte vi om pasienter tapte leveår på grunn av manglende hjelp fra luftambulansetjenesten. Alle avbrutte og avviste luftambulanseoppdrag grunnet værforhold, samtidighetskonflikt, teknisk årsak eller grunnet hvilebestemmelser ble inkludert. Studiested var Sogn og Fjordane i perioden 2010-2013. Som en konsekvens av manglende luftambulanse ble pasientene behandlet av ambulansepersonell og legevaktleger. Et ekspertpanel bestående av ulike legespesialiteter ble satt til å vurdere om pasientene tapte leveår på grunn av manglende helikoptertransport og/eller vurdering og behandling av en anestesilege. Studien inkluderte 184 pasienter fra totalt 176 oppdrag. Konklusjonen var at syv pasienter (4%) ble vurdert å miste totalt 18 leveår. Hovedårsaken til tapte leveår ble vurdert til å skyldes mangel på rask transport til sykehus. Sannsynligheten for at en pasient med behov for luftambulanse ville tape leveår var 0,2%.

I **artikkel II** ble de samme oppdragene som i **artikkel I** brukt i en observasjonsstudie. Formålet med studien var å undersøke i hvilken grad legevaktlege var involvert, hvilken behandling de fikk når luftambulanse ikke kom og i hvilken grad ambulansetjenesten og legevaktlegen samarbeidet. Analysene inkluderte 172 oppdrag med totalt 180 pasienter. To tredjedeler av pasientene befant seg utenfor sykehus (primære oppdrag), mens en tredjedel av pasientene hadde behov for overføring fra lokalsykehus til region- eller universitetssykehus (sekundære oppdrag). I 95% av de primære oppdragene ble legevaktlegen alarmert, og de undersøkte 62% av pasientene de ble alarmert på. Av de pasientene som ble undersøkt av legevaktlege ble 30% fulgt av legen under transport til sykehus. Verken symptomkategori, alder eller tid på døgnet hadde betydning for om legevaktlegen var involvert eller ikke. I 41% av de primære oppdragene fikk pasientene ingen behandling eller bare oksygen.

I **artikkel III** undersøkte vi om antall luftambulanseoppdrag hadde økt etter at ni kommuner i Sogn og Fjordane gikk sammen og dannet en stor interkommunal legevakt 1. april 2009. Til å undersøke dette benyttet vi alle forespørsler om luftambulanse i perioden 2004-2013 i hele fylket. Metoden «interrupted time series regression» ble brukt i analysene, og de ni kommunene ble sammenlignet med resten av kommunene i fylket. 8 751 oppdrag ble inkludert. Av disse var 5 009 oppdrag

utført ved at anestesilege undersøkte pasientene. Hovedfunnet var at det ikke var noen endring i forespørsler om luftambulanse etter 2009. Separate analyser for de ni kommunene som hadde slått seg sammen til en stor legevakt og kontrollgruppen med de andre kommunene viste heller ingen økning etter 2009. En generell økning i luftambulanseforespørsler ble funnet over hele 10-års perioden i de kommunene som ble definert som rurale, men ingen spesifikk økning etter 2009. Reiseavstanden for pasientene økte signifikant i de ni kommunene etter endringen i 2009.

I **artikkel IV** undersøkte vi om to legevaktdistrikt med ulik praksis på utrykninger av legevaktleger påvirket forespørselen og bruken av luftambulanse. Studien inkluderte alle akutte oppdrag i et urbant legevaktdistrikt (Bergen) og et nærliggende ruralt legevaktdistrikt (Samnanger og Os). I Bergen var ingen legevaktleger tilgjengelig for å rykke ut, mens i Samnanger og Os var legevaktlegen nesten alltid med på akutte oppdrag. Vi fant at raten av akutte oppdrag var lik i begge legevaktdistriktene. Raten av forespørsler om luftambulanse var signifikant høyere i Samnanger og Os enn i Bergen. Hjertestans og trauma var de mest vanlige symptomkategoriene hvor anestesilege vurderte og behandlet pasienten, til sammen utgjorde disse to kategoriene mer enn halvparten av pasientene. Brystsmerter var den vanligste symptomkategorien hvor legevaktlege rykket ut. I nesten halvparten av pasientene i Bergen som fikk hjelp av luftambulanse hadde pasientene en NACA-skår på 5-7, mens dette var tilfelle for 40,0% av pasientene i Samnanger og Os som fikk hjelp av luftambulanse. Bare 12,8% av pasientene hvor legevaktlege rykket ut hadde NACA-skår mellom 5-7. Majoriteten av pasientene som fikk avansert behandling gitt av anestesilege hadde NACA-skår ≥5.

Hovedfunn i avhandlingen:

- Få pasienter tapte leveår på grunn av manglende luftambulanse. Hovedårsaken til at pasienter tapte leveår var mangel på rask transport til sykehus.
- Ambulansepersonell og legevaktleger har en viktig rolle når luftambulansen ikke er tilgjengelig.
- Majoriteten av pasientene som ikke fikk luftambulanse ble undersøkt av legevaktlege eller ambulansepersonell som hadde konferert med legevaktlege.

- Få pasienter fikk avansert behandling og det var ingen forskjell i behandling om legevaktlege var involvert eller ikke.
- Reorganisering av mindre legevaktdistrikter til et stort interkommunalt legevaktdistrikt resulterte ikke i en økning av luftambulanseoppdrag.
- Bruk av luftambulanse var ikke forskjellig i to legevaktdistrikt med ulik tilgjengelighet av legevaktleger til å kunne rykke ut ved akutte hendelser.
- Terskelen for å rekvirere luftambulanse ser ikke ut til å være påvirket av om legevaktleger er tilgjengelig for utrykning eller ikke.

5. List of Publications

Paper I

Erik Zakariassen, Øyvind Østerås, Dag Ståle Nystøyl, Hans Johan Breidablik, Erik Solheim, Guttorm Brattebø, Vegard Skalstad Ellensen, Jana Midelfart Hoff, Knut Hordnes, Arne Aksnes, Jon Kenneth Heltne, Steinar Hunskaar and Ragnar Hotvedt. Loss of life years due to unavailable helicopter emergency medical service: a single base study from a rural area of Norway. Scandinavian Journal of Primary Health Care 2019, 37:2.

Paper II

Dag Ståle Nystøyl, Steinar Hunskaar, Hans Johan Breidablik, Øyvind Østerås and Erik Zakariassen.Treatment, transport, and primary care involvement when helicopter emergency medical services are inaccessible: a retrospective study, Scandinavian Journal of Primary Health Care 2018, 36:4.

Paper III

Dag Ståle Nystøyl, Jo Røislien, Øyvind Østerås, Steinar Hunskaar, Hans Johan Breidablik and Erik Zakariassen. Helicopter emergency medical service (HEMS) activity after increased distance to out-of-hours services: an observational study from Norway. BMC Emergency Medicine 2020, 20:88.

Paper IV

Dag Ståle Nystøyl, Øyvind Østerås, Steinar Hunskaar and Erik Zakariassen. Acute medical missions by helicopter medical service (HEMS) to municipalities with different approach for primary care physicians. BMC Emergency Medicine 2022, 22:102.

In this thesis the four papers will be referred to by their Roman numbers, **Paper I-IV**.

Published papers are open access and free to use, copy and print.

6. Background

Prehospital emergency medical services are organised differently between industrial countries. Geographical and demographical differences are important to be aware of when discussing an optimal organisation. Norway has a prehospital system that includes primary health care with Local Emergency Medical Communication Centres (LEMC), general practitioners (GPs) on call and Out-Of-Hours services (OOH), and specialised health care with Emergency Medical Communication Centres' (EMCC) ground-, boat- and air ambulances. Hospitals are local, regional and/or a university hospital.

6.1 Two-tiered system

The health care system in Norway is a two-tiered system with primary health care and specialised health care as complementary services. The prehospital emergency services also follow the same two-folded system and current acts regulate the services:

- Regulation relating to the organisation of emergency services (2015) (1)
- Act relating to the municipal health services (2)
- Act relating to specialised health care (3)

The municipalities in Norway are responsible for organising primary emergency health care including GPs on call, OOH services and the LEMC, while the specialised health care system through the regional health authorities are responsible for organising the ambulance service (ground-, boat- and air ambulances), EMCC and the hospitals (1). Primary health care has a gatekeeper function in Norway. Gatekeeping has been associated with a lower utilisation of healthcare services and expenditures (4). Principally, no patients can be admitted to hospital in Norway without being referred by a physician in primary health care. This is thought to be an advantage of the two-folded system. From 1990 and until 2005 there was an increased focus on the chain of survival outside hospitals and the prehospital emergency services in Norway. The official Norwegian report "Hvis det haster…" (NOU 1998:9) recommended regulations on prehospital medical emergencies, which should include the ambulance

service, LEMC/EMCC and the OOH-services (5). The first regulation was implemented in 2005, but had few details about the OOH-service (6). Not until 2015, when the current regulation was implemented, were more details about the OOH-service formalised. Now it is stated in the regulation that an equal responsibility for patients with emergencies in the prehospital setting should be shared between primary- and specialised health care. Further, education and competence are stated in the regulation for both services (1).

Although the two-tiered system had advantages, there are also challenges to be aware of. Unclear responsibility for the patients in prehospital emergency services can be a consequence in this system. Most often the LEMC and EMCC are placed on different localisations and do not have the same data system for exchanging information, and organisational changes in both systems are done without involving the other part. In rural areas without a high number of critical conditions both ambulance workers and the GPs have limited experience in treating such patients, and regular training between ambulance workers and GPs is recommended. Our personal experience is that such training is seldom prioritised and difficult to organise due to the two-folded system.

The next chapters will more thoroughly describe the services and development in recent decades, as well as present some current challenges.

6.2 Emergency Communication Centres

In cases of non life-threatening emergencies, the intention is that inhabitants contact the LEMC by calling the national telephone number 116 117. LEMC are usually manned with nurses from the casualty clinics (79%), while other municipalities have outsourced this to the operators at the EMCC (4%) or hospitals (13%) (7). In the case of a potentially life-threatening medical emergency, the intention is that the inhabitants call 113 in order to contact the EMCC. Nurses operate the EMCC and guide the caller and dispatch to adequate resources to help the patient. An important difference between the LEMC and EMCC is that EMCC is obligated to answer 90% of the calls within 10 seconds, while LEMC is obligated to answer 80% of the calls

within 2 minutes (1). National statistics from part of the 2020 show that 86% were answered within 10 seconds in the EMCC and 66% were answered within 2 minutes in the LEMC (data presented from KoKom, more updated data had not been available due to the ongoing revision of the quality indicator).

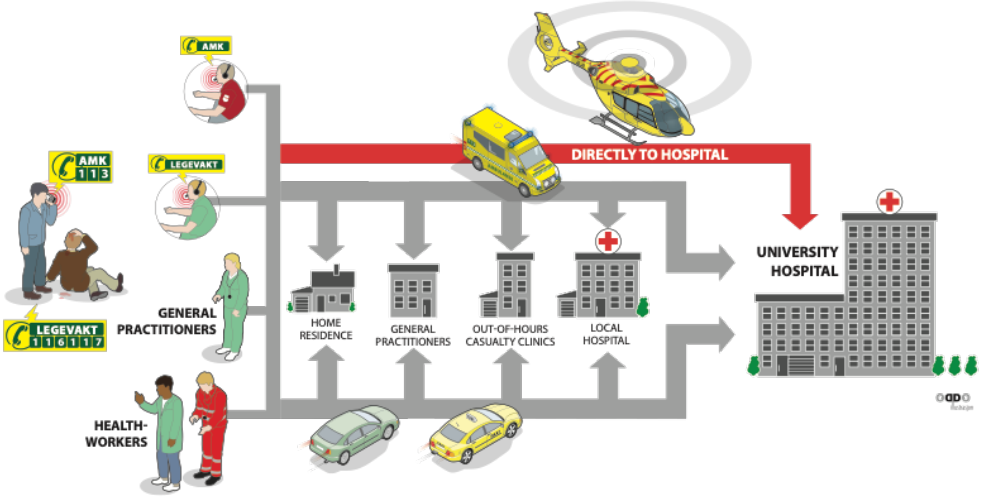

Figure 1. Overview of the system outside hospital

For the patient or caller it is difficult to distinguish whether situations are potentially life-threatening/time-critical. Therefore, in some situations, inhabitants call the LEMC when it is more correct to call the EMCC. For less severe situations, an opposite situation may occur, that is, the inhabitants call the EMCC rather than the LEMC. To ensure a correct level of care and allocation of services it is vital with rapid and good communication between LEMC and EMCC.

All EMCC use the triage tool Norwegian Index (hereafter Index) for medical emergency assistance (Index), while 90% of the LECM use the Index or other triage tool. Index is an criteria based tool that helps the operator define the urgency grade of the mission (8). Index uses acute (red) for situations with immediate need of help,

urgent (yellow) for situations in rapid need of help (up to a few hours) or normal (green) for situations that are not life-threatening. The urgency level is further used for dispatching or requesting prehospital resources. When EMCC identifies a red urgency level, this leads to the dispatch of a ground- or boat ambulance, while yellow and green urgency leads to the dispatch of resources based on the situation, e.g., transferring the call to the LEMC. An acute medical situation (red) requires that the nurse at the EMCC sends an alarm to the primary care on-call physician and the ground ambulance, simultaneously. A red response defined in the LEMC should immediately be transferred to the EMCC in order to dispatch prehospital resources.

The number of LEMC in 2020 was 95, while there were 16 EMCCs in 2020 (7). In absolute number of calls the EMCC had 1.05 million contacts in 2017, while LEMC/OOH-services had 2.15 million contacts in 2019 (9). This corresponds to 200 and 404 contacts per 1000 inhabitants per year, respectively. Of the total contact to EMCC, approximately 20% are categorised as acute, 30% as urgent and 35% as normal, while 15% have no urgency grade defined. Data from representative numbers of casualty clinics in 2019 show that 9% of the contacts were defined as acute, 32% as urgent and 59% as normal (according to Index-criteria)(10).

6.3 The municipalities´ responsibility throughout the day including out-of-hours services

GPs in Norway have a long tradition of serving the inhabitants in need of medical service both during office hours and out-of-hours. Bergen established Emergency care for the inhabitants in the municipality already in 1917 (11). Through the ethical guidelines, the Norwegian medical association stated a moral obligation for the physicians to be a part of medical emergencies, but this was first regulated by law in 1982. How the service should be organised was regulated in 1984 (12). Since 2015 (1), the municipalities are obligated to have a physician on call around the clock, although how the municipalities fulfil the legalisation vary. The service shall:

- Assess, give advice and guide in acute medical emergencies;

- Diagnose and treat medical conditions by consultations, home visits and referrals to other services like GPs and hospitals; and
- A physician shall be able to call immediately for assistance in emergencies, when needed (1).

During office hours the inhabitants normally contact a GP office, and each municipality has an arrangement for how to respond to medical emergencies. Many smaller municipalities have an on-call GP listening to the emergency public safety radio network, while larger municipalities have casualty clinics operating during the daytime. The majority of contact with the OOH-service is administered through the LEMCs. Many OOH services are inter-municipal co-operations. Inter-municipal OOH-services have a host municipality where the casualty clinic(s) is localised. Of the 356 municipalities in Norway in 2020, 270 had an intermunicipal organisation with a total of 83 casualty clinics. Eighty-six casualty clinics had a one-municipal OOH-service. The number of inhabitants and the geographical area vary, where the smallest OOH-service serves less than 5000 inhabitants and the largest over 500,000 inhabitants. Travel distance for the patients can in some areas be up to 2 hours driving by car (7).

Of the 2.15 million contacts in the OOH-service in 2019, patients received a consultation with a physician in 62.3% of the contacts and advice on the telephone in 31.8% of the contacts, while in 3.5% of the contacts the physician responded with a callout. Around 60% of the contacts occurred during weekdays, with 40% on the weekends. The most used diagnosis category concerned the respiratory system and muscle- and skeleton system. Children and elderly use the OOH-services most, and apart from children, it is consulted by more women than men (9).

Despite the varying organisation of the OOH-services in the municipalities, the legalisation imposes that the municipalities have at least one physician on-call 24/7 with the possibility to callout when needed in emergencies (1). Some municipalities have the policy to callout in nearly all emergencies, while others do not have a infrastructure to fulfil the demand, e.g., a rapid response car for the on-call physician

(13). Regardless of the organisation, it is the on-call physician that decides whether to callout. In order to conduct duty in the OOH-service without supervision, the physician has to be specialist in general practice or have work experience similar to being specialist (6). Courses in emergency medicine are also mandatory every fifth year.

6.3.1 Recent changes in the OOH-services

From 2007 to 2020, the number of OOH casualty clinics in Norway decreased from 230 to 169 (7). Driven by the need for organisational reinforcement (14), less duty time for the GPs, and a more stable recruitment of personnel, several inter-municipal OOH districts has been established. The 83 inter-municipal OOH districts in 2020 involved 2-12 municipalities, of those 82% were involved in cooperation between 2-4 municipalities (7).

As an example of such organisational change, nine municipalities in the rural county of Sogn og Fjordane (S&F) reorganised their OOH-services into one large inter-municipal OOH district in April 2009. Another example is the eight municipalities around Arendal that had a similar reorganisation in 2000 (15). The result was that one or two on-call GPs covered a larger geographic area and thus a higher number of residents. Larger OOH districts have not led to OOH clinics with better equipment, more training or callouts. More important, decrease in GPs competence is reported (16, 17).

In 2019, 56.7% of all on-call physicians in the OOH-services were a general practitioner (GPs), and 28.9% were specialists in general practice. The majority of the patients in the Norwegian OOH-service have medical problems that GPs normally handle, and together with the gatekeeper function GPs have in Norway, it is thought that they are most suitable for working in the OOH-service. Traditionally, small OOH-districts also had the positive benefit of a physician with local knownledge about patients and geography. The shift towards inter-municipal districts may reduce this effect. The trend in callouts has stabilised since 2015 (sligtly more use) after a

decrease in use since 2000. Callouts are more used in smaller OOH districts compared to larger OOH districts (9).

Few studies are conducted to explore how reorganisations of inter-municipal OOH-districts affect callouts. One recent study indicates that inter-municipal cooperation weakens the quality of the medical workforce and equipment, but regarding workforce it seems that the cooperation needs to reach a certain size to achieve an optimum scale of operation (18). The different organisation of OOH-services regarding callouts and how this affects other services, i.e., ground ambulances and HEMS, has not previously been examined. Therefore, further studies in this area are warranted.

6.4 Ground ambulance service

The ground ambulance service in Norway has developed since the 1970s from a transport service to a medical emergency service. From 1985 to 2002 the county authorities were responsible for the service, but there were no regulations regarding education, competence, response times or medical standard. Hence, the ambulance service was based on local engagement, private actors and the use of ideal organisations with no formal regulations. Already in 1976 an official Norwegian report (19) suggested the need for a minimum competence consisting of a 3-month education. In 1996, the education to become ambulance worker was formalised as two years at high school and a two-year apprenticeship. In 2001, ambulance workers were authorised as health personnel (20), and on 1 April 2005 a national regulation regarding education and medical standards in the prehospital emergency services was decided (5, 12). Now a bachelor's degree in paramedicine has been established, and the Norwegian Board of Health Supervision specified in 1997 that the on-call physician in primary care health was responsible for the patients under ambulance transport (21).

The ground ambulance service consists of car ambulances and boat ambulances. The EMCC are responsible for dispatching and coordinating the service. Ground ambulances are normally/minimally manned with two ambulance workers. There were

524 ground ambulance in Norway in 2019. Many ground ambulance stations are localised nearby hospitals or OOH-services, but the service also has decentralised stations around the districts. Boat ambulances are used in coastal areas and are minimally manned with one ambulance worker in addition to the captain/skipper.

6.4.1 Recent changes in the ambulance service

To ensure equal access to public health services regardless of residence, the ambulance services in Norway must be sustainable in all areas and seasons, even under challenging weather conditions. Over recent decades, ground ambulances have been centralised such that they now cover larger geographical areas, resulting in longer response times (22). In the period of 2003–2013, acute missions with a ground ambulance increased almost 100% in Western Norway (23). A focus on using Index is probably one reason for the increase, but between the EMCCs there are differences. The rate of acute missions are found between 21/1000 to 42/1000 inhabitants/year (24).

There are no formal regulations on response time from alarm until the ground ambulance personnel encounter the patient in acute situations. Due to the scattered population in Norway, quality indicators have been established regarding response time for ground ambulances on acute missions, divided into an urban and rural setting based on population density. In urban areas they should be able to encounter the patients within 12 minutes after the call to EMCC in 90% of the alarms, while in rural areas they should be able to respond within 25 minutes. None of the regional health trusts was able to fulfil these recommendations in 2020 (25).

Although the competence for ambulance workers has increased, many medical situations demand the presence of a physician together with the ground ambulance. Most acute medical emergencies are solved by the OOH-services and ground ambulances, but there is scarce knowledge of how the change in these services affects the cooperation between them. More specifically, how acute medical situations are solved when HEMS is unavailable has not been examined before, and further scientific projects are needed.

6.5 Helicopter Emergency Medical System

Helicopters manned with an anaesthesiologist in Norway was introduced in 1978 by the physician Jens Moe. He established Bård Østgaards foundation, which later changed its name to the Norwegian Air Ambulance Foundation. Since 1988, the air ambulance service has been a national service funded by the government through the health trusts (26).

The air ambulance service has both helicopters and fixed wing airplanes. The air ambulance is to be used for severe cases of illness or injuries that require rapid transport, clinical assessment, or advanced treatment. HEMS in Norway are manned with an anaesthesiologist, a rescue paramedic and a pilot. Fixed wing airplanes are manned with a specially trained nurse (anaesthetist or intensive care nurse) and two pilots. National guidelines advise the use of an air ambulance when this is anticipated to improve health outcome compared to the use of a ground ambulance (27). As of 2021, Norway has 7 fixed wing airplanes, 14 helicopters and 7 search-and-rescue (SAR) helicopters. An SAR is manned with an anaesthesiologist, a rescue paramedic, a pilot and a technician/lift operator. HEMS services also have a rapid response vehicle in addition to the helicopters, which is used near the base or in situations with bad weather (27). The goal of reaching 90% of the inhabitants within 45 minutes flight time is achieved on a national level, and many areas in the southern part of Norway have HEMS-bases whose areas overlap with one another (28).

In 2020 HEMS was requested in 12,432 missions, and HEMS and SAR completed, respectively, 7,149 and 1,342 missions with a patient encounter (29). Of all acute missions from the EMCC, HEMS is normally involved in about 8% of those (30). Of the total number of missions in the ambulance service, boat- and ground ambulances complete 97.5% of the missions without involving HEMS (31).

When the EMCC dispatches a ground ambulance on an acute mission, they shall immediately respond to the alarm and encounter the patient, while when requesting HEMS, the anaesthesiologist can decide whether to callout.

6.5.1 Recent changes in HEMS

The use of HEMS has been relative stabile over the years. When comparing the same period, there was an almost 100% increase of ground ambulance missions in western Norway, whereas HEMS had only a 1.3% increase in use (23). However, differences between HEMS bases have been reported (28). Changes in hospital organisation and a focus on prehospital delay in the treatment of acute myocardial infarction, stroke, or trauma can potentially increase the use of HEMS in a rural country, such as Norway (32, 33). In 2009, a new SAR helicopter was established in Florø, on the west coast of Norway. In 2015 they established a new HEMS-base in Evenes in northern Norway, and the latest HEMS-base came in 2020 in Kirkenes, on the border to Russia in the northern part of Norway.

Few studies have been conducted on whether the establishment of new HEMS-bases has benefits in terms of better prognosis for the patients. There is also scarce knowledge on whether areas with good access to HEMS benefits the patients compared to remote areas where HEMS has a longer travel distance.

6.5.2 Benefits of using HEMS

HEMS has several potential benefits, depending how benefit is defined. Regarding inequity, HEMS may be used to compensate for potentially unequal access to emergency medical care. The Norwegian guidelines states that HEMS can be used in cases of long travel distance to hospital for patients. Regarding benefits for patients in terms of better outcome, the use of HEMS is debated. Previous studies have shown inconsistent results (34-41). The benefits of HEMS for trauma patients have been described in several studies (34, 36, 38, 42, 43). Still, if it is rapid transport or the medical treatment provided by HEMS that are beneficial for the patients is still unclear, showed in a Cochrane review including adult trauma patients (35). Two studies from Norway have concluded that life years were gained when an anaesthesiologist encountered the patient (39, 40). Observational study designs are most common, which limits the validity and generalisation of the study results. However, study designs with randomisation to mode of transportation in emergency cases have both ethical and practical concerns.

Most of the research about HEMS has been concerned with better outcome for the patients. However, there are other aspects that should be addressed in the discussion about HEMS. The inhabitants in Norway describe that having HEMS available is considered a safety. Local hospitals use HEMS regularly, and on-call physicians in primary health care take HEMS into account when they have to solve acute medical emergencies. These potential benefits of HEMS is not easily generalised and sometimes based on personal experience. Further research discussing HEMS use in the whole prehospital system are needed, and this thesis aims to give more knowledge in this area.

6.5.3 Regularity of HEMS

The challenges of providing emergency missions in rural areas are well known in both Norway and other countries (42, 44, 45). Long distances and small hospitals with limited resources increase the need for HEMS, but inclement weather conditions reduce HEMS' availability.

In 2019, 39% of all HEMS requests in Norway were cancelled. The main reason for cancellation was that there was no longer a medical indication (19%). Other reasons for cancellation included weather conditions (9%), concurrency conflicts (4%) and other reasons (7%) (46). Scarce data are available regarding the alternative handling of patients for HEMS missions that are cancelled despite a persistent medical indication. Also, the health consequences of an unavailable HEMS, in cases where advanced life support or rapid transport is deemed necessary, are unknown. Previous studies have mostly estimated the gain of having HEMS on site. What is the role of ground ambulances and on-call physicians in such cases where HEMS is unavailable? This is highly relevant in discussions regarding the centralisation of ambulances and GPs' out-of-hour service in the county, especially in rural areas where travel distances can be long when HEMS-evacuation is not possible.

6.6 Other countries

The involvement of GPs in emergency patients differs between European countries. As an example, Denmark has GPs performing telephone triage and consultations at

the OOH-services without being involved in acute missions outside hospital. Anaesthesiologists are manning rapid response vehicles, and GPs are not involved in acute emergencies as in Norway (47-49). Prehospital emergency services staffed with anaesthesiologists are used worldwide. The Scandinavian countries use systems that are similar in many ways, but that also differ in the volume of patient encounters, service areas, and time variables. Denmark and Sweden have higher volumes of patient encounters compared to Norway and Finland (50).

Few other countries have the same two-folded system as Norway with primary care and specialised health care integrated into the emergency prehospital services, and in majority of European/Nordic countries the inhabitants can be admitted to hospital without referral from a primary care physician. Similar services between the countries are not realistic or a goal in itself, but knowledge about how organisational differences and changes affect other prehospital services is useful and can contribute to improve resource use and allocation. Our neighbouring countries also have remote areas with challenging weather conditions where the regularity of HEMS varies throughout the year.

6.7 Cooperation and allocation of prehospital resources.

On-call physicians in primary health care and the ground ambulance service constitute the backbone of the prehospital emergency medical service (EMS) in Norway (6, 51). GPs and the ambulance service handle the majority of medical emergencies without requesting helicopter emergency medical services (HEMS). Still, cooperation between prehospital services is vital to ensure the correct level of care for the patients. Over-triage is to some extent necessary and accepted when encountering patients in need of the competence of, i.e., an anaesthesiologist or on-call physician. In retrospect, some missions could have been handled with less specialised resources.

Using the lowest effective level of care (LEON) is always a goal when diagnosing and treating patients in Norwegian health services (52). Due to the gatekeeper function, the referral of emergencies to hospitals demands a prior contact with a physician in

primary health care, as a general principle. However, Figure 1 illustrates that patients in time critical situations can be transported to hospital by ground ambulance workers without consulting an on-call physician. In many situations they have been communicating on the emergency public safety radio network with the on-call physician. The latest study regarding acute admissions to hospital showed that 64% were referred from GPs or on-call physician and 35% directly admitted (53, 54).

In some municipalities the on-call physicians are very active and do callouts in most of the acute medical situations within the OOH district. In contrast, other municipalities have no callouts. Consequently, all acute missions are handled by the ambulance service, with the support of HEMS when there is a need for a physician to attend the patient. Several possible positive effects of having an on-call physician available have been presented in the debate about callouts from primary health care. It is assumed that assessments and decisions can be done on a higher level of competence. The assessment can be done on site, with less use of ground ambulance transport and unnecessary admissions to hospital if the physician decides to treat the patient at home. The elderly and patients at nursing care facilities can especially gain an advantage from a physician on site. Further, medical emergencies often need several resources, i.e., cardiac arrest. Finally, having a physician on site can have benefits for the patients beyond the medical care (55).

Other medical emergencies are assessed differently. In cases where rapid transport to hospital seems to be the most important, it can be contraindicatory to callout from the OOH if it can delay the prehospital time. Moreover, local geographical factors can contribute to the patient being transported directly to hospital. Concurrencies are normal in the OOH service where the majority only have one physician on call, which results in no callout to the emergency.

In areas with few callouts from the on-call physician it has been speculated whether HEMS is used to compensate for the lack of an unavailable on-call physicians, especially near the HEMS base. The decreasing number of OOH-services in Norway has led to worries that the on-call physician is less available in emergencies because

the distance between the patients and on-call physician has increased. A consequence can thus be an increased use of HEMS. A previous study from the county of Trøndelag shows a decreasing involvement of on-call physicians in acute medical situations over a 10-years period, from 53% to <30% (56). Other reports have also indicated an increase in HEMS missions, with clinical content handled previously by the on-call GPs. Organisational changes in OOH-services resulting in larger geographical distance between the patient and on-call physicians have been speculated as a reason for this evolvement (57, 58). The guidelines for requesting HEMS in Norway states that HEMS is not intended to replace on-call physicians (27), which could be a consequence if the on-call physician in the OOH-services are less available.

A two-folded system, the possibility for direct admissions, and geographical and organisational differences can have both positive and adverse effects. The development of these services are important to improve the "chain of survival". A flexible system that can be adapted to both urban and rural areas is crucial to give the inhabitants equal access to the prehospital health care system. Nevertheless, such organisational changes and local variations should be evaluated to determine whether they had the intended or possibly an adverse effect.

Many areas in the prehospital emergency system in Norway lack important knowledge. There is scant information about how cancelled HEMS-missions are solved when HEMS is unavailable and the consequences for the patients. To our knowledge, few or no studies has been conducted recently to examine if the lack of HEMS has negative consequences. Hospital functions and prehospital services are centralised, while the treatment of acute myocardial infarction, stroke and trauma focuses on less prehospital delay. Further, no previous study has investigated whether the centralisation of OOH-services has changed the use of HEMS. Knowledge about callouts from OOH-services are low, and since there are local variations, it is important to explore if different approaches to callouts from OOH districts have any consequences for requesting HEMS.

It is important that the inhabitants can rely on the whole prehospital system in acute medical situations. The recent changes, especially in the OOH-service, can have adverse effects leading to negative consequences for the patients. Reports and worries from personnel in the services have raised important questions that should be addressed. This thesis aims to provide more knowledge in these areas.

7. Aims

The aim of this thesis was to investigate acute medical emergencies in the interaction between HEMS and the municipalities primary emergency health care. We seek to achieve this aim through four papers where the results are published.

Aim – Paper I

The aim of this study was to estimate the potential loss of life years when medically indicated HEMS-missions were cancelled.

Aim – Paper II

This study investigated HEMS missions that were cancelled for non-medical reasons, with the aims of determining the extent of primary care involvement, the treatment provided, and the cooperation between the prehospital services.

Aim – Paper III

The objective here was to investigate whether dispatches of HEMS increased following an organisational change where nine municipalities merged into one large inter-municipal OOH district.

Aim – Paper IV

This study examined how the different availability of on-call physicians that attend to emergency patients on site (callout) impacted the requests and use of HEMS. We also aimed to explore differences between patients encountered by HEMS and OOH on-call physicians.

8. Materials, methods and results

This chapter gives an overview of the geographical setting, materials, methods, and results as published in the individual papers. Since the geographical settings and the organisation of health services are the same in **Paper I-III**, these will be described together. The materials, methods and results for **Paper I-III** are presented individually. The data in **Paper I** and **II** are from the same data collection, while **Paper IV** has another geographical setting, which is presented separately.

8.1 Geographical setting and organisation of services in **Paper I-III**

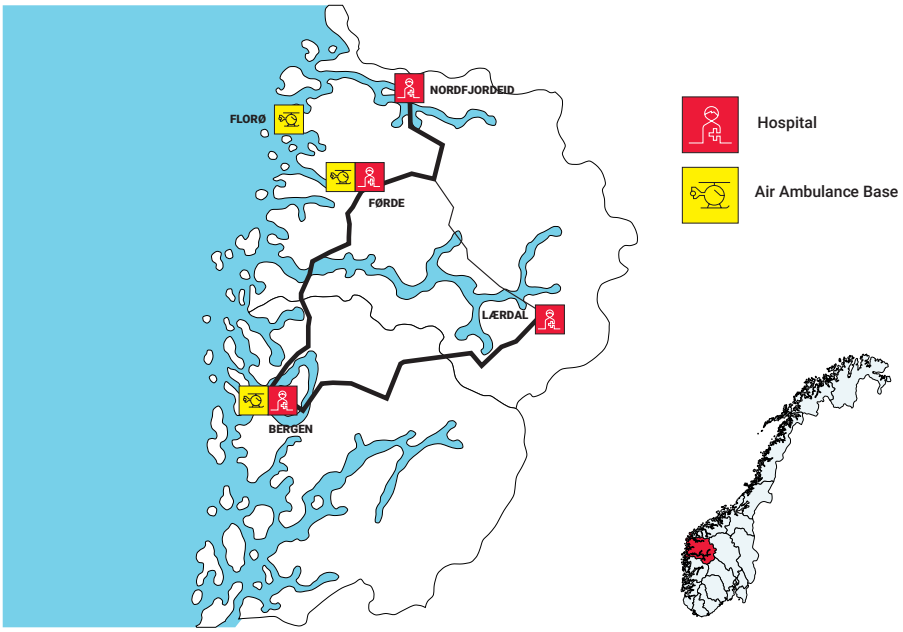

Figure 2. Map of the geographical area with hospitals, roads and HEMS bases.

The previous county Sogn & Fjordane (S&F) (now part of Vestland) consisted of 26 sparsely populated municipalities with a total of 110,000 (2019) inhabitants. Mountains, fjords, islands, and poor road quality are challenges for the prehospital system and any increase in response time for ground ambulances and HEMS in the

area. Especially during winter, weather conditions with reduced visibility are common.

The former county has three hospitals (Figure 2): Førde, Nordfjordeid and Lærdal. Førde has an emergency service for medical and surgical conditions, while Nordfjordeid and Lærdal only have medical emergency services. Patients with major trauma, severe burns, or the need for percutaneous coronary intervention (PCI) are transported to Haukeland University Hospital in Bergen, either directly from scene or after stabilising treatment at local hospitals.

A total of 21 ground ambulance stations are localised throughout the county (2019). Ground ambulance transport from Nordfjordeid to Førde takes about 90 minutes and from Lærdal to Førde approximately 120 minutes. Driving time from Førde to Bergen is approximately 150 minutes. Except from Lærdal to Bergen, a ferry crossing is necessary for all routes. The EMCC is located at the hospital in Førde. Since ground ambulances often have shorter driving time to the patients, compared to the on-call GP, ambulance workers can in some situations perform protocol-based treatment without a physician involved.

One HEMS is located in Førde. Most of the county is reachable within a 20 minute one-way flight time. In addition, neighbouring HEMS (Ålesund, Ål, Dombås and Bergen) can perform missions in S&F county when needed. There is a Search and Rescue (SAR) helicopter located in Florø, 60 km from Førde. Both the HEMS base in Førde and SAR in Florø have a rapid response car available.

Many of the municipalities in S&F have reorganised their OOH-services since 2000. S&F had 15 out-of-hours emergency services in 2009, each with one on call physician. A major reorganisation was performed in 2009, where nine municipalities relocated all local OOH-services to one large inter-municipal OOH-service (SYS-IKL) in Førde. The new OOH service now covers an area of 6,400 km^2 and 35,000 inhabitants. As a result, the driving distance for patients can be up to 100 km, and the median driving time to SYS-IKL for patients in the same area has increased to 1 h 45 min compared to the 40 min median driving time before 2009 (59). In the rest of the

county (2009), eight of the municipalities had a local OOH service, while nine had an inter-municipal OOH service.

8.2 Methods and results in **Paper I**

Data

HEMS requests are registered in the AirDoc activity registration database. First we used Airdoc for the identification of cancelled missions and to further identify the patients in the Acute Medical Information System (AMIS), in which all alarm calls to EMCC are registered. AMIS contains patient information, administrative response data and a national personal identification number that makes it possible to access and link data from other records. The national person identification number was used to identify patient records from GPs, OOH-services, ground ambulances and the hospitals. These records were collected and made available for assessment.

At all EMCC in Norway, operators use Index as dispatch guidelines for determining mission urgency and the appropriate level of response (8, 60). Based on the information provided and the Index criterion, the operator determines whether HEMS should be requested. An acceptance of the mission requires both a medical indication evaluated by the HEMS anaesthesiologist and the pilot´s evaluation of the weather conditions.

Design

We identified all cancelled HEMS requests in S&F county for the years 2010–2013, and both primary missions (on-scene missions) and secondary missions (inter-hospital transports) were included. Symptom categories used for further analysis were based on the clinical information available at the time of dispatching HEMS.

Only missions that were cancelled due to non-medical reasons were included, such as bad weather conditions, concurrencies, technical issues or out of duty time. The patients included were transported to hospital by ground ambulance, and ambulance personnel and on call physicians provided treatment, if needed. This observational

study was designed to include cases not biased by patient-related clinical information as a reason for cancellation.

All available medical records from symptom start to discharge from hospitals was used in a written case report for each of the included patients. A timeline for the prehospital services, calculation of flight times for HEMS, remaining life expectancy and alternative treatment(s) by HEMS was described in the case report.

Loss of life years estimations

The case reports were presented to a multidisciplinary expert panel that estimated the patients' potential loss of life years (nominal group process) exclusively due to the lack of helicopter transport and potential interventions by an anaesthesiologist (61). An anaesthesiologist, a cardiologist, a general practitioner, a neurologist, an obstetrician and a surgeon were invited to participate on the panel. Using the following algorithm, loss of life years was estimated in the following manner:

1. The cases were divided into two groups: one with no anticipated loss of life years and another group with a potential loss of life years. This was done individually by each expert.
2. Case reports from the group of patients with potential loss of life years were then assessed by all experts again. Expected remaining life years were adjusted using comorbidity, in accordance with literature (62-64). For each patient, loss of life years was calculated as the difference between expected remaining life years after actual evacuation and the experts' estimate of remaining life years if an HEMS evacuation had been available.
3. Finally, the estimates were presented at an expert group meeting. All steps from the individual assessment described above were discussed thoroughly within the group with consensus on estimated loss of life years as a goal.

Statistical analysis

Standard descriptive data analyses were performed. Pearson Chi-Square tests were used to analyse differences between the two groups "possible life years lost" and "no life years lost". *P* values of <0.05 were considered statistically significant.

Results

HEMS Førde and SAR Florø (included search- and rescue missions) completed 2,582 missions during the study period. We identified 627 cancelled missions (Figure 3). The majority of these missions (72%) were excluded; 33% were completed by another HEMS, 20% were cancelled due to no persistent medical indication, and 19% were excluded due to duplicates. The study ended up with 176 cancelled missions with 184 patients. The probability of not receiving a medically indicated HEMS evacuation in S&F County during the study period was thus 5.9%.

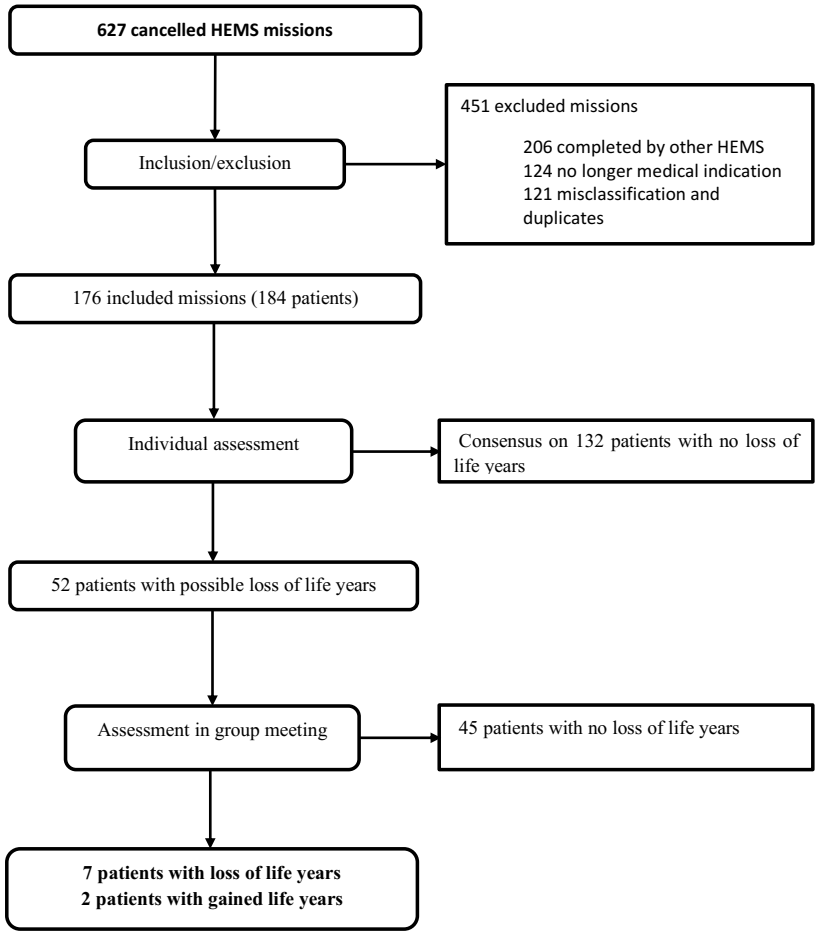

Figure 3. Flowchart showing included missions and patients.

The median age of the 184 patients was 59 years (IQR 31-72), and 61% were male. The median remaining expected life years was 25 years (IQR 15-52). The most frequent symptom category was cardiac and neurologic symptoms, respectively 35% and 20%, while trauma patients constituted 14%. Individually, the experts identified 52 (28%) of the 184 patients with a potential loss of life years. Finally, the expert panel concluded that 7 of these (4%) had most likely lost a total of 18 life years. Thus, the probability of a patient losing life years when in need of HEMS evacuation was found to be 0.2%. Two patients were found to have gained life years.

Median age for the seven patients with loss of life years and for the two patients with life years gained was 69 years (IQR 58-77), and median adjusted life expectancy was 10 years (IQR 4-11). The total remaining life years for the seven patients with loss of life years was estimated to 158 years before adjustments, and 83 years when adjusted for comorbidity.

In most cases, a lack of rapid transport to the University hospital in Bergen was considered to be the main cause of loss of life years, rather than a lack of advanced treatment.

8.3 Methods and results in **Paper II**

Data

We used data from the same emergency missions in S&F county as in **Paper I** where HEMS were requested but cancelled.

Design

Paper II was designed as a retrospective observational study. We obtained mission data from AMIS and records from ground ambulances, hospital and OOH services including: age, gender, date, Index criteria code, resources alarmed, response to alarm, timeline for each resource, site, destination, clinical data about the patients, treatment provided and which health personnel being involved. All data were collected retrospectively. Cooperation was defined as presence at the scene, assuming communication and involvement between health personnel.

Statistical analysis

Standard descriptive analyses were performed. Age is presented as a median with interquartile range (IQR). For categorical variables, Pearson's Chi-square and Fischer's exact test were used. A P-value of 0.05 or below was considered statistically significant.

Results

The same 627 cancelled missions as in **Paper I** were accessed. Among these, 73% were excluded from our analysis because the missions were completed by neighbouring HEMS (33%), there was no longer a medical indication for HEMS (20%), or other reasons, such as misclassification or duplicates (20%). Compared to **Paper I**, four more missions were excluded due to a new evaluation by the researchers. The patients in these four missions had at some point during the mission been encountered by an anaesthesiologist and were excluded in the further analysis. Ultimately, the study included a total of 172 missions with 180 patients.

In nearly 90% of primary and secondary missions the main reason for mission cancellation was weather conditions. During the period from October through March, we registered 74% of the cancelled missions, and 46% of the cancelled missions were rejected or aborted during the afternoon (16:00 to 23:59).

Two-thirds were primary missions. Based on the Index, 73%, 26% and 1% of the missions were considered acute (red), urgent (yellow) or non-urgent (green), respectively. All patients were transported to a final destination by ground ambulances.

Figure 4 shows that among the primary missions, the on-call GP was alerted for 95% of the patients and responded with a callout for 46% of these patients. Time of day ($p = 0.601$), diagnostic group ($p = 0.309$), patient's age ($p = 0.490$), or the patient's final destination did not differ in accordance with GP involvement ($p = 0.410$). A GP followed 40% of the patients who were examined on scene during transport to their destination.

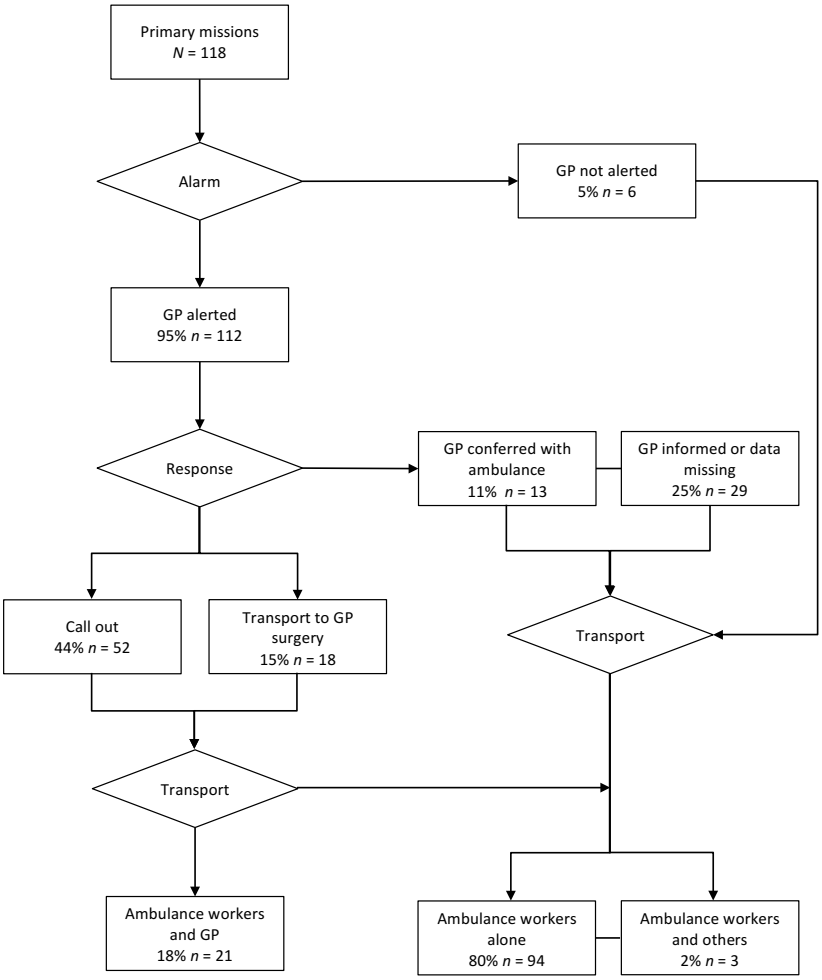

Figure 4. Flow chart of primary mission, showing alerts, GP responses, and transport options.

One fourth of the patients in primary missions did not receive treatment, and a further 14% were provided oxygen. The involvement of a GP did not influence the provision of treatment. Among the secondary missions, 31% of the patients received no treatment during transport.

In 13% of the secondary missions, the patient ultimately stayed at their initial hospital when HEMS had to cancel, while 16% of the patients were accompanied by a physician during transport between hospitals.

8.4 Methods and results in **Paper III**

Data

The study included all HEMS dispatches in S&F from 1 January 2004 to 31 December 2013. We obtained timeline, patient- and operational data, and a National Advisory Committee for Aeronautics (NACA) score (65) was registered in missions with a patient encounter. Data were retrieved from databases at all HEMS bases having missions in S&F, and statistics from the National Air Ambulance Services.

Design

In order to evaluate the potentially statistically significant effect of introducing the SYS-IKL organisational change on the number of dispatches, we applied interrupted time series regression (ITS) (66).

Data were aggregated to obtain the total number of dispatches per month. Subgroups of SYS-IKL and municipalities outside SYS-IKL (hereafter called MOS) were created. The municipalities were categorised as urban or rural, whereas municipalities with >7,000 inhabitants were defined as urban. Distances between the municipalities and OOH service were measured.

Statistical analysis

The outcome variable in the analyses was the monthly aggregated number of HEMS dispatches. A Poisson ITS step change model was first used. However, preliminary analyses indicated statistically significant overdispersion and varying HEMS dispatches throughout the year (23). Thus, the final analyses were performed using a quasi poisson regression model adjusted for seasonality.

Mann-Whitney-Wilcoxon non-parametric tests and a chi-squared test were used to analyse differences in travel distance between the patients and on-call doctor for SYS-IKL and MOS and changes in NACA scores before and after the policy change.

Results

We identified 8,751 HEMS dispatches during the study period, 5,009 (57.2%) missions were completed with HEMS attending the patient.

We found no statistically significant change in HEMS dispatches after the policy change ($p = 0.251$). Using the model separately for SYS-IKL and MOS resulted in no statistically significant change for SYS-IKL ($p = 0.400$) or MOS ($p = 0.056$).

We found a greater monthly number of dispatches for MOS compared to SYS-IKL. Adjusted per 1000 inhabitants, the monthly mean (SD) rate for SYS-IKL was 0.58 (0.22) and 0.60 (0.17) prior to and after the policy change. For MOS the same data was 0.61 (0.19) 0.78 (0.17).

HEMS was dispatched more in the rural areas. An overall significant linear increase in HEMS dispatch in the rural group was found throughout the period ($p = 0.045$), but there was no additional increase following the policy change ($p = 0.502$).

Travel distances to the OOH service increased statistically significantly in SYS-IKL after the change ($p < 0.05$). Distance within MOS also increased statistically significantly ($p < 0.05$). The distances were statistically significantly higher for rural (8.9 [6.2, 22.0] km) rather than urban (5.0 [3.0, 8.3] km, $p < 0.05$) contexts.

Within MOS, the change of NACA scores was statistically significant ($p < 0.05$), with a mean NACA score of 3.76 vs. 3.84. Within the SYS-IKL NACA, the change in scores were not statistically significantl, with a mean score of 3.99 vs. 3.88 ($p = 0.07$).

8.5 Methods and results in **Paper IV**

Geographical setting and organisation of services

The city of Bergen is the second largest city in Norway and is located on the west coast of Norway. Bergen has about 300,000 inhabitants (2020) and spans an area of 445 km^2. The city has organised the OOH service with one large casualty clinic and three smaller casualty clinics in the suburban areas. The OOH service was not able until November 2018 to perform callouts. Os and Samnanger, two smaller municipalities near Bergen, have a total of 23,455 inhabitants (2019) living in an area of 409 km^2. This region has an intermunicipal OOH service with one casualty clinic and a rapid response car available for callouts.

All three municipalities have Haukeland University Hospital (HUS) as the nearest hospital. It takes about 5 minutes to drive from Bergen OOH casualty clinic to HUS and approximately 30 minutes from the intermunicipal casualty clinic at Os to HUS. HEMS Bergen covers the three municipalities, and is based close to HUS and a two-minute drive from the casualty clinic in Bergen. The rapid response car is more suitable compared to helicopter, to reach the inhabitants in Bergen city. The ground ambulance service has four stations localised around in Bergen. A varying number of ambulances are available in Bergen, from 5 ambulances in the evening/night up to 13 ambulances during daytime on weekdays. Os and Samnanger have one ambulance available 24/7.

Data

Acute medical missions, outside of the hospital, with an on-site physician, in three municipalities from November 1 2017 to 30 November 2018 were retrieved. Data from HEMS Bergen were retrieved from AirDoc, and data from the OOH service in Os/Samnanger (hereafter called "rural OOH-service") were registered using an iPad with a digital form. Data including patient data and operational data regarding each mission with a patient encounter was retrieved. Through the AMIS database at EMCC in Bergen we collected the total number of acute medical missions in the municipalities.

Design

The study was a prospective, observational study. Since the OOH service in Bergen had no car available for callouts in emergencies, acute medical situations were handled by ambulance workers, without a physician involved in most of the situations. On-call physicians could be contacted by telephone, or the patient could be transported to the casualty clinic in less severe cases. In more acute situations, HEMS Bergen could be requested to assist the ambulance workers. An opposite situation was in the municipalities Os and Samnanger, where the OOH on-call physician most often responded with a callout. In addition, HEMS was requested together with ground ambulances and the on-call physician in severe cases.

In summary, the municipalities differed in callouts from the OOH service and had different distance to HEMS Bergen, but had the same EMCC, HEMS base, and hospital serving the inhabitants.

Statistical analysis

Data are presented in groups of patients who were attended by either HEMS in Bergen or the on-call physician in the rural OOH district. We categorised the diagnoses into ten predefined symptom categories (67). Interventions and treatments were categorised into none, basic, and advanced, with advanced interventions being those performed only by anaesthesiologists. Basic interventions are expected to be performed by on-call physicians. NACA scores were dichotomised into 0–4 and 5–7. Age is presented as the mean, and means were compared using a t-test. Fisher's exact test and Pearsons's Chi-square test were used for categorical variables. A P-value of <0.05 was considered statistically significant. Incidence is presented as the rate per 1000 inhabitants per year, with the 95% confidence interval (CI).

Result

Bergen and the rural OOH district had similar rate of acute medical missions. Still, request of HEMS was higher in the rural OOH district compared with Bergen, but with no differences in numbers of completed missions between the two areas. In 66 % of the acute missions in the rural district, an on-call physician was present at site. All together there was a physician at site in 70 % of the cases in the rural OOH district (HEMS physician or OOH physician). The same figure for Bergen was 4 %. In 80 % of the HEMS missions to the rural OOH district, an on-call physician also attended the patient.

Symptom categories differed between HEMS and OOH services. Within HEMS missions, cardiac arrest and trauma were the most registered categories, both in Bergen and in the rural municipalities (57.4% and 56.6%, respectively). The same symptoms categories counted for only 20.2 % of all the callouts by the on-call physicians, while chest pain alone was most common (21.0 %).

Among the patents, 74.2% of those attended by HEMS in Bergen and 66.7 % of those attended by an on-call physician in the rural district, were hospitalized ($p < 0.05$). In the rural district rate of hospitalisation was similar between patients attended by HEMS and patients attended by the on-call physician.

Nearly half of the HEMS patients in Bergen got a NACA score between 5-7, while 40% of the patients attended by HEMS in the rural OOH district got the same (not statistically different). On the contrary, and statistically significant, patients attended by the on-call physician in the rural OOH district, only 12.8 % got a NACA score between 5-7.

In nearly one-third of the patients taken care of by HEMS in Bergen and the rural OOH area, an advanced treatment was carried out, normally among cardiac arrest and trauma patients. Among those patients, NACA score of five or higher was estimated to 87.6 % of the patients in Bergen and 54.5 % of the patients in the rural OOH area.

8.6 Statistical program

Data in **Paper I-IV** were entered and analysed using SPSS Statistics Version 22/23/25 (IBM Corp., Armonk, NY, USA) and R3.5.2 in **Paper III** (68).

8.7 Ethical approvals

The studies resulting in **Paper I-IV** were approved by the Regional Committee for Medical and Health Research Ethics (REK West decisions 2013/373, 2017/280, and 2017/283, Norway).

9. Discussion

9.1 Methodological considerations

9.1.1 Research in the prehospital setting

Acute medical emergencies are potential time-critical situations, sometimes with limited recourses in the initial phase. The patients can be unconscious and/or critically ill without the possibility to give valid information. Patients' clinical measures are made based on the given situation and not systematically, thus ethical dilemmas concerning informed consent for being part of a study is problematic.

Although the ambulance service and HEMS have digital forms for the registration of data, the majority of clinical data are still plotted on paper forms and retrospectively registered digitally. Ground ambulance personnel report to the EMCC over the radio network. EMCC often register these clinical data, but not systematically. Many of the health trusts have ongoing projects to register all data digitally with the possibility to exchange the information between the services, including hospitals. Due to the difficulties in comparing services across areas/borders, extensive work has been done in defining indicators for further research on HEMS (67, 69-72).

The OOH-service has no national digital system for plotting data in callouts.
The journal systems are not uniform and do not have the possibility to extract data easily. The National Centre for Emergency Primary Health (NKLM) has since 2005 performed questionnaires about the organisation of the OOH-services in order to have valid data for research and quality improvements (73). The NKLM also have the Watchtower-project with a representative number of OOH-districts that report data in a digital form (74). The Watchtower-project illustrates the problem with data collection: each of the OOH-services must register all relevant data in both the journal system and the digital form, and the automatic ion of information is not possible from the journal.

Hence, both the clinical setting and lack of systematic data collection creates a challenge when planning research in the prehospital setting. Performing randomised

controlled studies or similar designs with a high grade of quality is therefore difficult and often ethically problematic.

Given the general limitations in research in prehospital medicine, a discussion regarding methodological issues in **Paper I-IV** will follow. The discussion focuses on the chosen design and the studies validity and reliability. Validity is the study's ability to measures what it claims to measure. Internal validity shows to what degree the results represent what is intended to be discovered, while external validity is to what degree the results can be generalised to another setting or population. A poor internal validity will threaten the external validity of a study (75, 76).
Reliability is about the consistency of a measure and tells us the extent to which the results can be reproduced if repeated under the same conditions. A valid measure is generally reliable, but a reliable measure is not always valid.

9.1.2 Paper I

Paper I is a retrospective observational study with the use of an expert panel in a nominal group process. This method for estimating loss of life years has been used in similar studies, and the reliability of the method is acknowledged (39, 40, 61, 77, 78). However, some elements should be discussed more thoroughly.

Data sources

Paper I used AMIS, AirDoc, ambulance journals, OOH-records and hospital records as sources for data. All data was collected retrospectively.
AMIS is a digital software used in all EMCCs in Norway. The operators register all missions in AMIS regarding patient data and operational data. The software has the possibility to search for previous missions and has some functions for exporting statistics (79). It is primarily a tool for the operator and is not developed for the purpose of research. Variables regarding clinical information about patients are plotted manually in the free text field. Missing or wrong data is possible considering that the data are registered during acute medical situations. In the work of collecting data, it was clear that AMIS is not suitable for extracting data without manual control.
AirDoc is an equivalent software to AMIS and is used by HEMS. AirDoc has the

same issues about data quality as AMIS. **Paper I** had, in addition, access to relevant hospital records, OOH-records and ambulance journals, whereas much of the relevant information was unsystematically found in free text fields. In total, the databases have potential information bias, threatening the validity. As a compensative mechanism we crosschecked data sources, where possible, with intentions to identify missing data but have not found an amount significant enough to influence the result.

Sample size and study site

Paper I had all relevant missions and patient data about cancelled HEMS-missions over a four-year period available. Unexpectedly, a large share of missions was handled by neighbouring HEMS units, which resulted in a much smaller number of included missions compared to our preliminary calculations. In planning the study, we estimated an inclusion of 400 missions, based on the national statistics of cancelled missions. The large number of excluded missions could threaten the external validity. There were no children or young adults among the patients with estimated loss of life years. In studies where life years gained are estimated, children have a major impact on the results (39, 40). This increases the uncertainty of the calculated loss of life years, as one or a few patients could have a major impact on the results. One patient in our material represented more than half of the total loss of life years. If this patient was an outlier, the mean loss from the rest of the patients was barely clinically significant. The studies where children had impact on the results found life years gain in respectively 7% and 11% of the patients. All three studies (including the present) have results in the same end of the scale and been performed in different areas with different expert groups. Thus, the result should be representative in other areas with the same prehospital system.

All cases in **Paper I** were from a single rural HEMS base. During the period of data collection there were no changes in indication in requesting HEMS or organisational changes in HEMS Førde. There is no national consensus among the 16 EMCCs regarding strict HEMS dispatch criteria, and HEMS responses differ between the bases. Varying use of HEMS between bases in Norway is known (28). The external validity and thus generalisation of these results to other areas in Norway must be

interpreted with precausions. Also, the prehospital emergency system in Norway is well developed, and on call physicians and local hospitals can give advanced treatment. This may reduce the external validity of the findings to services in other countries with different HEMS use.

Accuracy of scoring

Paper I estimated loss of life years due to cancellation of HEMS. The measure of loss or gained life years can be interpreted as a narrow measure of HEMS utility. Other utility measures, e.g., sequelae after stroke, quality of life score among stroke patients and length of hospitalisation could have given a more nuanced picture of the positive effect of using HEMS. Other estimates like Disability-adjusted life year (DALY) are commonly used in public health research (80). However, interpreting such measures in our data is not feasible because we only had approval to aquire short time data from the hospital records and no information from the patients themselves.

Nominal group process/Expert panel

Health service research faces a problem trying to gain more knowledge in situations where there is insufficient and/or contradictory information. When statistical methods are not suitable, consensus methods provide another way to synthetise information. Two consensus methods commonly adopted in health services research are the Delphi process and the nominal group technique (also known as the expert panel) (61). To avoid conflicting interests in the nominal group process we assembled the expert panel consisting of persons with no affiliations to HEMS Førde or the health authorities in S&F county. As a goal, the expert group was instructed to strive for consensus in their estimates. If not, a calculation of the mean was done. The panel reached a consensus in all cases and thus strengthened the internal validity. Still, an expert panel consisting of six different persons will not conclude with exactly the same estimates. Nonetheless, the reliability of the method is acknowledged (78).

9.1.3 Paper II

Paper II is a retrospective observational study with descriptive analyses of cancelled HEMS missions in S&F. The same missions as in **Paper I** were used, and those issues

discussed about data sources, sample size and study site are also relevant in **Paper II** (see *Data sources* and *Sample size and study site* discussed under **Paper I).**

Data sources

In addition to the previous discussion about data sources under **Paper I, Paper II** provides a good representation of how challenging missions are solved in a rural part of Norway. The results show an extensive overlap and use of other HEMS bases in cases of cancellation from the nearest HEMS base. These are data that are not presented in the national statistics but are available when we use data from several sources and manually go through the missions from alarm to final destination. This provides useful information when discussing capacity and regularity of HEMS in Norway.

Representative study population compared to completed HEMS missions

The proportion of trauma patients in **Paper II** (15%) differs from the proportion among completed HEMS missions on the west coast of Norway (30%) (23). A skewed proportion of symptom category can indicate a lower external validity of our findings. A lower proportion of trauma patients may indicate different response thresholds depending on the medical indication. HEMS in Norway can be used on a broader indication compared to other countries, i.e., in missions where the patient has a long travel distance to hospital. Ideally, the anaesthesiologist decides if there is a medical indication for using HEMS without being influenced by operational factors. It is also possible that the pilot's decision to reject a mission may have been influenced by the anticipated severity of the patient's condition. The experience of the crew can also be a factor in the decision to reject a mission. However, these mechanisms are relevant at other HEMS bases, and our findings are probably relevant in other rural areas of Norway and other countries with similar prehospital services.

9.1.4 Paper III

Paper III explores HEMS requests over a 10-year period in order to find out if organisational change in the OOH-service had an impact on use of HEMS. Airdoc and AMIS were again used as data sources in the county of S&F. Methodological

discussions about these issues can also be applied in **Paper III** and are found under **Paper I** *Data sources and Sample size and study site.*

Sample size and study population

All HEMS requests registered over 10 years were included, which involved a large number of missions before and after the policy change. S&F was used as a study site due to the major change into a large inter-municipal OOH-district (SYS-IKL) on a specific date. Also, to our knowledge, no other major system changes occurred in the study period. Theoretically, the establishment of a SAR helicopter in Florø in 2009 could have had an impact on HEMS use. Still, the same dispatch criteria are used for requesting SAR on medical missions, and SAR is usually requested when HEMS is unavailable due to concurrency, bad weather or technical reasons.

Interrupted time series regression model

In **Paper III** we apply ITS as model to analyse if there was a change in HEMS requests. ITS is a regression model specifically developed for analysing interventions introduced at a population level over a clearly defined time period, when the pre-intervention and post-intervention period is clearly defined. Further, the model is most suitable when the intervention has short-term outcomes and sequential measures with, preferably, equal numbers of data points distributed before and after the intervention (66). During the preliminary analyses, we adjusted the model due to known factors like seasonality. Data was aggregated per month, and we used an area where, to our knowledge, no other changes were made during the study period. As for all observational studies, unknown factors could have had an impact and thus be confounders in the findings.

NACA score

The National Advisory Committee on Aeronautics' (NACA) severity score is widely used in prehospital emergency medicine to grade the severity of illness or trauma (65). The score grades the severity from 0 (no disease) to 7 (dead). Previous studies indicate that the score has good discrimination for predicting mortality and the need for respiratory therapy. Patients given NACA 4-6 are thought to have gained in outcome

by being attended by HEMS (81). However, the validity of the NACA score has not been thoroughly examined, and one study revealed large differences between individual raters and references in some clinical cases (82). **Paper III** used the NACA score to evaluate changes in severity before and after the organisational change.

The NACA score has some limitations: there are inter- and intraindividual variations since the score is given on site in acute time-critical situations. One study showed differences between experienced and less experienced physicians when scoring the same patient (81). Also, the NACA score is crude, and it can be difficult to choose the correct score in each situation. Analysing NACA-scores showed statistically significantly differences, but the differences found have most likely no clinical significance. However, one strength of the NACA-score is the wide use of the score in international prehospital research.

9.1.5 Paper IV

Paper IV explores acute medical situations in two areas with different approaches to callout from the OOH-service. Descriptive analyses were performed. Although the investigated area is different from that in **Paper I-III**, the study also used AMIS and AirDoc as data sources, which have limitations as discussed previously (see **Paper I** *Data sources*). **Paper IV** also used NACA to distinguish between HEMS missions in different areas and callouts from an OOH-service. The NACA score also has limitations as discussed under **Paper III** *NACA score*.

Sample size, data sources and study population

Paper IV is a prospective observational study that used a digital form on an iPad at the OOH-service. This made it possible to check the data during the study period and receive missing data prompt after registration. Destination was missing in 6.8%, while other variables were missing in 2.2% or below. The variables were predefined and equal to variables used by HEMS to compare missions performed by both services. To minimise differences between the areas compared, the study included municipalities served by the same hospital, EMCC, and HEMS base. However, there

are differences that can threaten the internal validity. The city of Bergen is much larger than the centre of Os and Samnanger, which may correspond to increased numbers of intoxications and traumas. A multicentre data collection could have strengthened the internal validity. Generalising the results to other areas in Norway are probably still relevant since the heterozygosity of size and different organisation of OOH-services are common in Norway. However, generalising the results to other countries has perhaps more limited value. HEMS attended only 30 patients in the rural OOH district. However, the rate of using HEMS is similar to the municipality of Bergen with 279 patients during the study period.

Accuracy of scoring

The study used rates of requests and completed HEMS missions in the municipalities to investigate whether the OOH-services' availability to callout had any impact. Assuming that the areas are similar, rates are a good way of measuring any differences in use of HEMS. Symptom categories were used as a measure of which patients the OOH-service and HEMS encountered and is important for understanding differences in the use of the services. A limitation in the design of the study was that it had information about the destination for the patient, but no information regarding outcome among the hospitalised patients. Discussions about the effect of an on-call physician in callout must be investigated with other designs. A comparison of survival rates between patients attended by HEMS compared with ground ambulances discovered similarities, although HEMS patients were more critically ill (83).

9.2 Discussion of results

A discussion of the results from **Paper I-IV** will follow in this chapter. The results from all papers will be discussed together focusing on elements regarding the prehospital system, clinical considerations, and the level of care for the patients.

9.2.1 Prehospital system

The prehospital system in Norway is comprehensive, involving services from both primary and specialised health care. Each mission is solved with resources that are

requested based on the initial information. Our main findings contribute to the knowledge that we have a robust prehospital system that serves the inhabitants. Still, the two-tied system has areas where the cooperation and changes of the services can be problematic, as mentioned earlier in chapter 7.1.

Overlapping and robust system

The overlapping system with ground ambulances, OOH-services and HEMS have benefits that are confirmed in our results. **Paper I-II** shows that the majority of patients received adequate transport and treatment when HEMS was unavailable, without a major loss of life years**.** One of the positive effects of the high density of HEMS bases in Norway is that neighbouring HEMS units can handle missions when the nearest HEMS has to cancel due to non-medical reasons. **Paper I** shows that a large part of the missions was excluded because another HEMS completed the mission. Norway has 13 HEMS bases, but by using advanced mathematical modelling to explore optimal HEMS base locations, one study has found that the national goal of covering 90% of the inhabitants within 45 minutes is possible with four bases (84). An important reason for this high density of bases is the challenging weather conditions and difficult topography with high mountains, fjords, and a long coastline. Finally, **Paper II** shows that when no HEMS was available, ground ambulances and on-call primary call physicians transported and treated nearly all patients without any consequences for the outcome. Among the patients in primary missions in **Paper II**, 70% were discussed over the radio network or encountered by the on-call physician. In **Paper IV** we found that 80% of the HEMS patients in the rural OOH-district were seen by the on-call physician together with the anaesthesiologist, illustrating that HEMS is a supplement to the backbone of the emergency system in the municipalities constituted of ground ambulances and OOH-services.

Centralization, travel distance and organisational differences

It is known that less frequent use of health services is related to increased travel distance, and not only in emergency medicine. Lower rates of mammography screening (85), lower hospitalisation rates for children (86), and major barriers to hospital referral by GPs (87) are among the findings in previous studies when the

distance between the patients and the health service increases. Longer distance between the patients and the OOH service is correlated to decreased use of OOH services including medical situations categorised as acute (88, 89). One study from the county of Trøndelag in Norway found decreasing percentages of patients that where seen by an on-call physician together with HEMS in the period 2006-2015 (53% vs <30%) (56). The authors have linked this to the centralisation of OOH-services. In 2012 the OOH service SYS-IKL reported that only 0.5% of the consultations at the OOH service was completed with a callout. Having only one doctor on-call and the long distances to the patients was used as explanation in the annual report (90). Some have described this as an abdication of the OOH services from large areas in Norway (14). The findings in **Paper III** with no change in HEMS dispatch within SYS-IKL after 2009, despite the increased travel distance, is an important finding. In the rural municipalities there was an increase in HEMS dispatch in the study period. This was found both in municipalities with increased distance from the OOH service and municipalities with unchanged travel distance. A combination of reasons may contribute to the increase in HEMS dispatches overall, such as a general centralisation of many health services, including ground ambulance stations, OOH services, and hospitals,.

In the western part of Norway (the county of Rogaland and the former counties Hordaland and S&F), HEMS had a stable annual number of dispatches from 2004 to 2013, while acute missions with ground ambulances were increased by 95% in the same period (23). The centralisation of OOH services has probably resulted in an increased number of missions for the ground ambulances. However, HEMS is involved in a small part of all acute missions compared with ground ambulance and the OOH services. Hence, HEMS is probably not affected by the structural change to the same degree. Due to the lack of on-call physicians doing callouts, more patients are transported to the OOH services by ground ambulances. Further, there was an increased focus on using Index in the same period (8).

Due to structural changes in the OOH service and increased focus on Index to dispatch ambulances, use of ground ambulance and increased patient transport to the OOH services should be further explored.

Another important finding regarding organisational differences is what we found in **Paper IV.** HEMS Bergen completed similar rates of missions in the two compared areas, and also that the rate of acute medical missions was similar. This indicate that the operators at the EMCC, independently of the location of the patient, concluded with the same level of urgency. The distance between HEMS and the patient, independently of use of helicopter or rapid response car, did not affect the decision to use HEMS. The rate of requests to HEMS is higher in the rural municipalities, and EMCC may request and discuss the mission with HEMS at an earlier stage in these municipalities, since the distance and response time are increased compared to missions in Bergen. Still, HEMS encountered the same rate of patients. An on-call physician may already have attended the patient and concluded that there was no medical indication for HEMS.

Compared to the findings from Trøndelag (56), the active use of callouts from the OOH service in the rural OOH district at Samnanger and Os could have a positive effect on the over-triage of HEMS.

Dispatch criteria HEMS

A systematic review has concluded that HEMS use is region-specific, and that dispatch criteria should be adjusted to the specific prehospital system (91). National guidelines exist for HEMS requests in Norway. However, the EMCC/areas in Norway use the service differently (28). Depending on available resources, demographics, and distance to hospitals with a capacity to handle trauma and other acute medical illnesses, each EMCC has a different policy for requesting HEMS. As an example, HEMS Førde had a three times higher rate of missions per inhabitant compared to the other HEMS bases in Norway in 2011 (28). In 2019, there was a reorganisation of the system for requesting HEMS. Only one EMCC in each health region is now operating as a HEMS-EMCC. One of the reasons for this change was to have a more uniform

request of HEMS. The results from **Paper III and IV** shows that each EMCC had the same threshold for requesting HEMS within their area, independent of the distance and availability of on-call primary care physicians.

The distance from site to hospital influences the requests for HEMS, and in S&F county the long travel distance is compensated by using HEMS more often.
An ongoing research project is examining the effect of the reorganisation into these HEMS-EMCCs (92).

Given the more wide use of HEMS in S&F (28), over-triage may be an important contributing factor explaining the low proportion of patients with life years lost in **Paper I**. More uniform HEMS dispatch criteria could reduce over-triage. However, an important strength of HEMS in Norway is its flexibility. HEMS crew decisions to accept a mission are based on several aspects like the condition of the patient and the patient's distance to an ambulance, on-call primary care physician and hospital. A lower threshold for dispatching HEMS can be a consequence in areas with long distances for patients to travel to health services. The stable dispatch of HEMS in our analysis in **Paper III** supports the conclusion that HEMS still seem to have the same threshold for dispatch. Our analyses are also similar to the findings in another study (23). Concurrencies can be a problem if HEMS is requested often. The high density of HEMS in Norway shows that the capacity of HEMS in Norway has not reached the upper limit of missions, and that HEMS has a low rate of concurrencies (83).

9.2.2 Clinical considerations

The benefits of HEMS use are still under debate. Internationally, HEMS is used more often in trauma patients, and previous research focuses on this group of patients. The most recent systematic review concluded that it remains unclear which elements of HEMS service benefit trauma patients: rapid transport and/or advanced interventions (35). In prehospital emergency care, the "First Hour Quintet" (cardiac arrest, respiratory failure, trauma, acute coronary syndrome, and stroke) are critical conditions with great importance (93), and are conditions for which HEMS can be indicated.

Regarding symptom categories, HEMS in **Paper IV** had statistically significant higher rates of cardiac arrest and trauma compared with the OOH service in the rural area. Stroke and chest pain were more common among the callouts by the on call physician in the rural area. HEMS could improve survival after cardiac arrest in a prehospital setting, but basically after circulation is restored (94). Even in a cardiac arrest patient HEMS could be cancelled due to complementing information from site, like start time of bystander CPR, comorbidities, and other clinical findings. The consequence of this is cardiac arrest patients without HEMS as part of the treatment group in the rural OOH area, as shown in **Paper IV**. It was expected that HEMS was more used in situations where HEMS could increase health outcome, compared with ground ambulance and/or on-call physicians alone. As a time-critical condition, stroke is one condition that could benefit from the fast transport HEMS can provide to a hospital. Even in the rural OOH area in **Paper IV** it is a relatively short transportation time to hospital, which could be one reason for few patients with stoke symptoms were handled by HEMS. In **Paper II** there were a larger number of neurological conditions accepted by HEMS, and the longer distances is an important reason for this difference.

Regarding patients receiving advanced interventions by HEMS, airway management, such as intubation, is most frequent. Sunde et. al. concluded that HEMS patients frequently received advanced interventions (95). Further, patients with NACA scores of 4–6 are thought to have better outcomes when attended by HEMS (81).

In primary missions in **Paper II**, two-thirds of the patients received no specific intervention, or only received treatment that ambulance workers in Norway can administer without physicians' guidance. Together with the minor loss of life years in the same patients in **Paper I**, we conclude that on-call physicians and ambulance personnel provided sufficient treatment. This is similar to studies from the northern part of Norway, which found that GPs/on-call physicians often started important medical treatment before HEMS arrival and that GPs/on-call physicians could provide adequate treatment to more than half of the HEMS patients (41, 96). **Paper IV** revealed that advanced interventions were most commonly performed for HEMS patients with NACA scores of ≥5. It is difficult to predict which patients will benefit

from advanced interventions. The fact that advanced interventions are mostly used in cases with cardiac arrest and trauma with a NACA score ≥5 indicates a correlation between severity and the need for HEMS. One study of HEMS in Norway reported a high rate of advanced treatment provided by an experienced anaesthesiologist (23).

As isolated variables, NACA score, clinical condition, and use of advanced interventions are not sufficient to indicate whether HEMS is necessary; however, these measures can be used together to determine the need for HEMS and are useful for comparison between different services. If lifesaving treatment is the main goal of HEMS, the low rate of using advanced interventions and few life years lost due to cancellation of HEMS indicates a low threshold for using HEMS (possible overtriage). Delgado et al. have also discussed the presence of over-triage in a cost-benefit context of helicopter use; less transport of minor injuries will improve cost-effectiveness (97). Still, although few patients lost life years or received advanced treatment in our results, our experience is that clinical observation and monitoring of patients in potentially life-threatening situations is vitally important. Attendance by physicians probably improves the quality of the patient assessment, but there is scant evidence for which situations a physician is required (98).

9.2.3 Level of care

A key question discussing the level of care for patients in medical emergencies is how to predict when the different prehospital resources should be dispatched. Further, how should the patients be transported and treated, and what is the optimal destination for giving adequate care?

Independent of how the health care system is organised in Norway, two principles are important when discussing the level of care in medical emergencies: The citizens should have equal access to health care regardless of residence (58), and the services should use the lowest efficient level of care (LEON) (99). In this context, GPs and on-call primary care have significant roles as gatekeepers to reduce the use of the health care system and reduced hospitalisations in Norway (30). HEMS, on the other hand, can contribute to equal access to health care in areas with long travel distances.

Medical emergencies represent a continuum from moderate to life-threatening situations. HEMS has expertise in treating patients with life-threatening conditions, while the OOH services in Norway handle a majority of patients with mild and moderate symptoms. Nationally, 62% of the patients treated by HEMS got a NACA score between 4-7 (57), like the patients' NACA score given by the Danish HEMS (47). Among patients taken care of by the OOH service in Norway, 7.7% was in an acute and potentially life-threatening situation (10). Lack of on-call primary care physician on site in Bergen did not result in decrease of severity score among patients attended by HEMS. Results presented in **Paper IV** shows that NACA score given patients in Bergen were similar to NACA score given patients in the rural OOH area. Comparing NACA score between patients attended by the on-call physician and HEMS, revealed statistically significantly higher NACA scores among HEMS patients. At the same time, many patients attended by HEMS in both districts were given a NACA of three or below. This is probably due to deficient patient information, when performing triage based on a phone conversation.

Improved patient care concerning triage and less use of hospitalisations when an on-call primary care physician is on site is demonstrated in some studies (30, 100). Still, it is unclear which patients should be approached with a call-out reaction (98). Ambulance workers prefer on-call primary care physicians to be present in challenging prehospital emergencies (101), and GPs claim improved patient care when involved (102). Under unclear circumstances, having an on-site physician is an advantage and is useful to the ground ambulance personnel (101). Psychiatric issues are conditions that can be challenging to solve, and **Paper IV** shows that the on-call primary care physician is involved in 43 patients (8.7%) with such conditions compared to none for HEMS in the same area. HEMS in Bergen encountered 12 patients (4.3%) with psychiatric issues/intoxication, illustrating that these conditions often require a physician. Still, the presence of on-call primary care physicians in medical emergencies in Bergen may be less important, since the ambulance service in Bergen has short transport distances to both the hospital and the OOH casualty clinic. In both **Paper II and IV**, we found that few patients were followed by a physician

under transport to hospital. The reasons for low involvement during patient transport can include a stable condition of the patient, a less severe medical problem than initial indicated, or a concurrent conflict for the on-call physician.

Use of HEMS should, as a goal, increase health outcomes and HEMS should not replace the on-call physician (27). This is probably why main indications for alarming HEMS is severe illness or trauma. Under-triage could have a very negative impact on patients' outcome. Therefore, an over-triage of HEMS is, within some limits, accepted to prevent delayed arrival and negative impact on patients' outcome (81). HEMS missions occurring at the same time, can be a potential problem if HEMS also is alarmed and used as a replacement of the on-call physician.

The crew must reject missions if they have exceeded upper limit of duty hours. These HEMS regulations help maintain flight safety (103). A potential consequence of lower threshold for HEMS use is that more missions could be declined despite of being medically warranted. Until now, the capacity of HEMS in Norway has not reached the upper limit of missions, and HEMS has a low rate of concurrencies (83). Prehospital resources are dispatched to site based on limited information combined with use of Index (8). When assume needed, HEMS is alarmed and dispatched in addition to ambulance and on-call physicians, not as a replacement. Different prehospital resources are often needed in severe emergencies. Our results in **Paper IV** shows how interaction between the resources in the rural OOH area, where 80 % of the HEMS mission also was attended by the on-call physician at site, with the patients. This overlap and cooperation between the services is seen as a strength of the prehospital system.

The high proportions of alerted on-call physicians, callouts, and telephone conferences between ambulance workers and on-call physicians in **Paper II** indicates good collaboration between the OOH and ground ambulance services, as intended by national regulations. In eight of ten cases, the treatment was ordinated by a physician either on site or by telephone, indicating cooperation between the different prehospital services in the treatment of most acute patients outside the hospital in the area of S&F.

Compared with our present findings, a Norwegian study from 2010 reported a lower overall rate of alerting the on-call physician (47%), noting that it was less common for the on-call physician to be alerted when the event was not life threatening (30). In recent years, there has been increased focus on physician attendance in the Norwegian prehospital system. However, we still found in **Paper II** that the on-call physician decided not to see the patient in 40% of the cases where the on-call physician was alerted, which could be explained by long travel distances between the patient and on-call physician. Regarding patients in Bergen in **Paper IV**, it is likely that the ambulance service treated and transported many patients that would have been handled by on-call physicians in the rural OOH district.

Acute medical missions with a physician on site can, after clinical examination and treatment, be solved by leaving the patient on site, treating the patient at the OOH casualty clinic or admitting the patient to hospital. In **Paper II**, the patients were most often admitted to a hospital, with only a few patients left on-scene or at the GP's office/casualty clinic. Assuming that hospitalisation indicates a need for advanced care, this supports the conclusion that the initial level of response at the EMCC was appropriate in most cases. Among patients attended by on-call physicians in the rural OOH district in **Paper IV**, 13.2% were left on site. Although the initial triage was potentially severe, the on-site on-call physician was able to make a clinical judgment without transporting the patient to the casualty clinic by ambulance. This can be a time-saving action and reduce the use of prehospital resources. Further results from **Paper IV** show a statistically significantly lower rate of hospitalised patients who were attended by an on-call physician in the rural OOH district, compared with those attended by HEMS in Bergen. This is probably because the on-call physician attended patients with all grades of severity, and also due to the effect of having the on-call physician on site. However, when we compare patients encountered in the rural OOH district, the hospitalisation rate was the same between those attended by HEMS compared to the on-call physician. Although the NACA scores were lower in the group attended by the on-call physician, equal proportions of the patients required admission to the hospital. Further research should explore to which extent an on-call

primary care physician can reduce hospital admissions. This is of great importance in planning the capacity of the hospitals. As an example, if we assume that the OOH-service normally completes treatment in 96% of their patients and admit 4% of them to hospital, a change into completing 95% of all patients and admitting 5% will increase the amount of acute admissions in hospital by 25% (58).

9.3 Political statements and future perspectives

The previous discussion has mainly focused on findings where on-call primary care physicians and HEMS can benefit the patients in terms of better outcome. However, both political statements and expectations from the citizens have relevance discussing the use of HEMS and OOH services in the future.

The principles of equality and LEON is confirmed in political declarations and white papers (NOU). Cooperation between the two levels of health care must be strengthened and is one of the important issues in "The Coordination Reform" from 2011 (99). In the NOU 2015;17 the report has described the situation in both the OOH service and HEMS and recommended several improvements. In 2020, a guideline for the OOH service was implemented, and in March 2021 a report from an expert group about the future organisation of HEMS was published (31). The new government in Norway stated in their political platform in October 2021 that the OOH-service will be strengthened and maximum travel time for the patients to the OOH-service should be investigated further. A new white paper about the prehospital services that include the OOH-service, response times and a professional standard for the ambulance service is planned (104). Further discussion regarding these recommendations and statements will be addressed below.

9.3.1 OOH service

NOU 2015;17 stated that the OOH service should be a central element in the acute medical system in the municipalities. Few callouts from the on-call physician in acute medical missions indicate that the service has become a service for patients with a low grade of urgency rather than serving those who need it most. This can lead to an OOH

service that is a weak link in the prehospital system. The Norwegian Board of Health Supervision has said: "There is a general expectation that the OOH service is central in the prehospital system. This does not seem to be considered in planning of the service in terms of capacity and competence" (58). The OOH service has an approximately 3-4 times higher rate of cases supervised by The Norwegian Board of Health Supervision compared to GPs, and system failure is an increasing reason for this, especially in intermunicipal services. In the NOU 2015;17 report they suggested that further details in the OOH service should be regulated or stated in guidelines from the Norwegian Directorate of Health. A national requirement that 90% of inhabitants should have a maximum travel time of 40 minutes to the casualty clinic, and 95% a maximum travel time of 60 minutes, was suggested as a new regulation. Regarding callouts it was recommended that on-call physicians to a larger extent should be involved in acute medical emergencies outside the casualty clinic, and that the municipalities/OOH-services together with the health trusts should establish quality indicators measuring the proportion of physicians involved in medical emergencies and initiate research on the effect of increased involvement. The results of this research should give knowledge that can establish national norms for the participation of on-call physicians.

The guideline for the OOH-service and LEMC was implemented in 2020 (55). Although it contributes to national standards, the guideline has areas where the recommendations in the NOU 2015;17 have not been followed up. There is still no regulation on maximum travel time to the casualty clinics for the inhabitants. It is emphasised that the OOH service should be organised with possibility to callout and have highlighted the possible benefit of a physician on site. However, the reality is that many large intermunicipal OOH-districts are not capable of responding with callouts to patients with long travel distances to the casualty clinic. The National Centre for Emergency Primary Health Care has suggested compensating solutions in areas with long distances (105). Until now, the guidelines are not recommending such alternatives, but risk and vulnerability analysis should be performed to examine if the capacity in the OOH-service is adequate.

Over several years it has been difficult to recruit and stabilise physicians working as GPs in Norway. The situation now is described as an ongoing crisis. As a majority of the physicians in the OOH service are GPs, an undoubted fact is that this crisis also affects the stability and quality of the OOH service. The Norwegian Medical Association is arguing that duties in the OOH-services should be an integrated part of the total workload for the GPs, not placed on top of an already full-time job. More physicians on duty at the same time can contribute to more callouts and a more robust OOH-service. As long as the recruitment of a new GP is challenging it will also be problematic to increase the numbers of physicians in the OOH-service. The majority of patients in the OOH-service have symptoms and medical issues that are within the competence of GPs; GPs are thus considered most suitable for having on-call duty in primary emergency care.

The principle of equal access to health services regardless of residence is not fulfilled in the OOH service. This can threaten the principle of using the lowest effective level of care. Although we did not find an increased use of HEMS in S&F, the same worries about using HEMS to compensate for the lack of on-call primary care physicians is repeated in the report regarding the future structure of HEMS (31). In contrast, using ground ambulances without involving the OOH-service could also have negative consequences related to the LEON-principle. A research project on GPs' response to red response alarms has commenced and is investigating how factors related to the patient, time of incident, distance and geography is associated with the GPs decision regarding callouts (106).

9.3.2 HEMS

In 2018, there was a shift in the organisation of the air ambulance service in Norway. All helicopters are now operated by the Norwegian Air Ambulance, while Babcock operates the fixed wing airplanes (107). During spring 2018 this reorganisation led to a situation where the preparedness of the fixed wing airplane service was challenging. An expert group was established to give advice about the future structure of the air ambulance service. The report was published in March 2021.

The report confirmed that national guidelines advise the use of air ambulance when this is anticipated to improve health outcomes compared to the use of a ground ambulance. However, the benefits should be related to the geographical area the service is covering, and both the expert group and the NOU 2015;17 have recommended that national guidelines should be concretised to the specific region. Further, the report describes that the air ambulance service has developed from a service serving only acute medical missions towards a more complex service, where the service is important to fulfil the principle of equal access to health services for all inhabitants. This is also confirmed in the "National health- and hospital plan 2020-2023", which stated that: "The air ambulance service is important for achieving health policy goals, and the organization of the service must support the overall objectives".

The use of specialised health care is regulated by law (3), and three criteria are used in prioritising use of the resources: benefits for the patient, the cost in use of resources and severity of the condition. The total cost of the air ambulance service in Norway in 2020 was 1.510 million NOK (31). The NOU 2015;17 concluded that "even if air ambulances have a high cost, it can be a profitable social investment". Due to the challenging geographical conditions in Norway, we have a high density of HEMS bases. The extra cost of using HEMS on missions with lower severity is not very large since the personnel are on standby 24/7. However, the number of concurrencies could increase. The safety of the personnel in HEMS is also important to consider. There have been several accidents in the Norwegian HEMS with fatal consequences for the personnel.

It is a political goal that HEMS contribute to equality in access to health services in the future. If this has a consequence of lowering the threshold for use of HEMS, the principle of using lowest effective level of care could be threatened. The collaboration reform has emphasised that generalist competence, which GPs have, is central to treat patients with multimorbidity and avoid unnecessary diagnostic and treatment in specialised health care. Therefore, research that can result in more precise dispatch criteria for HEMS is highly relevant.

9.3.3 Communication to the inhabitants and decisionmakers

Inhabitants that experience an acute medical situation are less concerned about how the prehospital system is organised. The important issue is to get adequate help within a short time. Searches in newspapers reveal that there are many patient stories indicating that the lack of HEMS, ground ambulances or the OOH-service had a negative outcome for the patient. Decisionmakers in the municipalities are worried about centralisation of ambulance stations, while many of the same municipalities have reorganised their own OOH service with long travel distances. Local hospitals claim their further existence and argue that HEMS is not 100% reliable due to weather conditions. These are important discussions and should be met with updated knowledge, where available. If the knowledge is uncertain, this is also important to address. The inhabitants can deal with such uncertainty and should encourage researchers to further research. It is important that the inhabitants experience safety, meaning that they can rely on the whole prehospital system rather than only one service. One study from the northern part of Norway found that the patients were considering the options of transport when they decided whether to contact the health services (108). Another study from the same area found that HEMS was unavailable in a majority of the winter months (109). If the inhabitants have an impression that HEMS is highly needed in many situations, this can lead to adverse effects such as fear of not receiving adequate help in periods where HEMS is unavailable. Our findings in this thesis indicate that our system is capable of serving the inhabitants in acute medical situations with high quality, and that the flexible and robust system might be one reason that few patients lost life years.

10. Future research

In order to identify unintended consequences of changes in the prehospital services, organisational changes should be evaluated more often with suitable methods. Changes in the use of ground ambulances should be evaluated in more detail.

Further studies are essential to offering recommendations on the capacity of OOH services and organisational matters. The research should investigate which patients benefit from attendance by an on-call primary care physician, and how dispatch criteria can be more accurate.

The threshold for HEMS use seems to be independent of the availability of on-call primary care physicians, and we found no reasons to recommend a change in the current policy for accepting missions in HEMS. However, political goals and a change in guidelines should be evaluated in order to discover if they have the intended or adverse effect. More precise dispatch criteria for requesting HEMS is recommended.

Digital platforms and tools for extracting data are lacking in many of the services, or they are not easily transformed into variables that can be compared. It is especially a problem in the OOH services, which is fragmented and has several journal systems. Templates and quality indicators are needed and should be validated before implementation.

11. Conclusions

The main conclusion in this thesis is that the prehospital emergency system in Norway is capable of solving medical emergencies in most cases with a good outcome for the patients. The system is robust and flexible, and few patients losing life year due to an unavailable HEMS. A high degree of overlapping HEMS-bases, decentralised ground ambulances and a high involvement of on-call primary care physicians are possible reasons for the minor loss of life years when HEMS is unavailable, while lack of rapid HEMS transport was the primary cause of the estimated loss of life years.

The majority of patients were examined by an on-call primary care physician or cared for by ambulance workers who conferred with a physician when HEMS was unavailable. Few patients received advanced treatment in the absence of HEMS and treatment was not different if the on-call physician was involved.

The worries about increased use of HEMS due to reorganisation into larger inter-municipal OOH district was not confirmed in this thesis. The threshold for HEMS use seems to be independent of the organisational changes in the OOH-services regarding longer distances between the patients and the on-call primary care physician. Moreover, HEMS usage did not differ between the compared areas with different availability of callouts from the OOH-service.

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SCANDINAVIAN JOURNAL OF PRIMARY HEALTH CARE
https://doi.org/10.1080/02813432.2019.1608056

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RESEARCH ARTICLE

Loss of life years due to unavailable helicopter emergency medical service: a single base study from a rural area of Norway

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ABSTRACT

Background: Despite the potential benefits of physician-staffed Helicopter Emergency Medical Service (HEMS), many dispatches to primary HEMS missions in Norway are cancelled before patient encounter. Information is sparse regarding the health consequences when medically indicated HEMS missions are cancelled and the patients are treated by a GP and ambulance staff only. We aimed to estimate the potential loss of life years for patients in these situations.

Method: We included all HEMS requests in the period 2010–2013 from Sogn and Fjordane County that were medically indicated but subsequently cancelled. This provided a selection of patients, with the purpose of studying cancellations independently of the patient's medical status A multidisciplinary expert panel retrospectively assessed each patient's potential loss of life years due to the lack of helicopter transport and intervention by a HEMS physician.

Results: The study included 184 patients from 176 missions. Because of unavailable HEMS, seven patients (4%) were anticipated to have lost a total of 18 life years. Three patients suffered from myocardial infarction, three from stroke and one from abdominal haemorrhage. The main contribution from HEMS care in these seven cases might have been rapid transport to definitive care. The probability of a patient losing life years when in need of HEMS evacuation was found to be 0.2%.

Conclusion: During the four years period seven patients lost 18 life years. Lack of rapid transport seems to be the primary cause of lost life years in this specific geographical area.

KEY POINTS

- Knowledge about to what extent HEMS contributes to an increased survival and a better outcome for patients is limited.
- Compared to similar studies on life years gained the estimated loss of life years was minor when HEMS evacuation was unavailable in this rural area.
- The findings indicates that lack of rapid HEMS transport was the primary cause of the estimated loss of life years.

ARTICLE HISTORY
Received 19 June 2018
Accepted 30 December 2018

KEYWORDS
Emergency medicine system; Primary health care; Air ambulance; rural area

Introduction

The challenges of providing emergency missions in rural areas are well known in both Norway and other countries [1–4]. Long distances and small hospitals with limited resources increase the need for Helicopter Emergency Medical Services (HEMS), but inclement weather conditions reduce HEMS' availability. To what extent HEMS contributes to an increased survival and

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The challenges of providing emergency missions in rural areas are well known in both Norway and other countries.

a better outcome for patients has been discussioned. The advantages of HEMS for trauma patients have been described in several studies [1,5–8]. However, a Cochrane review on the use of HEMS in adult trauma patients concluded that it is still unclear which elements provided by HEMS are beneficial for the patients [9]. Two studies from Norway have concluded that life years were gained [10,11]. Observational study designs are most common, which limits the validity and generalization of the study results. Randomization to mode of transportation in emergency cases has both ethical and practical concerns.

In Norway, the general practitioner (GP) on-call is an important contributor in emergency medicine, together with the ambulance service [12–13]. HEMS is an integrated part of the emergency medical system and is to be used for cases of illness or injuries that require rapid transport, clinical assessment, or advanced treatment.

Sogn and Fjordane county (SF county) is a rural part of Western Norway. Of all HEMS requests in 2014, 40% were cancelled. Figures from the National Air Ambulance Service showed that the most common cause for not completing a mission was stated as "no longer medical indication" (30%), followed by "bad weather conditions" (6%). Technical problems, exceeded duty time for the crewmembers, or concurrent missions were less frequent (4%) [14].

The health consequences of unavailable HEMS, in cases where advanced life support or rapid transport is deemed necessary, are unknown. This is relevant when discussions regarding centralization of ambulances and GPs out-of-hour service in the county. The aim of our study was to estimate the potential loss of life years when medically indicated missions were cancelled.

Methods

Setting and data sources

SF county consists of 26 sparsely populated municipalities with a total of 108,000 inhabitants. It spans 200 kilometres west to east and 130 kilometres south to north. The challenging geography with mountains, fjords, islands, and poor roads quality increases response time for ground ambulances. Especially during winter, weather conditions with reduced visibility are common. There are 15 out-of-hours emergency services in the area, each with one general practitioner (GP) on call. A total of 21 ground ambulance stations are localized throughout the county.

There are three hospitals in the county; Førde, Nordfjordeid and Lærdal (Figure 1). The latter two provide services for medical emergencies only. However, there is always an anaesthesiologist on call in all hospitals. The main hospital in Førde has emergency services for most common medical and surgical/(incl. trauma) conditions. Patients with major trauma, severe burns, a need of percutaneous coronary intervention (PCI), or with other severe medical conditions are transported after emergency treatment (or directly from scene) to Haukeland University Hospital in Bergen. Transport time by ground ambulance from Nordfjordeid and Lærdal to Førde is 90 and 120 minutes, respectively. From Lærdal and Førde to Bergen, 150 and 130 minutes, respectively. A ferry crossing is necessary for all routes, except from Lærdal to Bergen. The Emergency Medical Dispatch Centre (EMCC) is located at Førde.

One HEMS is located in Førde. The team consists of a pilot, an anaesthesiologist, and a rescue paramedic. It covers most of the county within a 20 minute one-way flight time. HEMS in neighbouring counties also perform missions in SF county when needed. Additionally, the military operates an anaesthesiologist-staffed Search and Rescue (SAR) helicopter located in Florø, which also responds to emergency medical missions, if needed. All HEMS bases in Norway have a rapid response car available. If weather conditions restrict flight, it is an option to transport the anaesthesiologist to the patient by car.

HEMS requests are registered in the AirDoc activity registration database, which was used for identification and inclusion of missions, and to identify the patients in the Acute Medical Information System (AMIS), in which all alarm calls to EMCC are registered. AMIS contains patient information and administrative response data (including date, time of dispatch of prehospital resources, responding unit, response time, and where the patient was transported).

All HEMS requests in SF county for the years 2010–2013 were identified. SAR data were available from 2012. Both primary missions (on-scene missions) and secondary missions (inter-hospital transports) were included.

Due to cancellation of HEMS the included patients were transported to hospital by ground ambulance. Ambulance personnel and GPs on call provided treatment. Subsequently the physicians at local hospitals also treated the patients. Patient records from GPs, ground ambulances and the hospitals were collected and made available for assessment. Symptom categories were based on the clinical information available during HEMS dispatch.

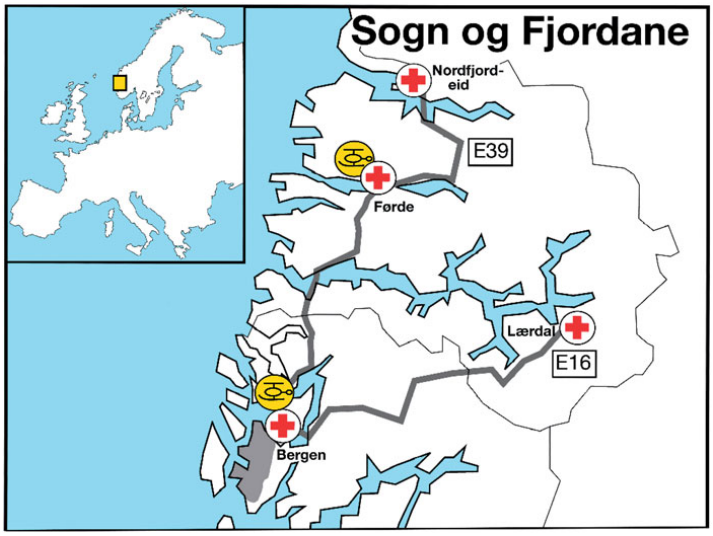

Figure 1. Map of the geographical area with hospitals, roads and HEMS bases. Link to map of HEMS bases in Norway with 30 minutes flying time circles. http://www.luftambulanse.no/sites/default/files/LAT-kart-2015.pdf

Case definition and study design

A cancellation was defined as either a declined mission before helicopter take-off or an aborted mission after take-off. Only medically-indicated missions that were subsequently cancelled due to non-medical reasons were included. Missions performed with a rapid response car were also excluded. This provided a selection of patients with the purpose of studying cancellations independently of the patient's medical status. This observational study was thus designed to include a case mix not biased by patient-related clinical information as a reason for cancellation.

Case assessments

Written case reports were prepared for each of the included patients by one of the authors (DSN), based on medical records from the prehospital services and discharge summary from hospitals, including symptoms, clinical signs, other known diseases (comorbidity), preliminary International Classification of Primary Care (ICPC-2) and International Classification of Diseases (ICD10) at discharge from hospital. Data on medical interventions, time intervals, approximate transportation time to desired hospital if the HEMS had arrived, and hospital stay were recorded and assessed. Direct flight track times were calculated based on information from the National Air Ambulance Services, and the approximate transportation time from the location to the relevant hospital was calculated. The remaining life expectancy based on Norwegian life expectancy tables was found (Statistics Norway) for each patient [15].

An anaesthesiologist from a different HEMS unit then assessed the case reports. Alternative treatment(s) was described in addition to the potential destination hospital if an HEMS evacuation had taken place.

Loss of life years estimations

A multidisciplinary expert panel assessed the patients' potential loss of life years (nominal group process) exclusively due to the lack of helicopter transport and potential interventions by an anaesthesiologist [16]. The panel consisted of an anaesthesiologist (GB), a cardiologist (ES), a general practitioner (AA), a neurologist (JMH), an obstetrician (KH) and a surgeon (VSE). Due to broad experience in emergency medicine both pre- and in-hospital, three of the members (GB, ES, AA) received all the case reports, while the others (JMH, KH, VSE) received reports within their specific area of expertise. Loss of life years was estimated using the following algorithm:

1. The experts individually divided the cases into two groups, one with no anticipated loss of life years, the other with a potential loss of life years. Cases selected to the group "no anticipated loss

of life years" by all the experts, were not further assessed.

2. Then, all experts assessed the case reports from the group of patients with potential loss of life years. Comorbidity at the time of incident, as well as the actual incident were used for adjusting expected remaining life years by the experts' best estimates, and in accordance with literature [17–19]. For each patient, loss of life years was calculated as the difference between expected remaining life years after actual evacuation and the experts' estimate of remaining life years if a HEMS evacuation had been available. The expert group assessed the following factors: transport mode, treatment performed, confirmed diagnosis at hospital discharge, and patient outcome. An example of potential life years lost could be a case of myocardial infarction with ST-segment elevation in ECG. This condition can be treated with thrombolysis or PCI, but unavailable helicopter transport increased the actual transport time to a hospital with PCI capability to more than 90 minutes.
3. The estimates and the experts' arguments were presented at an expert group meeting. All steps from the individual assessment described above, were discussed thoroughly within the group with consensus on estimated loss of life years as a goal. In the event of disagreement, the mean of the various experts estimates of life years lost were used in the analysis.

Statistical analysis and ethical approvals

Standard descriptive data analyses were performed. Age and expected remaining life years were presented as the median and interquartile range (IQR). Pearson Chi-Square tests were used to analyse differences between the two groups "possible life years lost" and "no life years lost". A p-value of 0.05 or below was considered statistically significant. Data were entered and analysed using SPSS Statistics Version 22 (IBM Corp., Armonk, NY, USA). The probability of not getting medically indicated HEMS evacuation was calculated as the total number of declined and aborted missions divided by the total number of missions during the study period. Probability of loss of life years was calculated as number of patients with loss of life years divided by total number of patients.

The study was approved by the Regional Committee for Medical and Health Research Ethics (2013/373 REC West, Norway). All patient data were anonymized before assessment by the expert panel.

Results

Missions and patients

During the study period, the total number of completed missions was 2,582 for HEMS Førde and SAR Florø combined. There were 627 cancelled missions (24%; Figure 2). However, the majority of these missions (72%) were excluded; 33% were completed by another HEMS, 20% were cancelled due to "no longer medical indication", and 19% were excluded due to duplicates. The 176 remaining cancelled missions involved 184 patients. The probability of not getting a medically indicated HEMS evacuation in SF County during the study period was thus 5.9%.

The median age of the 184 patients was 59 years (IQR 31-72), and 61% were male. Median remaining expected life years was 25 years (IQR 15-52). Cardiac and neurologic diseases were the two most frequent medical conditions (35% and 20%, respectively), while trauma patients constituted 14%. The proportion of patients with cardiology conditions was higher in the group of "possible life years lost", compared to the group "no life years lost". For trauma patients, the opposite was found (Table 1).

Loss of life years

During the first selection stage, 52 (28%) of the 184 patients were identified with a potential loss of life years. The expert panel finally concluded that 7 of these (4%) had most likely lost a total of 18 life years (Table 2). Consensus on estimated loss of life years was achieved in all patients. The probability of a patient losing life years when in need of HEMS evacuation was found to be 0.2%. Three of the seven patients were transported from local hospitals to a higher level of care. Two patients were found to have gained life years (Table 2).

Median age for the seven patients with loss of life years and for the two patients with life years gained was 69 years (IQR 58-77), and median adjusted life expectancy was 10 years (IQR 4-11). Colorectal cancer, prostate cancer, atrial fibrillation, stroke, depression, hypercholesterolaemia, COPD, and a history of smoking were the main causes of reduced life expectancy. The total remaining life years for the seven patients with loss of life years was estimated to 158 years before adjustments, and 83 years when adjusted for comorbidity.

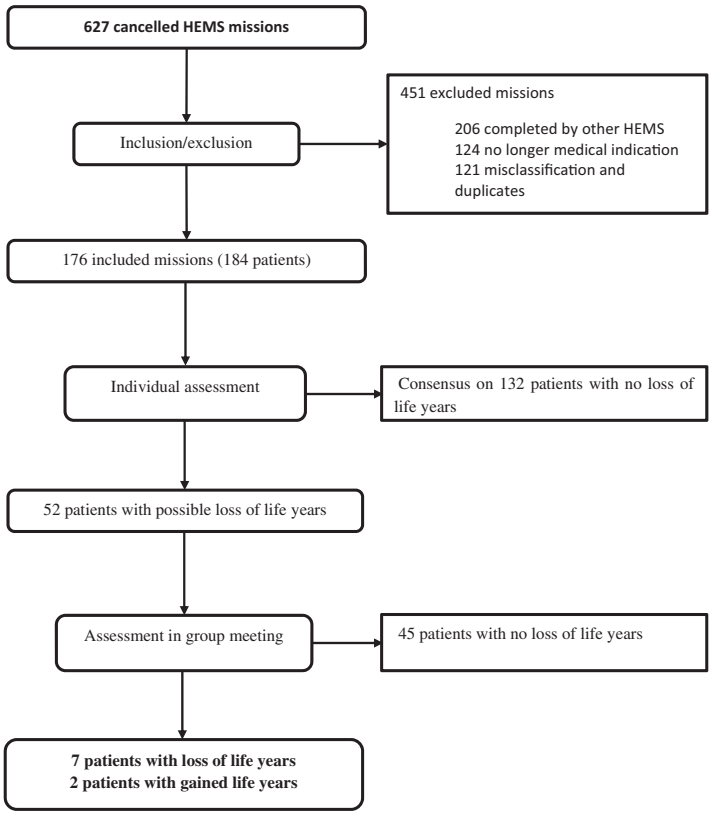

Figure 2. Flowchart showing included missions and patients.

In most cases, lack of rapid transport to the hospital in Bergen was considered to be the main cause of loss of life years, rather than lack of advanced treatment. One patient who died may have been saved at the hospital in Førde, but arrived too late. Five other patients died, at site of cardiac arrest. Ambulance crew and GPs on call started and terminated CPR at site.

Discussion

The expert panel concluded that loss of life years due to unavailable HEMS evacuation was minor in this specific rural area of Norway. A large part of missions that were cancelled by Førde HEMS due to weather conditions or other non-medical reasons was handled by neighbouring HEMS units. Hence, the probability of a patient experiencing a lack of HEMS, and then subsequently experiencing a loss of life years was very low. This is one of the positive effects of the high density of HEMS bases in Western Norway [20] and active GPs together with the ground ambulance service.

Strengths and limitations

Our study has important strengths; all relevant mission and patient data were available and retrieved; the expert panel consisted of persons with no affiliations to HEMS Førde or the health authorities in SF county; the panel reached a consensus in all cases; and the method (a nominal group process) has been used in similar studies [10,11,15,21,22].

An expert panel consisting of six different persons will not conclude with exactly the same estimates. Nonetheless, the reliability of the method is acknowledged [21]. All cases are from a single rural HEMS base. The prehospital emergency system in Norway is well developed, and GPs on call and local hospitals are capable of giving advanced treatment, like thrombolysis. This may reduce the external validity of

Table 1. Demographic data on included patients. In the first assessment the patients ($n = 184$) were divided by the experts between the groups "possible life years lost" and "no life years lost"; gender, mission type, patient's location and type of patient when HEMS was alerted.

	Possible life years lost[a] ($N = 52$)		No life years lost ($N = 132$)		
Variables	*n*	(%)	*n*	(%)	*P* value
Gender					0.83
Female	21	(40)	51	(39)	
Type of mission					0.87
Primary mission	34	(65)	88	(67)	
Location					0.52
Home	23	(44)	54	(41)	
Primary health care	4	(8)	11	(8)	
Public place	8	(16)	24	(18)	
Hospital	17	(32)	43	(33)	
Type of patient					0.01
Cardiology	27	(52)	38	(29)	
Neurology	14	(26)	22	(17)	
Trauma	3	(6)	24	(18)	
Infection	3	(6)	10	(8)	
Surgery	3	(6)	7	(5)	
Obstetrics	1	(2)	11	(8)	
Other	1	(2)	10	(8)	
Breathing difficulties	0		7	(5)	
Intoxication	0		3	(2)	

Pearson Chi-Square tests were used to analyse for statistically significant differences between the groups.
[a]Possible life years lost after first round of classification.

the findings to services in other countries and the presented results must be interpreted with caution.

Weather or other non-medical reasons were anticipated to be the main reason for declined or aborted HEMS missions, unrelated to the patient's clinical condition. When assessing the distribution of diagnoses we found that trauma patients constituted 14% in our study, in contrast to approximately 30% for HEMS missions on the west coast and for Norway as a whole [15,23]. In addition, both cerebral infarction and myocardial infarction were the main problem among the patients that lost life years. This may indicate a lower response threshold for the HEMS crew in trauma missions. The decision to undertake a flight in bad weather is the pilot's decision, but may be influenced by the patient's condition and the total experience of the crew.

Measure of loss or gained life years can be interpreted as a narrow measure of HEMS utility. Other utility measures could e.g. be sequelae after stroke, quality of life score among stroke patients and length of hospitalisation.

Our chosen method may have led to a selection bias. That such a large share of missions was handled

Table 2. Patients with an estimated loss of life years, main emergency medical condition, reasons for estimated loss of life years and mission type for 9 missions.

Estimated loss of life years	Main emergency medical condition (ICD-10)	Reason for loss of life years	Mission type
9.5	Abdominal haemorrhage (I72.8)	Survived to hospital admission (Førde) from local hospital, delayed by 1h 40 min than if transported by helicopter. Surgical procedures were available, but the patient suffered circulatory collapse and died of haemorrhage in the ER at Førde hospital. Autopsy demonstrated a ruptured, dissecting aneurysm in a. mesenterica sup.	Secondary
5.0	Cerebral infarction (I63.3)	Delayed start of thrombolytic treatment. Sequelae; hemiparesis, aphasia and apraxia.	Primary
2.0	Cerebral haemorrhage (I61.8)	The patient did not reach PCI centre and suffered a cerebral haemorrhage as side effect of thrombolytic treatment. Sequelae (after evacuation of hematoma): hemiparesis.	Secondary
1.0	Cerebral infarction (I63.9)	Delayed start of thrombolytic treatment and lack of facilities for thrombectomy. Sequelae: hemiparesis, facial paralysis.	Primary
0.3	Myocardial infarction (I21.4)	The patient arrived at local hospital 2 hours after estimated air transport arrival to PCI centre, too late for thrombolytic treatment. He received conservative treatment only. If transported to HUS, revascularization within 3-4 hours after debut of symptoms would have been possible, reducing infarction size and improving life expectancy. Sequelae: major damage apically with akinesia and thin-walled myocardium.	Primary
0.2	Myocardial infarction (I21.1)	Revascularization delayed by 1h 30m. Earlier treatment would have reduced the infarction size, and the transport delay influenced life expectancy. Sequelae: concentric hypertrophy and anterolateral hypokinesia.	Primary
0.2	Myocardial infarction (I21.0)	The time from debut of symptoms was >6 h at arrival, with ST elevations still present. There was still indication for acute PCI, but not for thrombolytic treatment. The abortion of air transport resulted in conservative treatment; revascularization was performed 6 days later. An acute PCI could have decreased infarction size and improved life expectancy. Sequelae: anterolateral hypokinesia	Secondary
−0.1 **−0.2**	Myocardial infarction (I21.0)	Both patients with gained life years received thrombolytic treatment with documented good clinical outcome (pain relief, normalization of ECG and flow in the actual artery at the following coronary angiography) within a shorter time than possibly obtained by revascularization after helicopter transport to the PCI centre.	Primary

All patients were adults (47–80 years).
ICD-10 is an international classification of diseases retrieved from hospital records of the patients. Mission type; Primary mission is response to a patient outside hospital and secondary mission is inter-hospital transport.

by neighbouring HEMS units was unexpected, and resulted in a much smaller number of included missions than our preliminary calculations. There were no children or young adults with estimated loss of life years in this study. In studies where life years gained are estimated, children have a major impact on the results [10,11]. Missions using the rapid response car for transport to patients were also excluded. Hence, some seriously ill or injured patients may not have been included due to treatment by crew from a neighbouring HEMS unit and/or the use of rapid response car. This increases the uncertainty of the calculated loss of life years, as one or a few patients could have a major impact on the results. This was confirmed by the fact that one patient in our material represented more than half of the total loss of life years. If this patient was an outlier, the mean loss from the rest of the patients was barely clinically significant.

Comparison with previous studies

The expert panel concluded loss of life years for 4% of the patients. One Norwegian study found that life years were gained by 7% of the patients attended by HEMS, with an average of 6.8 years per patient [11]. Another study from Norway concluded that 89% of the patients transported by a physician-staffed HEMS would have done just as well in a ground ambulance without a physician [10]. A new publication showed no differences in survival to discharge between patients taken care of by HEMS, compared to the group of patients not taken care of by HEMS due to concurrencies [24]. This indicates a low threshold for using HEMS (possible overtriage), if lifesaving treatment is the main goal of HEMS. Delgado et al. have also discussed presence of overtriage in a cost-benefit context of helicopter use; less transport of minor injuries will improve cost-effectiveness [25]. In 2011, HEMS Førde had a three times higher rate of missions per inhabitant compared to the other HEMS bases in Norway [17]. Thus, overtriage may be an important contributing factor explaining the low proportion of patients with life years lost in our study. There is a lack of a national HEMS dispatch criteria, which could reduce overtriage. However, undertriage could have a very negative impact on patients' outcome. We have to accept some degree of overtriage to avoid undertriage. Still, an important strength of HEMS in Norway is its flexibility. HEMS crew decision to accept a mission is based on several aspects like condition of the patient and patient's distances to ambulance, GP and hospital.

Local GPs and ambulance personnel provide important treatments [26]. In such conditions, rapid transport might have been the main advantage of HEMS rather than advanced interventions. Contrary, in the case of abdominal haemorrhage, treatment with available blood products (erythrocytes and plasma) was started at the local hospital.

The experts concluded that two patients experienced a health benefit due to the lack of HEMS. These patients would have been transported to acute coronary intervention if HEMS was available. In both cases the patients received thrombolytic treatment with a documented good clinical outcome (pain relief, normalization of ECG and flow in the actual artery at the following coronary angiography) within a shorter time than potentially achieved by revascularization after helicopter transport to PCI centre. Reducing the myocardial ischaemia time period most probably reduced the infarction size and improved the life expectancy in these patients [27].

For the seven patients with loss of life years, the HEMS physician chose not to use the rapid response car. Hence, unavailable rapid transport to advanced treatment in hospitals seems to be the main factor for loss of life years. Another study on the same patients indicated that in cases when HEMS units were not available, ambulance personnel, GPs and physicians at local hospitals provided appropriate emergency procedures and treatments [26]. A study based on data from Hotvedt et al. 1996, concluded that Norwegian GPs could provide adequate treatment to more than half of the patients treated by an HEMS doctor [28]. Another study on HEMS patients from the northern part of Norway concluded that GPs often started important medical treatment, if needed, before HEMS arrival [29].

Conclusion

During the four years period seven patients lost 18 life years. The findings indicates that lack of rapid HEMS transport was the primary cause of the estimated loss of life years.

Ethics approval

The study was approved by the Regional Committee for Medical and Health Research Ethics (2013/373 REC West, Norway). All patient data were anonymized before assessment by the expert panel.

Consent for publication

The Regional Committee for Medical and Health Research Ethics found that the legal requirements were fulfilled in the project and approve that patient information could be collected, anonymized and published without the consent from the patients.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Partial grant was provided by the Regional Health Trust West [NOK 400 000]. National Centre for Emergency Primary Health Care was responsible for administration and additional founding of the study.

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SCANDINAVIAN JOURNAL OF PRIMARY HEALTH CARE
https://doi.org/10.1080/02813432.2018.1523992

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RESEARCH ARTICLE

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Treatment, transport, and primary care involvement when helicopter emergency medical services are inaccessible: a retrospective study

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ABSTRACT

Objective: To examine handling of cancelled helicopter emergency medical services (HEMS) missions with a persisting medical indication.
Design: Retrospective observational study.
Setting and subjects: Cancelled HEMS missions with persisting medical indication within Sogn og Fjordane county in Norway during the period of 2010–2013. Both primary and secondary missions were included.
Main outcome measures: Primary care involvement, treatment and cooperation within the pre-hospital system.
Results: Our analysis included 172 missions with 180 patients. Two-thirds of the patients (118/180) were from primary missions. In 95% (112/118) of primary missions, GPs were alerted, and they examined 62% (70/112) of these patients. Among the patients examined by a GP, 30% (21/70) were accompanied by a GP during transport to hospital. GP involvement did not differ according to time of day ($p = 0.601$), diagnostic group ($p = 0.309$), or patient's age ($p = 0.409$). In 41% of primary missions, the patients received no treatment or oxygen only during transport. Among the secondary missions, 10% (6/62) of patients were intubated or received non-invasive ventilation and were accompanied by a physician or nurse anaesthetist during transport.
Conclusions: Ambulance workers and GPs have an important role when HEMS is unavailable. Our findings indicated good collaboration among the prehospital personnel. Many of the patients were provided minimal or no treatment, and treatment did not differ according to GP involvement.

KEY POINTS

- Knowledge about handling and involvement of prehospital services in cancelled helicopter emergency medical services (HEMS) missions are scarce.
- Ambulance workers and general practitioners have an important role when HEMS is unavailable
- Minimal or no treatment was given to a large amount of the patients, regardless of which health personnel who encountered the patient.

ARTICLE HISTORY
Received 27 April 2018
Accepted 5 September 2018

KEYWORDS
Emergency medical services; primary health care; air ambulances; Norway; HEMS; general practitioners

Introduction

On-call general practitioners (GPs) and the ambulance service constitute the backbone of the pre-hospital emergency medical service (EMS) in Norway. GPs regularly complete re-training in emergency medicine. Ambulance workers complete at least two years of upper secondary school and two years as an apprentice [1]. Every municipality in Norway is obligated to have a doctor on call around the clock, who can potentially call out immediately in emergencies [2]. Many OOH services are inter-municipal co-operations. GPs and the ambulance service handle the majority of medical emergencies without requiring helicopter emergency medical services (HEMS). Involvement of GPs in emergency patients differs between European countries, i.e. Denmark where GPs perform telephone

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triage and anaesthesiologists encounter patients outside hospital [3–5].

HEMS have been an integrated part of the Norwegian EMS since 1988. The main indication for HEMS is severe disease or trauma requiring rapid transport and/or advanced triage, treatment, and supervision. National guidelines advise the use of HEMS when this is anticipated to improve health outcome compared to the use of ground ambulance [6]. Norway has 13 helicopters and 6 search-and rescue (SAR) helicopters staffed with anaesthesiologists. The goal of being able to reach 90% of the population within 45 minutes is achieved on a national level, but with some differences between the HEMS bases [7].

To ensure equal access to public health services regardless of residence, the EMS must be sustainable in all areas and seasons, even under challenging weather conditions. Over the last decade, ambulances and OOH services have been centralized such that they now cover larger geographical areas, resulting in longer response times [8,9]. In this context, HEMS may serve to compensate for potentially unequal access to emergency medical care. However, the advantages of HEMS are controversial, with previous studies showing inconsistent results regarding the benefits for patients [10–18]. A Cochrane review concluded that it is unclear which elements provided by HEMS benefit the patients [19].

In 2014, 38% of all HEMS requests in Norway were cancelled. The main reason for cancellation was that there was no longer a medical indication (20%). Other reasons for cancellation included weather conditions (9%), concurrency conflicts (5%) and other (4%) [20]. Scarce data are available regarding the alternatively handling of patients for HEMS missions that are cancelled despite persisting medical indication. Such knowledge is important for the development of an optimally organized EMS.

In the present study, we investigated HEMS missions that were cancelled for non-medical reasons, with the aims of determining the extent of primary care involvement, the treatment provided, and the cooperation between the prehospital services.

Methods

Design and study setting

We designed a retrospective observational study to investigate the aims. The study area was the county of Sogn og Fjordane (S&F), located in the western part of Norway and has a challenging topography with fjords, islands, and high mountains. The total area is 18,623 km^2 and the county is sparsely populated with a total of 109,000 inhabitants (2013). Rough weather conditions present a challenge for HEMS and ground ambulances. The county has three hospitals. One is located in Førde, and admits patients with emergency internal medical and surgical needs. The other two are located in Nordfjordeid and Laerdal, and each treats emergency internal medical conditions and has an on-call anaesthesiologist. Patients suffering major trauma and/or severe head injury, and patients requiring PCI or thrombectomy are transported to Haukeland University Hospital in Bergen. One HEMS base is located in Førde, and one SAR helicopter is located in Florø, which is approximately 45 minutes by road from Førde. Four other HEMS bases are located in the neighbouring counties, and can be alerted when HEMS Førde is unavailable. These helicopters can also reach a majority of the population of S&F county within 45 minutes.

At the time of this study, S&F county had 21 ground ambulance stations and 15 OOH services. Within the largest OOH service area, it can take up to two hours of driving time for the on-call GP to reach a patient. Ground ambulances have often shorter driving time to the patients, compared to the on-call GP, and ambulance workers can in some situations perform protocol-based treatment, such as administration of morphine, oxygen, nitroglycerine, and acetylsalicylic acid (MONA), without physician involvement.

At all Emergency Medical Commination Centers (EMCC) in Norway, operators with emergency care experience use the Norwegian Index for Emergency Assistance (Index) as dispatch guidelines for determining mission urgency and the appropriate level of response [21,22]. The Index is a symptom-based criteria system that includes three response levels: acute, urgent and non-urgent. Based on the information provided and the Index criterion, the operator determines whether HEMS should be dispatched. Subsequently, the HEMS anaesthesiologist evaluates whether there is a medical indication for HEMS, and the pilot decides if the weather conditions are acceptable.

Materials

For this study, we evaluated emergency missions in S&F county for which HEMS were requested, during the period from January 1, 2010 to December 31, 2013. Our analyses included all events where HEMS had to cancel the mission for non-medical reasons, including weather conditions, technical reasons,

Table 1. Demographic and mission data from 180 cases for which HEMS was unavailable. Stratification by primary and secondary missions[a].

	All patients		Patients from primary mission		Patients from secondary mission	
	$N = 180$		$N = 118$		$N = 62$	
Gender	*N*	(%)	*N*	(%)	*N*	(%)
Female	71	(39)	47	(40)	24	(39)
Median age	Years	IQR	Years	IQR	Years	IQR
Male	56	32–72	54	38–71	62	21–73
Female	61	30–72	64	31–73	58	16–67
Total	59	31–72	57	36–72	60	20–71
Diagnostic group	*N*	(%)	*N*	(%)	*N*	(%)
Cardiology	63	(35)	46	(39)	17	(27)
Neurology	34	(19)	28	(24)	6	(10)
Surgery	10	(6)	2	(2)	8	(13)
Infection	13	(7)	3	(3)	10	(16)
Breathing difficulties	7	(4)	6	(5)	1	(1)
Obstetric	12	(7)	2	(2)	10	(16)
Intoxication	3	(1)	2	(2)	1	(1)
Trauma	27	(15)	23	(19)	4	(7)
Other	11	(6)	6	(5)	5	(8)
Site/Scene	*N*	(%)	*N*	(%)	*N*	(%)
Home dwelling	76	(42)	76	(64)	0	(0)
Public area	29	(16)	29	(25)	0	(0)
Casualty clinic/Nursing home	11	(6)	11	(9)	0	(0)
Local hospital	35	(19)	0	(0)	35	(57)
County hospital	27	(15)	0	(0)	27	(43)
Other	2	(1)	2	(2)	0	(0)
Destination	*N*	(%)	*N*	(%)	*N*	(%)
Discharged on-scene	3	(2)	3	(3)	0	(0)
Dead on-scene	5	(3)	5	(4)	0	(0)
Casualty clinic	5	(3)	5	(4)	0	(0)
Local hospital	33	(18)	33	(27)	0	(0)
County hospital	74	(41)	57	(48)	17	(27)
University hospital	52	(29)	15	(13)	37	(60)
Remain in hospital	8	(4)	0	(0)	8	(13)
Supervision by health personnel during transport[b]	*N*	(%)	*N*	(%)	*N*	(%)
Ambulance workers only	121	(67)	94	(80)	27	(44)
+General practitioner	21	(12)	21	(18)	0	(0)
+Anaesthesiologist	10	(6)	1[c]	(1)	9	(15)
+Midwife	8	(4)	1	(1)	7	(11)
+Nurse anaesthetist	7	(4)	0	(0)	7	(11)
+Hospital physician	1	(1)	0	(0)	1	(1)
+Other	3	(2)	1	(1)	2	(3)
Missing	9	(5)	0	(0)	9	(15)

[a]Primary mission: patient outside hospital. Secondary mission: patient in need of interhospital transport
[b]Highest level of health personnel in contact with the patient during transport. Ranking: Anesthesiologist, GP/hospital physician, nurse anaesthetist/midwife and other.
[c]Mission during which an anaesthesiologist from the hospital called out to a patient living near the hospital.

exceeded duty time, or concurrencies. Both primary (on-scene) and secondary (inter-hospital) missions were included. SAR data were available for 2012–2013. The inclusion criteria allowed for patient inclusion independent of clinical condition.

In S&F county, HEMS register mission and patient data in the AirDoc database. Each dispatch in AirDoc has a unique identification number generated from the Acute Medical Information System (AMIS), a database in which the EMCC in Førde reports activity and mission data. AMIS contains national person identification numbers that makes it possible to access and link data from other records.

Cancelled missions were identified in AirDoc. AMIS identification numbers were extracted from AirDoc. We then obtained mission data from AMIS, including: Age, gender, date, Index criteria code, resources alarmed, response to alarm, timeline for each resource, site, destination and a free text field. Ambulance records contained clinical data about the patients, treatment provided and which health personnel being involved. Records from hospitals and OOH services were retrieved to supplement missing data, such as inconsistent information from AMIS or data about treatment. All data were collected retrospectively. Diagnostic group categorization was performed by the researchers (EZ and DSN) and was based on the assumed medical problem at the time of requesting HEMS, using both Index code and free text information. Cooperation was defined as presence at the

Table 2. Treatment provided on primary missions according to general practitioner (GP) response and involvement.

	GP response on primary missions ($N = 118$)						
	GP involvement						
	On site[a] ($N = 70$)		Conferred with ambulance ($N = 13$)		GP not involved ($N = 35$)		p Value
Treatment	n	%	n	%	n	%	
No treatment	17	(24)	3	(23)	11	(31)	0.490
Oxygen only	11	(16)	2	(15)	4	(11)	0.774
MONA[b]	19	(27)	4	(31)	10	(29)	1.000
CPR[c]	4	(6)	0	(0)	0	(0)	0.317
Single treatments[d]							
Nitro-glycerine	17	(24)	3	(23)	9	(26)	0.817
Morphine	20	(29)	4	(31)	13	(37)	0.385
O_2 on mask	16	(23)	0	(0)	3	(9)	0.181
O_2 nose catheter	31	(44)	7	(54)	16	(46)	1.000
Drugs in nebulizer	3	(4)	0	(0)	0	(0)	0.555
Ringer acetate	18	(26)	2	(15)	1	(3)	0.007
Acetylsalicylic acid	17	(24)	4	(31)	10	(29)	0.654
Clopidogrel	12	(17)	0	(0)	7	(20)	0.423
Metoclopramide	22	(31)	4	(31)	11	(31)	1.000
Neck collar	5	(7)	1	(8)	4	(11)	0.476
Data missing	1	(1)	0	(0)	1	(3)	

Comparison between GP involved and GP not involved using Fischer's exact test. Fisher's exact test was used for statistical analysis of GP involvement. Multiple treatments are possible.
[a]Includes call-outs and consultation at GP's office or out-of-hour service clinic.
[b]MONA: morphine, oxygen, nitro-glycerine, acetylsalicylic acid was ordinated.
[c]Cardiopulmonary resuscitation.
[d]One or more treatment was given.

scene, assuming communication and involvement between health personnel.

Statistical analysis

Standard descriptive analyses were performed using SPSS Statistics Version 22/23 (IBM Corp., Armonk, NY, USA). Due to skewed data, age is presented as median with interquartile range (IQR). Pearson's Chi-square and Fischer's exact test were used for categorical variables, and p values of <0.05 were considered statistically significant. Table 1 is stratified for primary and secondary missions. GP involvement vs GP not involved was compared in Table 2. Only treatments in primary missions are showed in Table 2, due to minimal treatments given in secondary missions.

Results

HEMS Førde and SAR Florø completed 2310 HEMS missions during the study period. We identified 627 cancelled missions. Among these, 73% (455/627) were excluded from our analysis because the missions were completed by neighboring HEMS (33%), there was no longer medical indication for HEMS (20%), or other reasons, such as misclassification or duplicates (20%). Ultimately, the study included a total of 172 missions with 180 patients.

The main reason for mission cancellation was weather conditions, which were reported in nearly 90% of primary and secondary missions. A total of 74% of the cancelled missions were during the six months from October through March, and 46% of the cancelled missions were rejected or aborted during the afternoon (16:00 to 23:59) (not in table).

Table 1 presents demographic data for the 180 included patients, along with mission sites and destinations. Median patient age was 59 years (IQR 31–72). Based on the Index, 73% of the missions were considered acute, 26% urgent, and 1% non-urgent (not in table). The most common diagnostic category was cardiology (35%), followed by neurology (19%) and trauma (15%). Two-thirds were primary missions. When necessary, all patients were transported to a final destination via ground transportation and/or boat ambulance (not in table).

Among the primary missions, the on-call GP was alerted for 95% (112/118) of the patients (Figure 1). For 46% (52/112) of these patients, the GP responded by calling out, while 16% (18/112) of these patients were transported by ground ambulance to the GP's office or OOH casualty clinic. In total, 63% (70/112) of the patients were examined by a GP. For 12% (13/112) of these

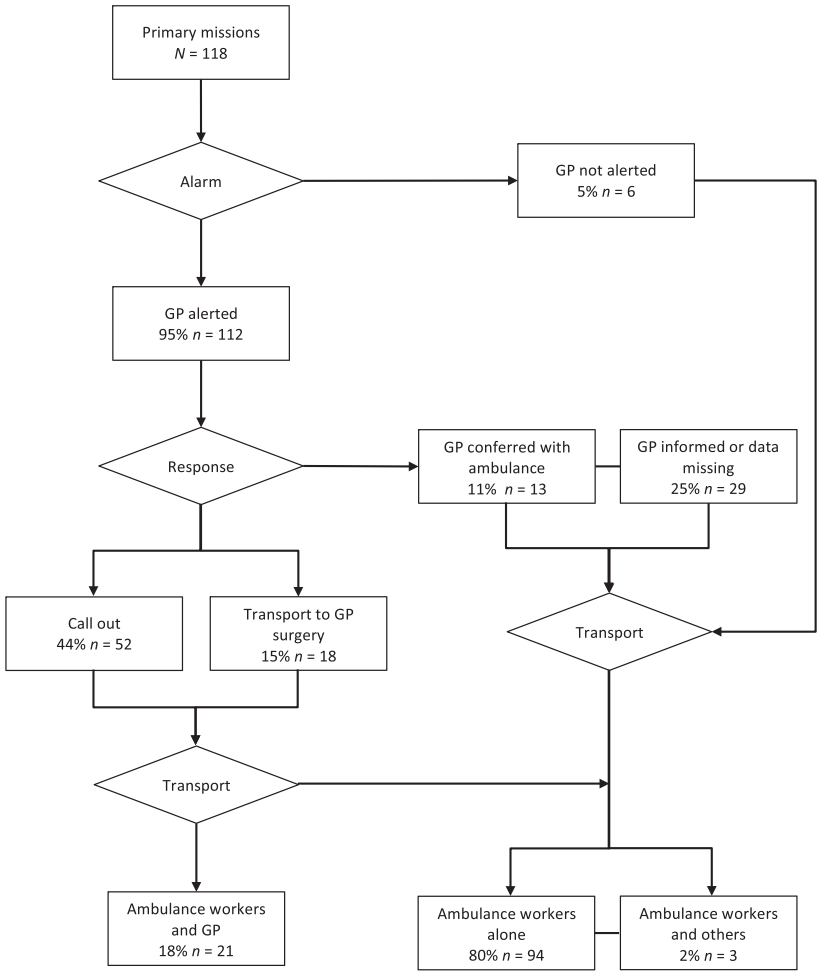

Figure 1. Flow chart of primary mission, showing alerts, GP responses, and transport options.

Table 3. Treatment provided by health personnel group in primary missions

	Primary missions ($N = 118$)	
Health personnel	*N*	%
Ambulance workers	11	(9)
General practitioner	83	(69)
Hospital physician	7	(6)
HEMS anaesthesiologist	9	(8)
Other	2	(2)
Missing	8	(6)

A physician was considered responsible if on scene or after telephone conferral with ambulance workers.
Ambulance workers can administer certain treatments that are pre-delegated by a physician when protocol criteria are fulfilled.

patients, the GP gave advice by telephone to ambulance workers. GP involvement did not differ according to time of day ($p = 0.601$), diagnostic group ($p = 0.309$), or patient's age ($p = 0.490$). The patient's final destination did not differ in accordance with GP involvement ($p = 0.410$) (not in table). Among the 52 patients who were examined by a GP on scene, 21 (40%) were accompanied by the doctor during transport to their destination. None of the patients who were primarily localized at a GP's office or a casualty clinic at the time of HEMS request were accompanied by a GP during transport.

Among the secondary missions (Table 1), 16% (10/62) of the patients were accompanied by a physician together with ambulance workers during transport between hospitals. In 13% (8/62) of cancelled HEMS missions, the patient ultimately stayed at their initial hospital instead of being transported by ground ambulance to a hospital with higher level of competence/care.

Among the patients in primary missions, 26% (31/118) did not receive treatment while 14% (17/118) were provided oxygen (Table 2). GP involvement did not influence the provision of treatment, with the exception of i.v. Ringer acetate. Table 3 shows which health personnel were responsible for the treatment provided to patients in primary missions. In secondary missions, 31% (19/62) of the patients received no treatment during transport. Four patients were intubated before transport, and two patients received continuation of non-invasive ventilation; these patients were accompanied by a physician or nurse anaesthetist (not in table).

Discussion

Principal findings

In this study, we investigated how patients with anticipated need of HEMS are handled when the HEMS mission is cancelled in a rural county in Norway. Many of the patients were provided minimal or no treatment. The on-call GP was alerted in almost all primary missions, and responded with a call-out for nearly half of these patients. The treatment provided in primary missions did not differ according to GP involvement. Many missions were completed by ambulance workers without a physician on site. A physician accompanied the patient during transport in only 17% of the missions; however, most patients received treatment after ambulance workers had conferred with a physician. The most common diagnostic categories were cardiology, neurology, and trauma.

Strengths and limitations

One strength of this study is that it included all available registered patients over a four-year period, thus providing a good representation of how challenging missions are solved in a rural part of Norway. The analysed patient sample was selected based on the reason for HEMS cancellation, regardless of clinical information. No changes in use of HEMS or organizational changes in the prehospital services has been reported since the study period.

Our present results should be interpreted with some caution, and may not be generalizable to other regions. Notably, there is no national consensus among EMCC areas regarding strict HEMS dispatch criteria, and HEMS responses differ between the bases. For example, in 2014, HEMS Bergen rejected 30% of the missions while HEMS Lørenskog rejected 20% [20]. Compared to other bases, HEMS Førde has a higher rate of completed missions [7], indicating a lower threshold for HEMS usage in this area. Moreover, the proportion of trauma patients in our present study (15%) differs from the proportion among completed HEMS missions on the west coast of Norway (30%) [10], which may indicate different response thresholds depending on the medical indication. It is also possible that the pilot's decision to reject a mission may have been influenced by the anticipated severity of the patient's condition and the experience of the crew. Still, our findings are relevant in rural areas abroad Norway with similar prehospital services. Finally, missing information from the databases was search for in several sources. However, the study design and validity of the databases is a potential information bias.

Findings in relation to other studies

The advantages of HEMS are controversial, and it remains unclear which elements provided by HEMS benefit the patients [19]. However, several studies have reported advantages of HEMS for trauma patients [11–15]. Norwegian studies involving both medical and trauma patients report inconsistent results regarding benefits. One study demonstrated gained life years among patients treated by an anaesthesiologist [16], while another showed that two-thirds of severely ill or injured patients received advanced treatment [10]. However, other studies have concluded that the majority of patients did not receive medical treatment requiring an anaesthesiologist, and thus could thus have been transported by ground ambulance [17,18]. Our findings may indicate the same, though it is difficult to compare the results of different studies due to the difference among study areas, methodological variations, and challenges intrinsic to RCTs in emergency medicine research. Although our present study has some of the same limitations, it contributes to the scarce body of knowledge about cancelled HEMS missions.

In the primary missions in our study, the patients were transported and cared for by ambulance workers, confirming the important role of ground ambulance services in Norway. Moreover, the high proportions of alerted on-call GPs, call-outs by GPs, and telephone conferences between ambulance workers and GPs indicates good collaboration between the OOH and ground ambulance services, as intended by national regulations. Compared with our present findings, a Norwegian study from 2010 reported a lower overall rate of alerting the on-call GP (47%), noting that it

was less common for the GP to be alerted when the event was not life threatening [23,24]. In recent years, there has been increased focus on physician attendance in the Norwegian prehospital system. However, we still found in our study that the on-call GP decided not to see the patient in 40% of the cases where the GP was alerted. This was likely due to long time that it would take for the GP to travel to the patient in many cases. Few studies have examined the effects of GP attendance in acute situations [25]; however, Norwegian legislation imposes GPs to call-out when needed [2], ambulance workers prefer GPs to be present in challenging prehospital emergencies [26] and GPs claim improved patient care when involved [27]. Anticipated reasons for low involvement of medical professionals other than ambulance workers during patient transport can include a stable condition of the patient, a less severe medical problem than initial indicated, or a concurrent conflict for the GP. Still, it is notable that no patient had a GP present during ambulance transport in the cases where HEMS was requested to an OOH office or GP office. These patients were considered in need of rapid transport and/or attendance of a HEMS physician. However, when HEMS was not accessible, the patients were transported by ground ambulance with only ambulance workers and with a prolonged transport time to the hospital. Moreover, the same pattern was observed for physician involvement in secondary missions, even though severe clinical conditions might be anticipated in such cases. In secondary missions, only one in six patients was accompanied by a specialist doctor from the requesting hospital.

In primary missions, two-thirds of patients received no specific intervention, or only received treatment that ambulance workers in Norway can administer without physician guidance. Even so, in eight of ten cases, the treatment was ordinated by a physician either on site or by telephone, indicating cooperation between the different prehospital services in the treatment of most acute patients outside of the hospital. For secondary missions, there was a similarly low volume of interventions or treatments. Although few patients received advanced treatment, our experience is that clinical observation and monitoring of patients in potentially life-threatening situations is vitally important. Stroke is one example of an acute situation that requires fast and correct diagnosis with minimal pre-hospital treatment. There is scarce evidence for which situations continuous observation by a physician is required and further research is needed [25,27]. Still, attendance by physicians is probably improving the quality of the patient assessment. The presently reported high proportion of patients receiving minimal treatment is similar to the findings of older studies in Norway [17,28]. However, a recent study of HEMS in Norway reported a high rate of advanced treatment provided by an experienced anaesthesiologist [10]. Procedures performed by an anaesthesiologist through HEMS are not directly comparable to procedures performed by ambulance workers or a GP, and it is not known whether an HEMS anaesthesiologist would have performed different interventions for the patients in our present study.

In primary missions, the patients were most often admitted to a hospital, with only a few patients left on-scene or at the GP's office. Assuming that hospitalization indicates a need for advanced care, this supports that the initial level of response at the EMCC was appropriate in most cases. Some patients who were considered to require interhospital transfer to a higher level of care ultimately remained at the initial local or county hospital. In these cases, the option to transport the patient via ground ambulance deemed less acceptable than the care provided at the initial hospital. While a local hospital can provide advanced care, critically ill patients may need more intensive care or surgery at another hospital and may therefore want HEMS to transport them. When HEMS was unavailable, some patients remained at their initial hospital. Intubated patients and patients with other advanced treatments who were transported by ambulance were all accompanied by specially trained nurses or physicians in addition to ambulance workers.

Conclusions

The present results showed that ambulance workers and on-call GPs have important roles when HEMS are unavailable. Our findings indicated good collaboration among the prehospital services. The majority of patient were examined by a GP or cared for by ambulance workers who conferred with a physician. Few patients received advanced treatment, and treatment did not differ according to GP involvement.

Ethics approval and consent to participate

The study was approved by the Regional Committee for Medical and Health Research Ethics (2013/373 REC West, Norway). Patient identification was made anonymous for the research group.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The Norwegian Air Ambulance Foundation financed the study.

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Nystøyl et al. BMC Emergency Medicine (2020) 20:88
https://doi.org/10.1186/s12873-020-00377-0

BMC Emergency Medicine

RESEARCH ARTICLE Open Access

Helicopter emergency medical service (HEMS) activity after increased distance to out-of-hours services: an observational study from Norway

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Abstract

Background: Organizational changes in out-of-hour (OOH) services may have unintended consequences for other prehospital services. Reports indicate an increased use of helicopter emergency medical services (HEMS) after changes in OOH services in Norway due to greater geographical distances for the on-call doctors. We investigated whether HEMS dispatches increased when nine municipalities in Sogn og Fjordane County merged into one large inter-municipal OOH district.

Methods: All primary dispatches of the HEMS in the county between 2004 and 2013 were included. We applied interrupted time series regression to monthly aggregated data to evaluate the impact of the organizational change 1 April 2009. The nine target municipalities were compared to the rest of the municipalities in the county, which served as a control group. A quasipoisson model adjusted for seasonality was found to be most applicable.

Results: We included 8,751 dispatches, 5,009 (57.2%) of which were completed with a patient encounter. Overall, we found no alteration in requests for HEMS after 2009 ($p = 0.251$). Separate analyses of the target municipalities and control group revealed no significant increase after 2009 ($p = 0.400$ and $p = 0.056$, respectively). When categorizing the municipalities into urban or rural, we found a general increase in HEMS dispatches for the rural group over the 10-year span ($p = 0.045$) but no added increase after 2009 ($p = 0.502$). The urban subgroup showed no change. Distance from the OOH service in regards to travel increased within the nine municipalities after 2009, median [quartiles] (5.0[3.0, 6.2] km vs 26.5[5.0, 62.2] km, $p < 0.001$).

Conclusion: After relocating nine local OOH services into one large inter-municipal OOH district, we found no increase in requests for HEMS.

Keywords: Emergency medical services, Primary health care, Air ambulances, Norway, HEMS, General practitioners, After-hours care, Out-of-hours medical care

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Background

The Helicopter Emergency Medical Service (HEMS) is part of the prehospital emergency medical service in many industrialized countries [1]. Studies have shown varying effects on health of such services [2], but their use is increasing worldwide [3]. In Norway, HEMS is an integrated part of the public prehospital emergency medical services, together with ground ambulances and primary care out-of-hours (OOH) services [4]. Ambulances and OOH services, with on-call general practitioners (GPs), are the backbone of prehospital services [4, 5], and the majority of medical emergencies are handled by the ground ambulance staff, often in cooperation with the GPs.

The organization of prehospital services in Norway has changed over the last few decades in order to meet the requirements of new treatment algorithms and to fulfill the demands of health regulations. In the period of 2003–2013, acute missions with a ground ambulance increased almost 100% in Western Norway. On the other hand, use of HEMS was stable during the same period [6], though differences between HEMS bases have been reported [7].

Emergency Medical Communication Centers (EMCCs) provide medical advice and coordinate responses to medical emergencies. The HEMS is dispatched to patients with severe illness and/or trauma in need of specialized medical assessment, treatment, and/or rapid transport. Dispatch of the HEMS is not intended to replace on-call GPs [8]. However, changes in hospital organization and a focus on prehospital delay in the treatment of acute myocardial infarction, stroke, or trauma can potentially increase the use of HEMS in a rural country, such as Norway [9, 10].

From 2007 to 2016, the number of OOH casualty clinics in Norway decreased from 230 to 182 [11]. Driven by the need for organizational reinforcement [12], less duty time for the GPs, and more stable recruitment of personnel, several inter-municipal OOH districts were established. In the rural county of Sogn og Fjordane (S&F), nine municipalities were reorganized into one large inter-municipal OOH district in April 2009. The result was that one on-call GP was responsible for a larger geographic area with a greater number of inhabitants than they had been previously. Nationally, such reorganization into larger inter-municipal OOH districts has not resulted in better equipped OOH clinics, increased practical training, or more call-outs with a car from the OOH services. The competence of on-call GPs has been reported to be decreasing [13, 14]. Reports have also indicated an increase in HEMS missions, with clinical content handled previously by the on-call GPs. This development has been linked to major organizational changes in OOH services [15, 16]. Such organizational changes should be evaluated to determine whether they had the intended, or possibly adverse, effects. Therefore, we investigated whether HEMS dispatches increased in response to the organizational change when nine municipalities in S&F merged into one large inter-municipal OOH district on 1 April 2009.

Methods

S&F covers 18 623 km^2 in Western Norway and is sparsely populated, with 110 000 inhabitants in 2019. One HEMS base is located in Førde, and one search and rescue (SAR) helicopter operates in Florø, a 45-min drive from Førde. Both the HEMS and SAR include an anesthesiologist in addition to a pilot and a rescue paramedic and operates 24/7/365 under challenging geography and weather condition. The HEMS base has a rapid response car available if weather conditions restrict flights (Fig. 1).

Each municipality in Norway is responsible for the OOH service, with at least one GP on-call and availability for call-outs in emergencies. On 1 April 2009, nine municipalities in S&F reorganized their OOH services, relocating all local OOH services to one large inter-municipal casualty clinic (SYS-IKL) in Førde, covering an area of 6 400 km^2 and 35 000 inhabitants. As a result of this organizational change, the driving distance for patients can be up to 100 km. The median driving time for patients in the same area to SYS-IKL is 1 h 45 min [17]. Before 2009 the driving distance could be up to 45 km and 40 min driving time. Until January 2016, SYS-IKL had one doctor on-call at the clinic, and on weekends and holidays a doctor was on-call from home with the possibility to come to the casualty clinic upon request. The rest of S&F's 17 municipalities had local ($n = 8$) or inter-municipal ($n = 9$) OOH services in 2009.

The change to SYS-IKL was a natural experiment with the possibility to evaluate use of the HEMS before and after the organizational change.

Data

All HEMS dispatches in S&F from 1 January 2004 to 31 December 2013 were included. The Førde HEMS registers the patient data, timeline, and operational data, including the reason for cancellation, for all dispatches in their database "Airdoc". Reasons for cancellation were: no longer medically indicated, bad weather conditions, concurrency conflicts, flight restrictions, or technical. Missions with a patient encounter also registered a severity score using the National Advisory Committee for Aeronautics (NACA) score [18]. Dispatches from other HEMS bases to missions in S&F were identified through the databases at the Ålesund, Bergen, Ål, and Dombås HEMS, Florø SAR Helicopter, and statistics from the National Air Ambulance Services. In addition, we

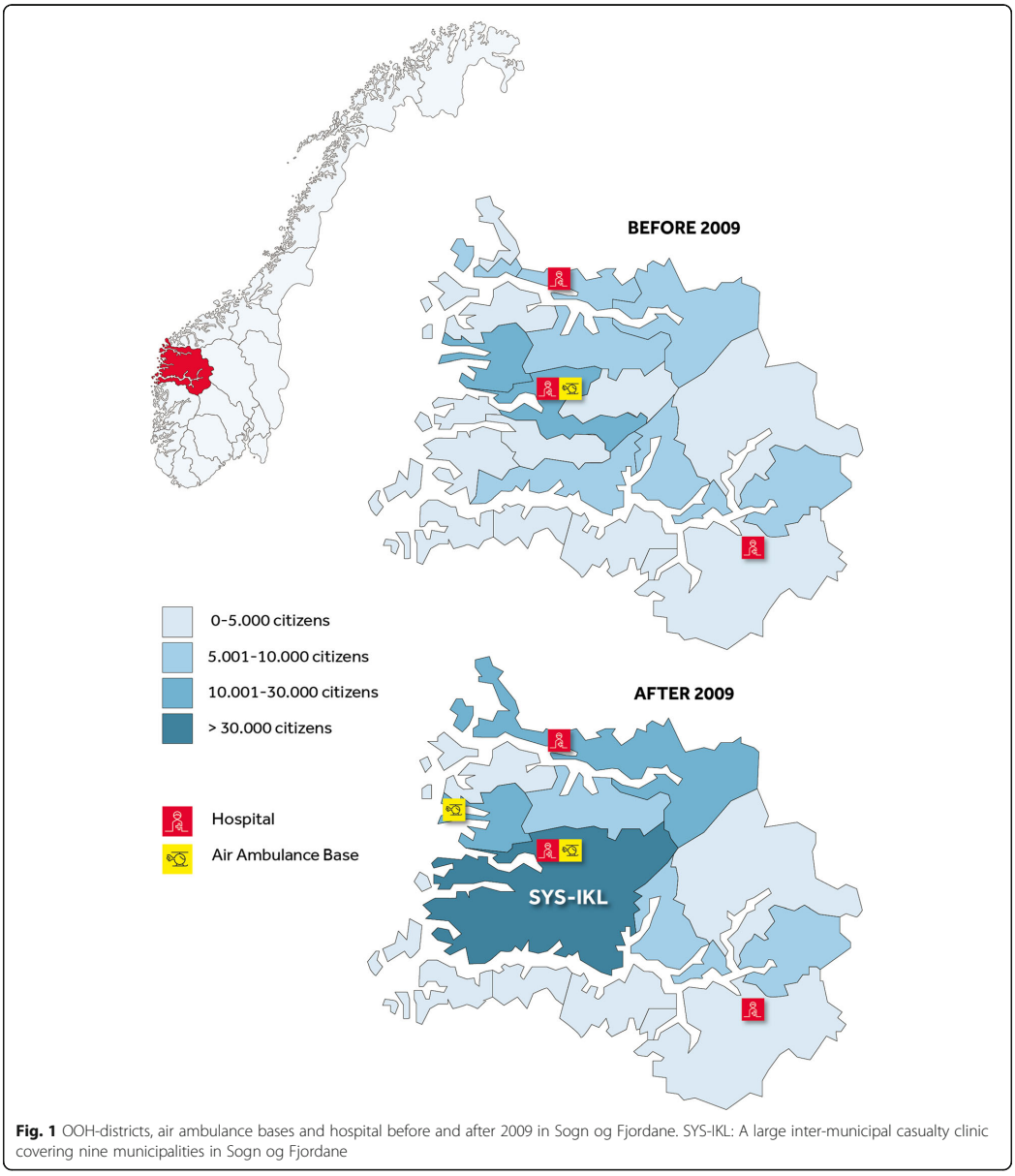

Fig. 1 OOH-districts, air ambulance bases and hospital before and after 2009 in Sogn og Fjordane. SYS-IKL: A large inter-municipal casualty clinic covering nine municipalities in Sogn og Fjordane

compared the number of missions with the requests of HEMS from the EMCC in Førde.

Data were aggregated to obtain the total number of dispatches per month. SYS-IKL and MOS (municipalities outside SYS-IKL) subgroups were also created, and the municipalities categorized as urban or rural. Municipalities with > 7000 inhabitants were defined as urban. For comparison across subgroups, data were analyzed as dispatches per 1000 inhabitants. Distances between the municipalities and OOH service were measured using

postal code coordinates [19] when available. The rest were measured between town hall in each municipality and OOH service.

Statistical analysis

In order to evaluate the potentially significant effect of introducing the SYS-IKL organizational change on the number of dispatches, we applied interrupted time series regression (ITS) [20]. ITS is a regression model specifically developed for analyzing interventions introduced at a population level over a clearly defined time period when the pre-intervention and post-intervention period is clearly defined, has short-term outcomes, and has sequential measures with preferably equal numbers of data points distributed before and after the intervention [20].

The outcome variable in the analyses was the monthly aggregated number of HEMS dispatches. As this outcome variable is a count variable, our intended approach was to fit a Poisson ITS step change model. However, preliminary analyses indicated significant overdispersion, i.e., larger variation in the data than the Poisson model can handle. To adjust for this, we used a more general quasipoisson model. As HEMS dispatches are known to vary throughout the year [6], the model was further adjusted for seasonality using harmonic terms. In order to transform results to rates, population data were used as an offset variable in the regression model.

Differences in travel distance between the patients and on-call doctor for SYS-IKL and MOS were analyzed using Mann–Whitney-Wilcoxon non-parametric tests. Changes in NACA scores before and after the policy change were tested using chi-squared.

The statistical analyses were performed using SPSS Statistics Version 22/23 (IBM Corp., Armonk, NY, USA) ang R3.5.2 [21].

Results

A total of 8751 HEMS dispatches were identified during the 10-year period. Of these, 5009 (57.2%) missions were completed with a patient encounter. The number of dispatches for individual years, both in total and for SYS-IKL and MOS, are presented in Table 1.

Total dispatches per month are shown in Fig. 2a. Fitting a quasipoisson regression model adjusted for seasonality (Fig. 2b), we found no significant change in HEMS dispatches after the policy change ($p = 0.251$).

Plotting the monthly number of dispatches for SYS-IKL (Fig. 2c) and MOS (Fig. 2e) separately, we found more dispatches for MOS. Adjusted per 1000 inhabitants, the monthly mean (SD) rate was 0.58 (0.22) and 0.60 (0.17) for SYS-IKL and 0.61 (0.19) and 0.78 (0.17) for MOS prior to and after the policy change, respectively. Fitting quasipoisson regression models and adjusting for seasonality (Fig. 2d and f respectively) resulted in no significant change for SYS-IKL ($p = 0.400$) and borderline significance for MOS ($p = 0.056$).

We found more HEMS dispatches in rural areas (Fig. 2 g and i). Fitting quasipoisson regression models adjusted for seasonality, we found a significant general linear increase in HEMS dispatches for the rural group over the whole time period (Fig. 2 h, $p = 0.045$), but no added increase after the policy-change ($p = 0.502$). The urban subgroup did not exhibit any significant changes over time in general ($p = 0.506$) or after introduction of the organizational change (Fig. 2j, p = 0.447).

Table 1 HEMS dispatches in the Norwegian county of Sogn og Fjordane

Year	Total		SYS-IKLa		MOSb		Inhabitants
	Dispatches	Rate	Dispatches	Rate	Dispatches	Rate	
2004	695	0.54	197	0.49	498	0.56	107 222
2005	831	0.64	252	0.63	579	0.65	107 032
2006	896	0.70	246	0.62	650	0.74	106 650
2007	766	0.60	220	0.55	546	0.62	106 194
2008	834	0.65	257	0.65	577	0.66	106 259
2009	806	0.63	222	0.56	584	0.66	106 457
2010	989	0.76	243	0.61	746	0.84	107 080
2011	1012	0.78	254	0.63	758	0.85	107 742
2012	961	0.74	232	0.57	729	0.82	108 201
2013	961	0.74	244	0.60	717	0.80	108 700
All	8751		2367		6384		

Data are presented as total count and rates per 1000 inhabitants per month
[a]SYS-IKL: Nine municipalities in Sogn og Fjordane with one large inter-municipal casualty clinic
[b]MOS: Municipalities outside SYS-IKL in Sogn og Fjordane with both municipal and inter-municipal casualty clinics

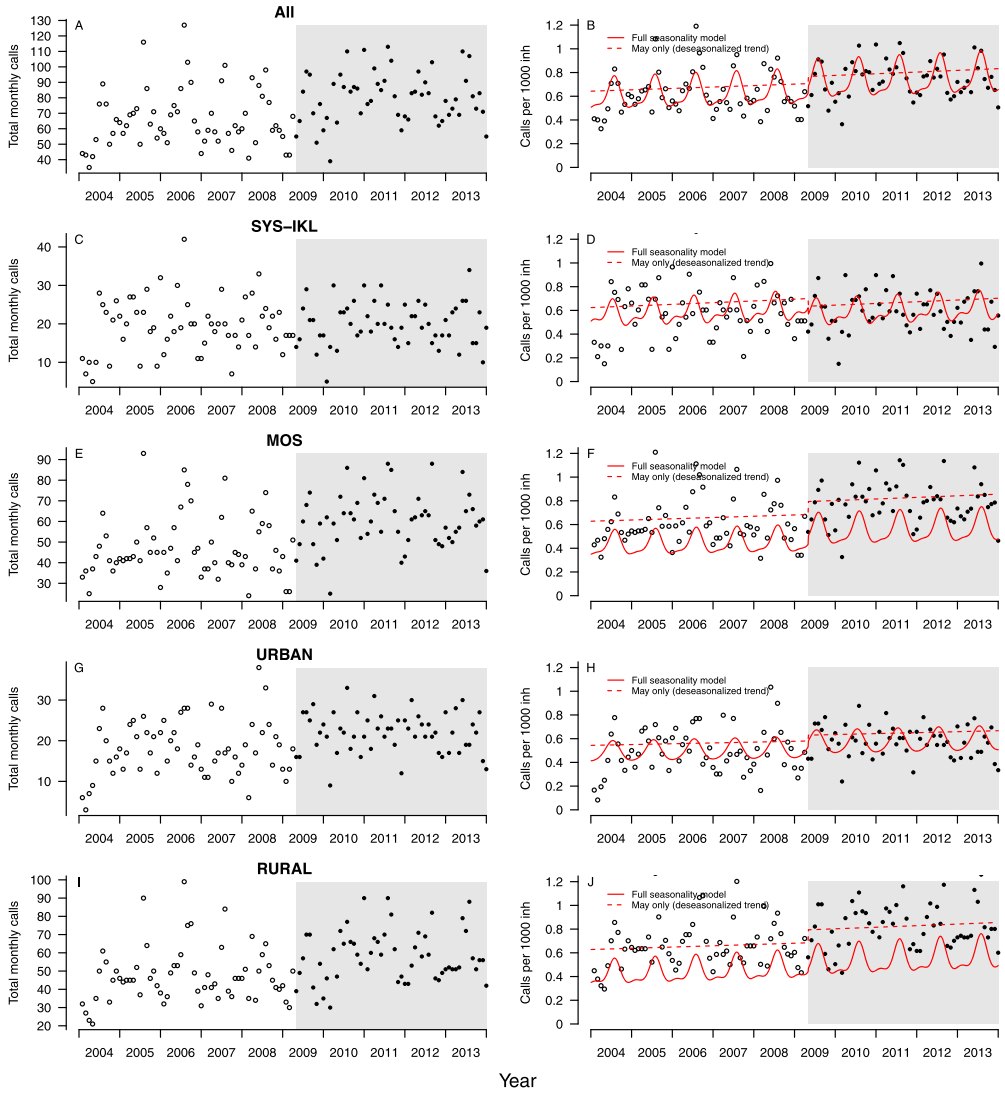

Fig. 2 HEMS dispatches in Sogn og Fjordane, 2004–2013. Left, monthly total calls. Right, calls per 1000 inhabitants. The red dotted line indicates the fitted quasipoisson model with breakpoint, and the red solid line indicates further adjustment for seasonality. SYS-IKL: Nine municipalities in Sogn og Fjordane with one large inter-municipal casualty clinic. MOS: Municipalities outside SYS-IKL in Sogn og Fjordane with both municipal and inter-municipal casualty clinics

Though there was generally no difference in the number of HEMS dispatches before and after the change in organization, travel distances to the OOH service increased significantly in SYS-IKL after the change, median [quartiles] (5.0[3.0, 6.2] km vs 26.5[5.0, 62.2] km, $p < 0.001$). Distance within MOS increased from 7.3 [5.1, 13.1] km to 8.3 [5.1, 22.0], $p < 0.001$. The distances were significantly higher for rural (8.9 [6.2, 22.0] km) than urban (5.0 [3.0, 8.3] km, $p < 0.001$).

NACA scores did not significantly change within the SYS-IKL, with a mean score of 3.99 before and 3.88 after

the policy change ($p = 0.070$). Within MOS, the change was significant ($p = 0.007$), with a mean NACA score of 3.76 before and 3.84 after.

Discussion

A change in HEMS dispatch rates between SYS-IKL and MOS after 1 April 2009 was not confirmed in our analysis. Though national guidelines exist for HEMS dispatch, the different bases in Norway use the service differently [22]. Rates of aborted or declined missions vary and depend on local routines. The EMCCs have varying HEMS dispatch criteria depending on available resources, demographics, and distance to hospitals with a capacity to handle trauma and other acute medical illnesses. A lower threshold for dispatching the HEMS can be a consequence in areas with long distances for patients to travel to health services. However, the stable dispatch of the HEMS in our analyses is similar to the findings in another recent study [6]. Our findings support that, despite an increase in emergency calls to the EMCC, increased ambulance missions and less frequently utilized the on-call doctor at the site, the HEMS still seemed to have the same threshold for dispatch.

Several studies have shown less frequent use of health services related to increased travel distance, such as lower rates of mammography screening [23], lower hospitalization rates for children [24], and major barriers to hospital referral by GPs [25]. Both decreasing use of OOH services and fewer medical situations categorized as acute due to longer distance between the patients and the OOH service are well-documented [26, 27]. We did not find any change in HEMS dispatch within SYS-IKL after 2009, despite the increased travel distance. However, over time, the rural municipalities had an increase in HEMS dispatch, but this applied to both municipalities with increased distance from the OOH service and municipalities with unchanged travel distance. Somehow, distance matters, but the correlation between HEMS dispatch and distance from OOH services is not consistent. A general centralization of many health services, including ground ambulance stations, OOH services, and hospitals, may contribute to the increase in HEMS dispatches. In 2012, only 0.5% of the contacts at the OOH service within SYS-IKL that resulted in a consultation with a doctor was responded with a call-out, and the annual report explained the low rate as consequences of having only one doctor on-call and the long distances to the patients [28]. The percentages of patients seen by both an on-call GP and HEMS decreased from 53% in 2006 to < 30% in 2015 in one area in Norway [22]. Some have described this as an abdication of the OOH services from large areas in Norway [29].

It seems plausible that the centralization of OOH services has resulted in an increased number of missions for the ground ambulances whereas this seems not to be the case for HEMS. Though the HEMS had a stable annual number of dispatches from 2004 to 2013 in the western part of Norway, acute missions with ground ambulances were increased by 95% in the same period [6]. In S&F, the total increase in ground ambulance missions was 27%, and nearly half of the increase occurred from 2009 to 2010. One explanation is that more patients require ambulance transport to the OOH services because the on-call doctor has a limited possibility of call-out. HEMS are only involved in a minority of the acute missions and are not affected by the structural change to the same degree as ground ambulances. Another reason for the increase in acute missions with ground ambulances can be the focus on triage using a decision tool called the Norwegian Index for Medical Emergencies [30]. This index is a criteria-based decision tool used in the EMCCs to classify the level of response. Though on-call doctors and the HEMS can accept or decline an acute mission when alarmed, ground ambulances are dispatched based on the level of response from the EMCC. A possible over-triage using the index and increased transport to OOH services, dispatch, and use of ground ambulance should be explored further, especially after structural changes in the OOH service.

Does it matter if ground ambulance workers, on-call GPs, or HEMS physicians encounter the patient? The main indication for dispatching the HEMS is a severe illness or trauma. Compared to transport and treatment by ground ambulances, the HEMS should have an anticipated gain in health outcomes and should not replace the on-call GP [8]. Concurrent missions can potentially be a problem if the HEMS is used as a compensatory mechanism due to unavailable on-call GPs. The crew can also have to decline missions if they have exceeded the duty hours. After working 14 h of the last 24 h, they are obliged to rest the next 8 h. These HEMS regulations help maintain flight safety [31]. As a consequence of the increased use of the HEMS, more missions could be declined despite of being medically warranted. On the other hand, equal access to health services regardless of residence is an important principle in Norwegian health policy. The HEMS can compensate for differences in the use of health services due to long distances.

Over-triage at the EMCC is both known and accepted to some extent [32]. However, on-call GPs play an important role as gatekeepers for reduced use of the health care system and to reduce hospitalizations [33]. The Norwegian health care system is based on the principal of using the lowest efficient level of care (LEON), and GPs cooperating with ambulance workers in acute missions reduce admissions to the hospital compared to ambulance workers alone [34]. In addition, GPs degrade the urgency/severity of many missions when on site [35].

On the other hand, a study from S&F looking at acute missions in which the HEMS had to cancel revealed no difference in treatment or reduced hospitalization when the on-call GP was on site or not [36]. Although improved patient care with on-call GPs on the site are demonstrated in some studies [34, 35], it is unclear which patients should be approached with a call-out reaction. Further studies are essential to offer recommendations on the capacity of OOH services and organizational matters.

The prehospital care system is organized differently in other countries, with limited involvement of the primary health care in acute medical situations [5]. However, equal access to health care in sparsely populated areas, resource allocations to HEMS, and dispatch criteria for HEMS, are highly relevant topics for discussion in many countries. After the establishment of a nationally organized HEMS in Finland in 2012, they discovered that a higher rate of requests were cancelled, compared to other countries. This could be due to over triage [37] and is an example of prehospital organizational changes which had an unintentional effect in a different area in the prehospital emergency service. Denmark uses anaesthesiologists in rapid response vehicles spread geographically around the country, in contrast to Norway's use of GPs in the OOH services [38]. These two systems are expected to manage emergency patients and both have to rely on HEMS in some situations. Nevertheless, when the on-call OOH doctors disappeared from some geographical areas in Norway, HEMS utilization was not increased. Our findings contribute to the body of knowledge on how organizational changes can influence the use of HEMS, which is important to acknowledge prior to implementing new services and systems.

Strengths and limitations

The present study has several strengths. First, all HEMS dispatches registered over 10 years were included. In addition, the ITS regression model is a well-established method for retrospective analysis of interventions introduced at a population level. However, the operational data used in our study were not registered with an intention to do research. Missing or wrong data is possible, especially considering that the data are registered during acute medical situations. We have checked different data sources (AirDoc, statistics from the Air Ambulance services and EMCC) with intentions to identify missing data and have not found a significant amount that influence the result. Furthermore, varying use of the HEMS between the bases in Norway is known [7] and should be taken into consideration if the results are compared to other areas. However, our analyses used rates before and after the organizational change within the area of one base and did not make a comparison between bases. To our knowledge, no other major system changes occurred in the study period. Theoretically, the establishment of a SAR base in 2009 could have had an impact on HEMS use. Still, the same dispatch criteria is used for requesting SAR, and SAR is usually requested when HEMS is unavailable due to concurrency, bad weather or technical reasons.

Interpretations

Based on our findings, the increase in HEMS dispatches was less than expected due to the organizational change. In order to identify unintended consequences of changes in the prehospital services, such organizational changes should be evaluated more often with suitable methods. Our result indicate that use of HEMS is not significantly affected by centralization of OOH services, but changes in the use of ground ambulances should be evaluated in more detail.

Conclusion

Reorganizing the local OOH services into one large inter-municipal OOH district did not result in an increase in HEMS dispatches. We found a trend, but not a statistically significant change, towards an increased use of HEMS in rural areas.

Abbreviations

EMCC: Emergency Medical Communication Center; GP: General practitioner; HEMS: Helicopter Emergency Medical Service; ITS: Interrupted time series regression; MOS: Municipalities outside SYS-IKL; NACA: National Advisory Committee for Aeronautics; OOH: Primary care out-of-hours service; SAR: Search and rescue; S&F: County of Sogn og Fjordane; SYS-IKL: Large inter-municipal casualty clinic in Sunnfjord og Ytre Sogn

Acknowledgements

Identification and collection of data from HEMS bases outside Sogn og Fjordane was possible with help from PhD candidate Kristen Rasmussen at the Ålesund HEMS and medical advisor Pål Madsen at National Air Ambulance Services of Norway.

Authors' contributions

DSN, JR, and EZ planned and designed the study. DSN and ØØ collected the data. JR and DSN performed the statistical analyses. DSN drafted the manuscript. JR, ØØ, SH, HJB, and EZ participated in critical revision of the manuscript. All authors read and approved the final manuscript.

Funding

The Norwegian Air Ambulance Foundation financed the study. The funder had no role in the study design, data collection, analysis or preparation of the manuscript.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study was approved by the Regional Committee for Medical and Health Research Ethics (2017/280/REC West, Norway). In addition, the regional health authorities approved the use of patient- and administrative data. Patient identification variables were deleted by the main author (DSN) before analysis in accordance with the approval from REC West.
Consent for publication.
Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 2 July 2020 Accepted: 9 October 2020
Published online: 02 November 2020

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Publisher's Note

IV

BMC Emergency Medicine

RESEARCH ARTICLE

Open Access

Acute medical missions by helicopter medical service (HEMS) to municipalities with different approach for primary care physicians

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Abstract

Background: The prehospital emergency system in Norway involves out-of-hours (OOH) services with on-call physicians. Helicopter emergency medical service (HEMS) are used in cases of severe illness or trauma that require rapid transport and/or an anesthesiologist's services. In recent years, on-call primary care physicians have been less available for call-outs in Norway, and HEMS may be requested for missions that could be adequately handled by on-call physicians. Here, we investigated how different availability of an on-call physician to attend emergency patients at site (call-out) impacted requests and use of HEMS.

Methods: Our analysis included all acute medical missions in an urban and nearby rural OOH district, which had different approach regarding physician call-outs from the OOH service. For this prospective observational study, we used data from both HEMS and the OOH service from November 1st 2017 until November 30th 2018. Standard descriptive statistical analyses were used.

Results: The rates of acute medical missions in the urban and rural OOH districts were similar (30 and 29 per 1000 inhabitants per year, respectively). The rate of HEMS requests was significantly higher in the rural OOH district than in the urban district (2.4 vs. 1.7 per 1000 inhabitants per year, respectively). Cardiac arrest and trauma were the major symptom categories in more than one half of the HEMS-attended patients, in both districts. Chest pain was the most frequent reason for an OOH call-out in the rural OOH district (21.1%). An estimated NACA score of 5–7 was found in 47.7% of HEMS patients from the urban district, in 40.0% of HEMS patients from the rural OOH district ($p = 0.44$), and 12.8% of patients attended by an on-call physician in the rural OOH district ($p < 0.001$). Advanced interventions were provided by an anesthesiologist to one-third of the patients attended by HEMS, of whom a majority had an NACA score of ≥ 5.

Conclusions: HEMS use did not differ between the two compared areas, but the rate of HEMS requests was significantly higher in the rural OOH district. The threshold for HEMS use seems to be independent of on-call primary care physician involvement.

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Keywords: Emergency medical services, Primary health care, Air ambulances, Norway, HEMS, General practitioners, After-hours care, Out-of-hours medical care

Background

Different industrialized countries exhibit different organizations of prehospital emergency medical services [1]. The system is two-tied, with the specialized health service responsible for the EMCC and ambulances included HEMS, while municipalities are responsible for primary care OOH services with a on call physician [2]. Norwegian legislation requires that municipalities have at least one physician on-call 24/7, with the ability to call-out when needed in emergencies [2]. Ambulances are manned by emergency medical technicians (EMT) who have a minimum of two years in high school and two years of apprenticeship, while helicopter emergency medical service (HEMS) is manned by an anesthesiologist and a nurse or paramedic. The on-call physicians in the OOH services are mostly general practitioners (GPs) who take regular courses in emergency medicine. Unlike in many other countries, in Norway, on-call physicians are usually in contact with emergency patients before hospitalization. However, patients in time-critical situations can be transported directly to a hospital by an EMT without consulting a physician, but rather in cooperation with the EMCC. A recent study of acute admissions to Norwegian hospitals revealed that approximately 65% were referred by GPs or on-call physicians, while 35% were directly admitted [3].

In Norway, HEMS is dispatched to cases of severe illness or trauma with an anticipated need for treatment or supervision by an anesthesiologist. In addition to helicopters, this service includes rapid response cars used for missions near the base or when the helicopter is unavailable, e.g. in bad weather [4].

Cooperation between prehospital services is vital to ensure that patients receive the correct level of care. Over-triage is to some extent necessary and acceptable to ensure adequate care for patients requiring an anesthesiologist or on-call physician. Retrospective evaluation shows that some missions could have been handled with less use of resources. In addition to the accepted over-triage, different approach regarding call-outs from OOH services can contribute to unintentionally increased HEMS usage when on-call physicians are unavailable.

One previous study reported the decreasing involvement of on-call physicians in acute medical situations in one HEMS area in Norway [5]. Another study revealed no increase of HEMS use after an organizational change in an OOH district, which led to fewer physicians on-call and a larger response area for these physicians [6]. There is limited knowledge regarding HEMS usage in areas where the on-call physician do not respond with a call-out. For future service planning, and to ensure correct allocation of resources, it is of great interest to evaluate the use of HEMS in OOH districts that apply different approaches regarding call-outs from local primary care physicians.

Municipalities in Norway differ in their organization of OOH services. Some municipalities have a policy of calling out in almost all emergencies, while others lack the infrastructure to fulfill the demand, e.g. due to lack of rapid response cars for on-call physicians [7]. Reports indicate that on-call physicians have been less available during the last decade compared to in previous years [8–10], and HEMS may be used in missions that could alternatively be handled by OOH services.

The present study investigates how different availability of an on-call physician to attend emergency patients at site (call-out) impacted requests and use of HEMS. We also aimed to explore differences between patients encountered by HEMS and OOH on-call physicians.

Methods

Geographical setting and organization of services

The city of Bergen is located on the west coast of Norway, has about 300,000 inhabitants (2020), and spans an area of 445 km^2. The OOH service is organized with one large casualty clinic that is open 24/7. There are also three smaller casualty clinics in the suburban areas, which are open from 4–10 pm on weekdays and during daytime hours on weekends. Until November 2018, the OOH service was not able to perform call-outs. Near Bergen, there are two smaller municipalities, Os and Samnanger, where a total of 23,455 inhabitants (2019) live in an area of 409 km^2. This region has an intermunicipal OOH service with one casualty clinic, and has a rapid response car available for call-outs.

Haukeland University Hospital (HUS) is the nearest hospital to all three municipalities. The driving distance to HUS is approximately 5 min from the Bergen OOH casualty clinic, and approximately 30 min from the intermunicipal casualty clinic at Os. HEMS Bergen covers the three municipalities, and is located near HUS and a two-minute drive from the casualty clinic in Bergen. The majority of the inhabitants of Bergen city can be reached faster by the rapid response car than a helicopter. The ground ambulance service in Bergen municipality has four stations. On weekdays, 13 ambulances are available

during the daytime and 5 in the evening/night. Eight ambulances are available on weekends. In the municipalities Os and Samnanger, one ambulance is available 24/7.

Design

The study was a prospective, observational study. Until November 2018, the OOH service in Bergen had no car available for call-outs in emergencies. Acute medical situations were handled by ambulance workers, without physician involvement in the majority of cases. In less severe situations, on-call physicians were contacted by telephone, or the patient was transported to the casualty clinic. In more severe situations, HEMS Bergen was requested to assist the ambulance workers. In the municipalities Os and Samnanger, the OOH on-call physician was alerted in all acute medical situations, and most often responded with a call-out. In severe cases, HEMS was requested together with ground ambulances and the on-call physician.

The three municipalities are served by the same EMCC, HEMS base, and hospital, but had different approaches to call-outs from the OOH service in acute medical situations. They also differed in their distances to HEMS Bergen. No changes occurred in the prehospital system in this area during the period of data collection for the present study.

Data material

Our analysis included all acute medical missions, outside the hospital, with an on-site physician, in the three municipalities during the 13-month period from November 1st 2017 to November 30th 2018. For all missions in Bergen, we used data from HEMS Bergen, registered in the database "Airdoc". The registered data included patient data (age, gender, International Classification of Diseases code (ICD-10), National Advisory Committee for Aeronautics (NACA) score, symptoms, clinical findings, and treatment provided) and operational data regarding each mission with patient encounter. All registered missions from the OOH service in Os/Samnanger (hereafter called "rural OOH-service") with an on-site on-call physician were registered using an iPad with a digital form including the date, symptoms, clinical findings, treatment administered (and by whom), location, destination, NACA, and diagnosis code (ICPC-2). Data collection was planned and prospective to ensure a valid data set. A nurse at the rural OOH service continuously followed-up on missing data during the study period. Through the AMIS database, used in the EMCC, we collected the total number of acute medical missions in the municipalities.

Data presentation and statistical analysis

Data are presented according to groups of patients within the Bergen municipality who were attended by HEMS, and patients in the rural OOH district who were attended by the on-call physician. To compare diagnostic codes from ICD-10 and ICPC-2, we categorized the diagnoses into ten predefined symptom categories [11]. Interventions and treatments were categorized into none, basic, and advanced (Table 1), where advanced interventions being performed only by anesthesiologists. It is expected that basic interventions can be performed by on-call physicians, based on personal experience and training scenarios at mandatory courses in emergency medicine. NACA scores of 5–7 were considered to represent patients with acute threat to life, and thus this score was dichotomized into 0–4 and 5–7.

Standard descriptive analyses were performed using SPSS Statistics Version 25 IBM Corp., Armonk, NY, USA). Due to skewed data, age is presented as median with interquartile range (IQR) and compared using Mann–Whitney U-test. Fisher's exact test and Pearsons's Chi-square test were used for categorical variables. A p value of < 0.05 was considered statistically significant. Incidence is presented as rate per 1000 inhabitants per year, with the 95% confidence interval (CI).

Ethics

The study was approved by the Regional Committee for Medical and Health Research Ethics (2017/283/REC West, Norway). Prior to analyses, the patient identification variables were deleted by the main author (DSN).

Results

Table 2 shows that the rates of acute medical missions per inhabitants per year were similar between Bergen and the rural OOH district. The rate of HEMS requests was significantly higher in the rural OOH district compared with Bergen ($p < 0.05$). However, the rate of missions, in which HEMS attended the patients, did not significantly differ between Bergen and the rural OOH district. Table 2 also presents the numbers and rates of HEMS subcategories and types of patient transport. We found significant differences in the shares of helicopter use and rapid car missions, with the majority of helicopter missions occurring in the rural OOH district, and the majority of rapid car missions in Bergen ($p < 0.05$). OOH call-outs exclusively occurred in the rural OOH district, and were used in 66% of acute medical missions. Overall, a physician was sent to the site in 70% of acute medical missions in the rural OOH district (HEMS physician or OOH physician), compared to 4% of such incidents

Table 1 Categories of basic and advanced interventions used in this study

Basic

- ■Chest compressions
- ■Establish intravenous access
- ■Establish intraosseous access
- ■ECG
- ■Blood glucose measurement and management
- ■Prehospital thrombolysis
- ■Treatment of seizures and overdoses
- ■Stabilize and splint fractures
- ■Stop external bleeding with compression, elevation, packing, and/or tourniquet
- ■Pain treatment
- ■Immobilization of trauma patient using a splinting device (e.g. SAM sling)
- ■Use of other drugs available in the ground ambulance service/GP (cyklokapron, amiodarone, furosemide, Solu-Cortef, ondansetron, nitroglycerine, acetylsalicylic acid)

Advanced

- ■Intubation/tracheostomy
- ■Mechanical ventilation
- ■Thoracostomy/chest drain
- ■Chest compression device
- ■External cardiac pacing
- ■Anesthesia
- ■Central venous or arterial cannulation
- ■Blood products
- ■Use of ultrasound or nerve blocks
- ■Use of other drugs not available for the ambulance/GP

(ketamine, fentanyl, and suxamethonium chloride)

GPs are expected to perform basic interventions, whereas advanced interventions are only to be performed by an anesthesiologist

Table 2 Acute medical missions, request for helicopter emergency medical service (HEMS) and out-of-hours (OOH) call-outs

Variable	Bergen		Rural OOH district		*P* value
	n	*Rate (CI)*	*n*	*Rate (CI)*	
Acute medical missions	9176	30 (29–31)	744	29 (27–32)	0.61
HEMS requested	513	1.7 (1.5–1.8)	62	2.4 (1.8–3.1)	< 0.05
HEMS cancelled	234	0.8 (0.7–0.9)	32	1.3 (0.8–1.7)	0.42
HEMS encountered	279	0.9 (0.8–1.0)	30	1.2 (0.8–1.2)	0.15
Helicopter missions	30	0.1 (0.1–0.1)	24	1.0 (0.6–1.4)	< 0.05
Rapid car missions	249	0.9 (0.8–1.0)	6	0.3 (0.1–0.5)	< 0.05
OOH call-outs	0	0 (0)	493	20 (18–21)	< 0.05

Numbers and rates (per 1000 inhabitants per year) of acute medical missions, request for and subgroups of helicopter emergency medical service (HEMS) responses, and out-of-hours (OOH) call-outs in the municipality Bergen and in the rural OOH district

p value analyzed between rates in Bergen and in the rural OOH district

in Bergen (HEMS physician exclusively). HEMS served Bergen and the rural OOH district areas at rather similar rates.

Table 3 presents demographic data regarding the patients in the rural OOH district and Bergen, according to the different services. The median age was significantly higher for the patients attended by OOH on-call physicians in the rural OOH district compared with patients attended by HEMS in both areas ($p < 0.05$). Among the patients encountered by HEMS in the rural OOH district, 80% were attended on-site, by the on-call physician.

We identified significantly different patterns of symptom diagnoses between HEMS and OOH services. Cardiac arrest and trauma were the major symptom categories among patients encountered by HEMS in both Bergen and the rural municipalities (57.4% and 56.6%, respectively), while these two categories represented only 20.2% of patients attended by OOH services in the rural OOH district. Chest pain was the most frequent reason for an OOH call-out in the rural OOH-district (21.1%).

The hospital was the final destination for 74.2% of the patients encountered by HEMS in Bergen, and 66.7% of the patients encountered by on-call physicians in the

Table 3 Demographic data regarding gender, mean age, medical condition, and destination categorized into three groups

	Bergen		Rural OOH district			
	HEMS		HEMS		OOH	
	n	**%**	***n***	**%**	***n***	**%**
Gender						
Female	96	34.4	10	33.3	209	42.4
Male	183	65.6	20	66.7	273	55.4
Missing	0	0	0	0	11	2.2
Total	279		30	100.0	493	
Age	*Median*	*IQR*	*Median*	*IQR*	*Median*	*IQR*
Female	53.0	27–70	47.0	12–51	54.0	33–77
Male	51.0	29–70	57.0	32–71	59.0	34–74
Total	51.0	29–70	50.0	27–62	58.0	34–75
Medical condition	*n*	*%*	*n*	*%*	*n*	*%*
Cardiac arrest	78	28.0	7	23.3	17	3.4
Trauma	82	29.4	10	33.3	83	16.8
Breathing difficulties	15	5.4	1	3.3	45	9.1
Chest pain	5	1.8	2	6.6	104	21.1
Stroke	3	1.1	0	0.0	51	10.3
Acute neurology, e.g. stroke	28	10.0	3	10.0	60	12.2
Psychiatry, including intoxication	12	4.3	0	0.0	43	8.7
Obstetrics and childbirth	7	2.5	2	6.6	10	2.0
Infection	15	5.4	1	3.3	26	5.3
Other	30	10.8	1	3.3	49	9.9
Missing	4	1.4	1	3.3	5	1.0
	279	100.0	30	100.0	493	100.0
Destination	*n*	*%*	*n*	*%*	*n*	*%*
Treated on site	0	0.0	0	0.0	65	13.2
Dead on site	43	15.4	7	23.3	17	3.4
Casualty clinic	27	9.7	3	10.0	42	8.5
Hospital	207	74.2	20	66.7	329	66.7
Other	2	0.7	0	0.0	6	1.2
Missing	0	0.0	0	0.0	34	6.9
	279	100.0	30	100.0	493	100.0

HEMS Helicopter emergency medical service, *OOH* Out-of-hours, IQR inter-quartile range

rural OOH-district ($p < 0.05$). Among patients in the rural OOH district, the hospitalization rate was the same between those attended by HEMS compared to those attended by the on-call physician alone (66.7%). A NACA score of 7 (death) was more frequent among HEMS patients.

Figure 1 presents the distributions of NACA scores in the OOH service and HEMS. A NACA score of 5–7 was reported in 47.7% of the HEMS patients in Bergen, compared to 40.0% of HEMS patients in the rural OOH district ($p = 0.44$). Among patients attended by an on-call physician in the rural OOH district, 12.8% had a NACA score of 5–7 ($p < 0.001$, compared with HEMS in Bergen).

Table 4 shows the usage of different interventions in each group. Advanced interventions were administered to approximately one-third of the patients attended by HEMS in both Bergen and in the rural OOH district. Of those patients, a NACA score of ≥ 5 was reported for 87.6% of the patients in Bergen and 54.5% of those in the rural OOH district. Intubation accounted for 75% of the advanced interventions in Bergen and 45.5% in the rural OOH district. Patients with cardiac arrest and trauma were most commonly administered advanced interventions: 59.6% and 24.7%, respectively, among HEMS patients in Bergen; and 27.2% and 36.3%, respectively, among HEMS patients in the rural OOH district.

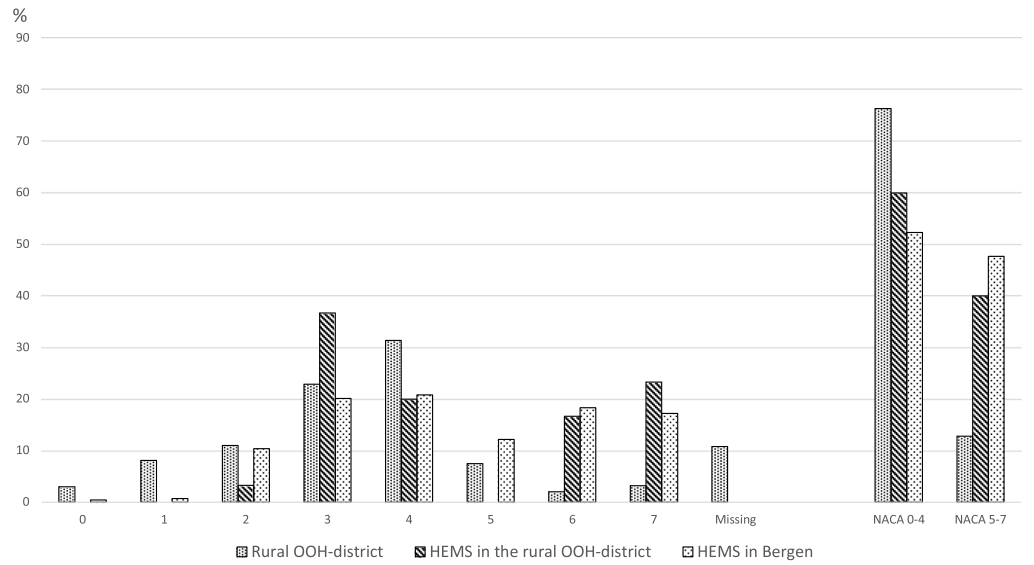

Fig. 1 Distribution of NACA scores. Distribution of NACA scores in primary missions with patient encounters by an on-call physician in the rural out-of-hours (OOH) district, helicopter emergency medical service (HEMS) in the rural OOH district, and HEMS in Bergen

Table 4 Level of treatment performed by physicians

	Rural OOH district		HEMS in Bergen		HEMS in rural OOH district	
	n	%	*n*	%	*n*	%
None	211	42.8	83	29.7	2	6.7
Basic	282	57.2	107	38.4	17	56.7
Advanced	0	0.0	89	31.9	11	36.6

Level of treatment performed by on-call physician in the rural out-of-hours (OOH) district, helicopter emergency medical service (HEMS) in Bergen, and HEMS in the rural OOH district

Discussion

The similar rates of completed HEMS missions in Bergen and in the rural OOH district indicate that the decision to use HEMS was not affected by the type of transport, or the distance between the patient and HEMS base. Neither did the attendance of an on-call physician from the OOH service have impact on the use of HEMS. The rate of acute medical missions was also rather similar between the municipalities, indicating that the EMCC assigns the same level of urgency regardless of patient location. HEMS was performing advanced interventions to the same amount of patients in both areas and indicating that patients in Bergen and the rural OOH district have same degree of severity and need for advanced treatment performed by HEMS.

A systematic review concluded that HEMS use is region-specific, and that dispatch criteria should be adjusted to the specific prehospital system [12]. In Norway, HEMS response requires a medical indication and acceptance from the HEMS physician. If the EMCC had requested HEMS more frequently in Bergen compared with the rural OOH district, we would expect a higher number of cancelled requests in Bergen since the rates of completed missions were similar. However, our data indicated the opposite trend, with a higher rate of cancelled requests in the rural OOH district compared with Bergen—although this difference was not statistically significant. It is possible that the EMCC may request HEMS at an earlier stage in the rural municipalities, due to the increased distance and response

time compared to missions in Bergen. Additionally, an on-call physician may already have attended patients in the rural OOH district, and concluded that there was no medical indication for HEMS. Finally, sometimes a patient may be less critically ill than expected, resulting in mission cancellation.

Prehospital services staffed with anesthesiologists are used worldwide, but comparison among European countries reveals large variations in the availability of helicopters for medical emergencies [13]. The systems used by Scandinavian countries are similar in many ways, but also differ in the volume of patient encounters, service areas, and time variables [14]. Compared with Norway and Finland, Denmark and Sweden have higher volumes of patient encounters by prehospital services. In Denmark, rapid response cars are staffed with anesthesiologists, and GPs do not play the same role in acute emergencies compared with Norway. While it is not necessarily a goal to ensure similar services across the borders, it is useful to exchange knowledge about how organizational differences and changes affect other prehospital services, which can contribute to improving resource use and allocation.

There are debates regarding the benefits of HEMS use. A Cochrane review concluded that it remains unclear which elements of HEMS service benefit trauma patients: rapid transport and/or advanced interventions [15]. Patients with NACA scores of 4–6 are thought to have better outcomes when attended by HEMS [16]. However, the validity of the NACA score has not been thoroughly examined, and one study revealed large differences between individual raters and references in some clinical cases [17]. The "First Hour Quintet" (cardiac arrest, respiratory failure, trauma, acute coronary syndrome, and stroke) are critical conditions with great importance in prehospital emergency care [18], and are conditions for which HEMS can be indicated. Patients encountered by HEMS frequently receive advanced interventions, especially airway management, such as intubation [19]. As isolated variables, NACA score, clinical condition, and use of advanced interventions are not sufficient to indicate whether HEMS is necessary; however, these measures can be used together to determine the need for HEMS, and are useful for comparison between different services.

In the present study, the NACA scores among HEMS patients were similar between patients in Bergen vs. the rural OOH district, indicating that the lack of on-call physicians on site in Bergen did not lower the severity threshold for HEMS use in this area. Comparing NACA scores between call-outs from the OOH service and HEMS revealed significantly higher NACA scores among HEMS patients. This illustrates that medical emergencies represent a continuum from moderate to life-threatening situations, and that the OOH services in Norway handle a majority of patients with mild and moderate symptoms, while HEMS has expertise in treating patients with life-threatening conditions. Nationally, among patients treated within the OOH services in 2018, 7.7% have an acute and potentially life-threatening situation [20], while 62% of patients attended by HEMS have a NACA score of 4–7 [21]. This is similar to findings regarding NACA score among HEMS patients in Denmark [22]. Still, many of the patients attended by HEMS in Bergen and the rural OOH district had a NACA score of ≤ 3. This reflects the difficulties faced by EMCC operators when performing triage with limited information about the patients. In Norway, an over-triage of requesting HEMS is accepted, to reduce late arrivals and the potential negative influence on patient outcomes [16].

With regards to symptom categories, the HEMS group showed significantly higher rates of cardiac arrest and trauma compared with the OOH service in the rural OOH district, while stroke and chest pain were more frequent in the rural OOH district. Previous findings suggest that HEMS may improve survival in cases of cardiac arrest outside of the hospital, primarily after return of spontaneous circulation (ROSC) [23]. Although cardiac arrest is a life-threatening situation, HEMS requests may be cancelled based on further information about the onset time of bystander CPR, comorbidities, and clinical findings; therefore, not all patients with cardiac arrest were attended by HEMS in the rural OOH district. It is likely that HEMS use was more commonly indicated when it was expected to promote a better health outcome compared with ground ambulance and/or on-call physicians alone. Stroke is a time-critical condition that benefits from rapid transport to hospital. The relatively short travel distance to the hospital from the rural OOH district can explain why few patients with symptoms of stroke were encountered by HEMS.

Advanced interventions were most commonly performed for patients with NACA scores of ≥ 5 in Bergen. Retrospective evaluation reveals that advanced interventions can sometimes have poor effects—for example, intubation of a patient who ultimately has a NACA score of 7 (death) would not have the intended effect, but should not be considered an unnecessary intervention, as it is difficult to predict which patients will benefit from resuscitation. The fact that advanced interventions are mostly used in cases with cardiac arrest and trauma with a NACA score ≥ 5 indicates a correlation between severity and the need for HEMS.

Our present results showed a significantly lower rate of hospitalized patients who were attended by an on-call physician in the rural OOH district, compared with those

attended by HEMS in Bergen. This is probably because the on-call physician attended patients with all grades of severity, and also due to the effect of having the on-call physician on site. Among patients encountered in the rural OOH district, the hospitalization rate was the same between those attended by HEMS compared to the on-call physician. Although the NACA scores were lower in the group attended by the on-call physician, equal proportions of the patients required admission to the hospital.

The role of on-site attendance by an on-call primary care physician is uncertain [24]. The presence of on-call primary care OOH physicians in medical emergencies in Bergen may be less important, since the ambulance service in Bergen has short transport distances to both the hospital and the OOH casualty clinic. In Norway, EMCC dispatches prehospital resources based on the limited information given by the caller and the potential severity, using a criteria-based triage system called the Norwegian Index for medical emergency assistance (Index) [25]. When warranted, HEMS is requested in addition to ground ambulances and on-call physicians, rather than as a replacement. In severe emergencies, multiple resources are often needed. Notably, in 2019, HEMS requests were cancelled in 14.2% of missions due to concurrencies, bad weather, or technical reasons [26]. Our present results demonstrate this resource allocation within the rural OOH district, where 80% of the HEMS missions also had an on-call physician at the site. The overlap and cooperation between different services is a strength of the prehospital system in Norway. Further research should investigate which patients benefit from attendance by an on-site physician, and how dispatch criteria can be more accurate.

Strengths and limitations

The two OHH services compared in our study had different abilities to call-out, and no major changes occurred during the study period. The inhabitants of the municipalities were all served by the same hospital, EMCC, and HEMS base. Our analyses included all data from HEMS Bergen in the three municipalities, and all registered call-outs from the OOH service in the rural OOH district. However, there are several differences between these areas. The city of Bergen is much larger than the municipality center of Os and Samnanger, which may correspond to increased numbers of intoxications and traumas. Furthermore, the data were from one EMCC area, and more robust data could have been obtained through multicenter data collection. Notably, HEMS attended only 30 patients in the rural OOH district. Nevertheless, our results are likely generalizable to similar geographical areas in Norway. Our present study did not include data regarding outcome among the hospitalized patients. which could have given knowledge if treatment and level of care had impact on survival.

Conclusions

Our results did not show different use of HEMS between the two compared OOH districts; however, the rate of HEMS requests was significantly higher in the rural OOH district. Additionally, NACA scores were significantly lower among patients attended by on-call physicians alone compared to those attended by HEMS. Use of advanced interventions did not differ between patients attended by HEMS in urban vs. rural OOH districts. Overall, the threshold for HEMS use seems to be independent of the availability of on-call primary care physicians, and we found no reasons to recommend a change in the current policy for accepting missions in HEMS.

Abbreviations

CI: Confidence interval; EMCC: Emergency Medical Communication Center; EMT: Emergency Medical Technicians; GP: General Practitioner; HEMS: Helicopter Emergency Medical Service; HUS: Haukeland University Hospital; ICD-10: International Classification of Diseases code; ICPC-2: International Classification of Primary Care; Index: Norwegian Index for medical emergency assistance; LEMC: Local Emergency Medical Communication Centers; NACA : National Advisory Committee for Aeronautics; OOH: Primary care out-of-hours service; Rural OOH-service: OOH service in the municipalities Os and Samnanger.

Acknowledgements

Collection of data from the rural OOH-district was possible with extensive help from the nurses at the casualty clinic at Os.

Authors' contributions

DSN, ØØ, SH and EZ planned and designed the study. DSN and ØØ collected the data. DSN performed the statistical analyses. DSN drafted the manuscript. ØØ, SH and EZ participated in critical revision of the manuscript. All authors read and approved the final manuscript.

Funding

Open access funding provided by University of Bergen. The Norwegian Air Ambulance Foundation financed the study. The funder had no role in the study design, data collection, analysis or preparation of the manuscript. Stiftelsen Norsk Luftambulanse

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Regional Committee for Medical and Health Research Ethics (2017/283/REC West, Norway). Prior to analyses, the patient identification variables were deleted by the main author (DSN). REC West approved an exception of informed consent from the participants due to no identifying data in the analysis.

Consent for publication

Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Received: 18 July 2021 Accepted: 25 May 2022
Published online: 08 June 2022

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Publisher's Note

Graphic design: Communication Division, UiB / Print: Skipnes Kommunikasjon AS

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ISBN: 9788230869338 (print)
9788230845684 (PDF)