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Pediatric Emergencies in Helicopter Emergency Medical Services: A National Population-Based Cohort Study From Denmark

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Study objective: To examine the diagnostic pattern, level of severity of illness or injuries, and mortality among children for whom a physician-staffed helicopter emergency medical service (HEMS) was dispatched.

Methods: Population-based cohort study including patients aged less than 16 years treated by the Danish national HEMS from October 1, 2014, to September 30, 2018. Diagnoses were retrieved from inhospital medical records, and the severity of illness or injuries was assessed by a severity score on scene, administration of advanced out-of-hospital care, need for intensive care in a hospital, and mortality.

Results: In total, 651 HEMS missions included pediatric patients aged less than 1 year (9.2%), 1 to 2 years (29.0%), 3 to 7 years (28.3%), and 8 to 15 years (33.5%). A third of the patients had critical emergencies (29.6%), and for 20.1% of the patients, 1 or more out-of-hospital interventions were performed: intubation, mechanical chest compressions, intraosseous vascular access, blood transfusion, chest tube insertion, and/or ultrasound examination. Among the 525 patients with hospital follow-up, the most frequent hospital diagnoses were injuries (32.2%), burns (11.2%), and respiratory diseases (7.8%). Within 24 hours of the mission, 18.1% of patients required intensive care. Twenty-nine patients (5.1%, 95% confidence interval [CI] 3.6 to 7.3) died either on or within 1 day of the mission, and the cumulative 30-day mortality was 35 of 565 (6.2%, 95% CI 4.5 to 8.5) (N=565 first-time missions).

Conclusion: On Danish physician-staffed HEMS missions, 1 in 5 pediatric patients required advanced out-of-hospital care. Among hospitalized patients, nearly one-fifth of the patients required immediate intensive care and 6.2% died within 30 days of the mission. [Ann Emerg Med. 2022;80:143-153.]

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INTRODUCTION

Background

Several different set-ups of helicopter emergency medical services (HEMSs) exist globally, and they provide various levels of medical care to pediatric patients with critical emergencies.[1-4] "Unintentional injuries" are the most frequent cause of death among children after the first year of life according to the Centers for Disease Control and Prevention, United States, and the Royal College of Paediatrics and Child Health and National Children's Bureau, United Kingdom.[5,6] Naturally, research on HEMSs concerning pediatric patients is largely focused on comparing outcomes of trauma patients in relation to ground emergency medical service (EMS) transport.[1,7-10]

In previous studies of pediatric patients for whom HEMS has been dispatched, descriptions were either limited to dispatch criteria pertaining to chief complaints, clinical signs, or specific accident types or categorized as "major/minor trauma" or "nontrauma" cases.[2,3,11-15] The studies do not provide hospital diagnoses explicating the external causes of injuries or etiology of illnesses that led to the dispatch of HEMS. The existing literature is short of studies describing out-of-hospital care, hospitalization, and mortality for pediatric HEMS patients with all types of medical emergencies.[3,15] An American study described demographics, types of illnesses and injuries, and treatments among patients in Pediatric Emergency Care Applied Research Network-affiliated EMSs, including 2

Editor's Capsule Summary

What is already known on this topic

Helicopter EMS systems are widespread.

What question this study addressed

What is the nature of pediatric helicopter transports in a single-nation EMS system?

What this study adds to our knowledge

This study of 651 pediatric helicopter EMS transports over 4 years details the demographics, out-of-hospital care and interventions, ultimate hospital diagnoses, and 30-day mortality.

How this is relevant to clinical practice

This study describes the care provided by helicopter EMS physicians to pediatric patients as recorded using a high-quality, centralized database.

HEMS agencies. However, data aggregation across agencies was complicated by variable data collection methods and missing data.[12]

Importance

We provide a population-based study that covers an unselected HEMS population and not exclusively trauma patients. The Danish health registries allow nationwide hospital follow-up. Thus, we were able to report the final hospital diagnosis and patient-centered outcomes, including short-term mortality, for the Danish pediatric HEMS population throughout the entire chain of care. For the individual HEMS physician or HEMS crew member, the infrequency of pediatric emergencies implies that it is important to train and maintain pediatric advanced life support skills and the management of common pediatric medical emergencies.[16,17] Population-based studies can help target in-service training of both ground and helicopter EMS personnel to improve patient outcomes.

Goals of This Investigation

The study objectives were to determine the final hospital diagnoses among pediatric patients for whom a physician-staffed HEMS was dispatched and level of severity of illness or injuries among those children, assessed by both out-of-hospital and inhospital outcomes: severity score assessed on scene by HEMS physician, performance of advanced out-of-hospital care, need for intensive care in hospital, and short-term mortality.

METHODS

Study Design and Setting

We performed a population-based historical cohort study including patients aged less than 16 years treated by the national physician-staffed HEMS for 4 consecutive years: October 1, 2014, to September 30, 2018. The total Danish HEMS population has been described in previous works.[16] In the present study, a separate dataset for the subgroup of children was made according to the inclusion criteria. The reporting of the study follows the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[18]

Denmark is geographically divided into 5 regions, each responsible for operating health care services, including general practitioners, university hospitals and district general hospitals, and EMSs. All Scandinavian countries have similar structures, where the health care system is publicly funded. The EMSs are free of charge for both citizens and noncitizens, and the HEMS is a national service integrated into the health care system. Each region operates an emergency medical dispatch center that is responsible for the disposal of all out-of-hospital units, such as ambulances and rapid response vehicles, which are manned by paramedics, and mobile emergency care units (MECUs) and helicopters, which are staffed with an experienced physician specialized in anesthesiology and intensive care medicine. A specially trained paramedic, "HEMS crew member," assists both the pilot and the physician. These physician-staffed units are dispatched along with an ambulance using a rendezvous model.[19] The MECU or HEMS physician can escort the patient to a hospital in an ambulance or in a helicopter.

The health professionals at the emergency medical dispatch center manage the dispatch of EMS units according to the level of urgency: A to E, with A as the most urgent. They use a criteria-based dispatch decision support tool, the Danish Index for Emergency Care. For pediatric patients, HEMS dispatch criteria are as follows: child with a serious life-threatening condition and the helicopter is the nearest physician-level EMS resource. This corresponds to the abovementioned dispatch decision support tool, chapter 30: Child with illness - urgency level A (Figure E1, available at http://www.annemergmed.com; translated from original language).

The dispatcher's choice of a physician-staffed ground- or helicopter-based unit depends on the location of both the incident and the unit at the time of dispatch. Consequently, an HEMS is dispatched for offshore island missions. The helicopters are type EC 135 P2e (Airbus Helicopters). In cases of major emergencies, 4 search and rescue helicopters can assist the HEMS. They are provided by the Joint Rescue Coordination Centre Denmark and operated by the Danish Air Force (https://www.forsvaret.dk/en/roles-and-responsibilities/national-role/).

In 2020, there were 5,952 emergency calls per 100,000 inhabitants in Denmark. An HEMS is dispatched for roughly 1% to 2% of the emergency calls to the national alarm number 112. The number of physician-staffed MECUs varies between the 5 regions, and they are engaged in about 20% to 25% of ambulance dispatches.[20] Approximately 11% of the patients attended by a physician-staffed MECU in one of the largest Danish cities were children.[17] Denmark has an area of 42,947 km^2 (16,582 sq mi) and no mountainous areas. During the study period, the national HEMS operated 24 hours a day from 3 bases. A fourth base was added to the national service in 2019. However, because the study period ended in 2018, no flights from this base were included. HEMS missions are mainly dispersed over the country's semirural and rural areas, including more than 65 inhabited islands (approximately 1% of the population lives on offshore islands). Children younger than 16 years of age comprised 18.0% of the background population of 5,707,252 Danes during the study period (per January 1, 2016).[21]

Ethics Approval

Danish Air Ambulance (https://www.akutlaegehelikopter.dk/en/) agreed to disclose data. We obtained permission from the North Denmark Region to collect and store data with reference to General Data Protection Regulation standards (ID 2018-152). The Danish Patient Safety Authority granted permission to disclose data from the patients' medical records (reference 3-3013-2707/1). According to Danish legislation, no approval from an ethics committee is required for registry-based studies without patient encounters.

Selection of Participants

Patients were included from the HEMS database (*HEMSfile*) delimited by age (<16 years) and study period. The database contains all helicopter dispatches registered since the implementation of the national HEMS in 2014.[22] Each event in the study represents a patient on a "primary mission." Before dispatch, a layperson or health professional would have contacted an emergency medical dispatch center via the national emergency phone number 112, or ground EMS personnel at the scene would have requested HEMS assistance. Interfacility transfers were excluded from the study. All inhabitants in Denmark have a unique 10-digit personal identification number, the Civil Personal Registry (CPR) number. A unique patient could be included in the study more than 1 time because a HEMS mission was the event unit.

Data Collection

Data collection for the *HEMSfile* database was conducted by the operator, Danish Air Ambulance (https://www.akutlaegehelikopter.dk/en/), by the attending HEMS physician. Data was collected consistently for all 4 years included in the study period. The completeness of the included variables is exceedingly satisfactory.[22] The database contains different types of operational data (eg, destination, timestamps for alarm, lift-off, etc). A brief medical record is written after each mission (eg, CPR number, type of emergency, and interventions performed at the scene or during transport). Data from the *HEMSfile* were linked to The Danish National Patient Registry via CPR number to retrieve valid patient-centered outcomes.[23] The registry contains all hospital encounters, whether they are acute, elective, or outpatient activities. The encounters are separated at a department level, and consequently, all encounters with an ICU are present in the registry. We linked a hospital encounter to the HEMS mission if the entry in the hospital registry had happened within 5 hours of alarming the HEMS. Linkage for the outcome mortality was possible through the Danish Civil Registration System.[24] Data management and analysis were performed by remote desktop accessed through a secure virtual private network tunnel at the Danish Health Data Authority for pseudonymization.

Outcomes

Diagnoses were labeled by the first hospital department receiving the patient after appropriate diagnostic tests. They used the *International Classification of Diseases, Tenth Revision* (ICD-10), and this signified that missing data on hospital diagnosis was minimal.[25] If the label read a diagnosis from chapters XVIII (*"Symptoms and abnormal findings, not elsewhere classified"*) or XXI (*"Factors influencing health status and contact with health services"*), the successive organ-specific or cause-specific diagnosis during the hospital stay was applied. The ICD-10 diagnoses were reported at a chapter level and, for the most common pediatric diagnoses, at a subchapter level.

Out-of-hospital outcomes of the level of severity of illness or injuries were the National Advisory Committee for Aeronautics (NACA) score and the administration of advanced out-of-hospital care. The eight-level NACA score is classified by the attending HEMS physician, ranging from no injury or disease (score of 0) to lethal injury or disease (score of 7).[26] The score was dichotomized for analysis: 0 to 3 denotes "noncritical emergencies" and 4 to 7 denotes "critical emergencies" according to existing literature.[16,21] The registration of out-of-hospital interventions, either performed by ground or helicopter EMS personnel, was reliable because all of the 7 variables denoting an out-of-hospital intervention had "a high degree of data completeness."[22] The time from HEMS alarm to "need for intensive care" was the interval between the timestamp of the emergency call and the patient's registration with a code for either "intensive care observation" and/or "intensive care" in the hospital registry. All patients with a known identity were followed for 30 days and only discontinued in the case of death. Time of death was available by date but not by the exact time of day. One-day mortality was defined as death on the date of the HEMS alarm or on the following date. As we did not have a registered CPR number for all patients and thus no registry data, we also used the predefined variable in the *HEMSfile*, "Mission outcome," denoting if the patient was alive at the end of the mission. We assumed a patient to be dead on arrival of the HEMS if he or she had a NACA score of 7 and no out-of-hospital interventions were performed. Age was grouped according to the Pediatric Triage Model used nationally in ground-based EMS systems.[27] Data from *HEMSfile* regarding patients without a registered CPR number who were registered with an age of "0" were not reliable. This was because the system automatically labeled birth date as today's date in the absence of a CPR number, and hence, they were not regarded as pediatric patients.

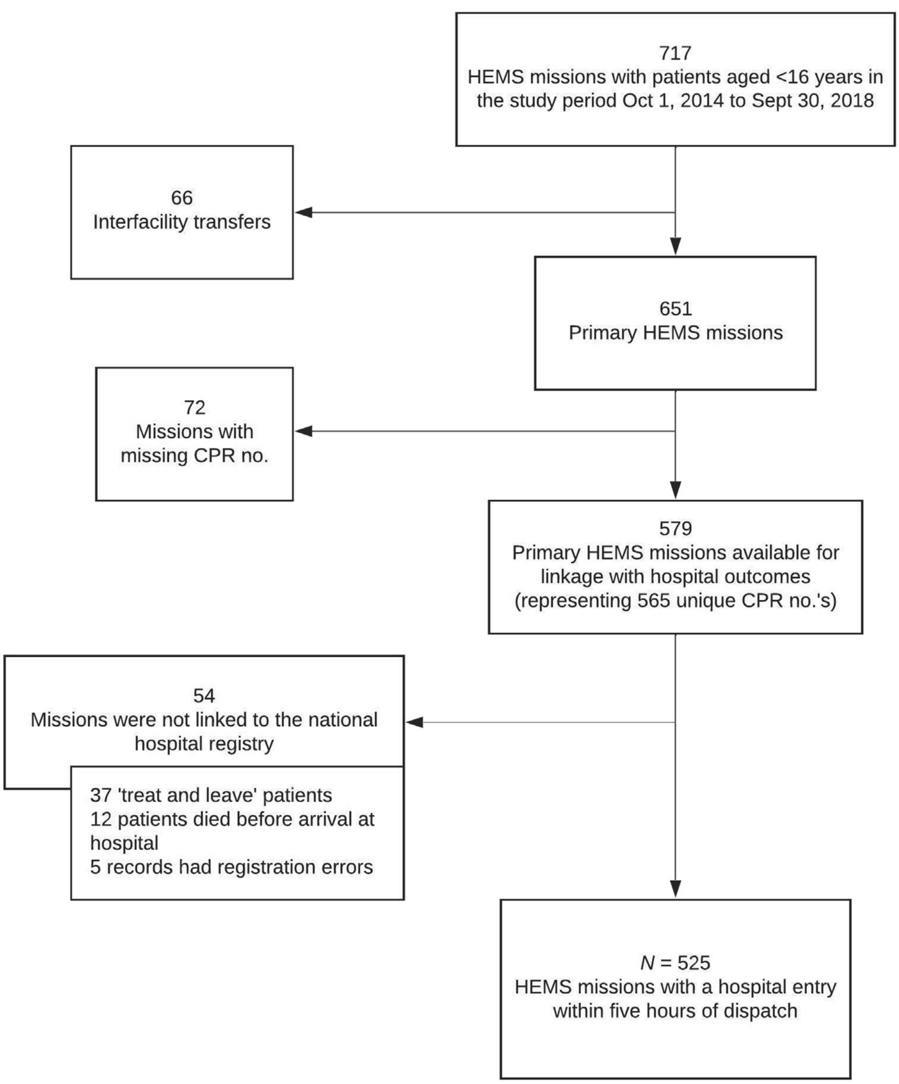


Figure 1. Patient inclusion flowchart. In Denmark, a CPR number is a personal identification number.

Table 1. Characteristics of HEMS missions with pediatric patients, displayed for all patients and for patients conveyed to hospital separately.

Variables	All Patients (N=651) n (%)	Patients Conveyed to Hospital (N=525) n (%)
Offshore island mission	80 (12.3)	65 (12.4)
Arrival at the scene, time of day		
Day 8 AM – 4 PM	298 (45.8)	239 (45.5)
Evening 4 PM – 12 AM	299 (45.9)	243 (46.3)
Night 12 AM – 8 AM	54 (8.3)	43 (8.2)
On-scene time, minutes		
0-15	192 (29.5)	158 (30.1)
15-30	315 (48.4)	257 (49.0)
30-45	90 (13.8)	74 (14.1)
45-60	26 (4.0)	19 (3.6)
≥60	13 (2.0)	8 (1.5)
Missing data*	15 (2.3)	9 (1.7)
Male sex	344 (52.8)	316 (60.2)
Missing data*	72 (11.2)	0 (0.0)
Age, y		
<1	60 (9.2)	50 (9.5)
1-2	189 (29.0)	160 (30.5)
3-7	184 (28.3)	135 (25.7)
8-15	218 (33.5)	180 (34.3)
NACA score		
Assessed on scene by HEMS physician		
0: No injury or disease	6 (0.9)	0 (0.0)
1: Injury or disease without any need for medical treatment	46 (7.1)	16 (3.1)
2: Injury or disease requiring medical treatment, but hospital admission is not indicated	122 (18.7)	101 (19.2)
3: Injury or disease without acute threat to life but requiring hospital admission	284 (43.6)	258 (49.1)
4: Injury or disease that can be potentially lethal	109 (16.7)	93 (17.7)
5: Injury or disease with acute threat to life, immediate treatment necessary	29 (4.5)	25 (4.8)
6: Injury or disease with manifest failure of vital organ functions	31 (4.8)	26 (5.0)
7: Lethal injury or disease (with or without resuscitation attempts) with death on scene or within the timespan, the service is responsible for	24 (3.7)	6 (1.1)
Mission outcome		
Treat and leave	48 (7.4)	5 (1.0)
Transported to a hospital:		
By helicopter	331 (50.8)	295 (56.2)
By ambulance, escorted by HEMS physician	28 (4.3)	28 (5.3)
By ambulance, no escort by HEMS physician	185 (28.4)	162 (30.9)
Patient dead	23 (3.5)	NA†
Missing data*	36 (5.5)	35 (6.7)

NA, Not applicable.
*"Missing data" rows indicate missions with missing data on the variable in question, if any. No data was imputed.
†Too few cases to report. Deceased patients were added to the "missing data" row.

Analysis

All categorical variables are presented by frequencies, followed by proportions. The outcome "need for intensive care" is reported as incidence proportion: the number of patients requiring intensive care within 24 hours of alarming HEMS divided by the number of patients at risk, that is, patients who were hospitalized. Kaplan-Meier failure curves for "need for intensive care" are presented both for the entire hospital population and grouped by the dichotomized NACA score. Curves were cut off at 24 hours as they leveled off. The curves are supplemented by risk estimates with 95% confidence intervals (CIs) in the 2 NACA groups for preset time points following the HEMS alarm. It was not appropriate to report the exact number of failures at each step because of a possible risk of identification of the subjects. The proportion of deaths was reported as prevalence using first-time missions only and calculated by "modified Poisson regression" with robust variance estimation.[28] For patients without a registered CPR number, hospital follow-up was not possible. Some of those patients were tourists or other residing noncitizens. In other cases, the registration of a CPR number might have been given a low priority in cases of very critical emergencies. Therefore, we performed sensitivity analyses for all patients without a CPR number. Risk differences were calculated for NACA scores and performance of out-of-hospital interventions among unidentified patients compared to patients with valid CPR numbers. For analysis, we used Stata/MP 17.0 (StataCorp LLC).

RESULTS

Characteristics of Study Subjects

We identified 717 HEMS missions with patients younger than 16 years of age, of which 66 were interfacility transfers. Out-of-hospital outcomes were available for all remaining 651 patients. A unique patient could have been involved in several missions; 555 patients had 1 mission and 10 patients had 2 or more missions within the study period. Patients with missing CPR numbers and some of the patients who died before arrival at the hospital had no hospital follow-up. Finally, 525 primary missions were linked with hospital outcomes (Figure 1). Characteristics of the study subjects are presented in Table 1. The majority of HEMS missions were for patients situated on the mainland with a median response time of 19 (interquartile range 13 to 27) minutes. Thirty-eight of the pediatric HEMS patients were infants and toddlers aged 2 years or younger. Most patients were conveyed either by a helicopter or by ground EMSs, with or without assistance from the HEMS physician (83.6% altogether). However, not all patients required hospital care; in 48 (7.4%) of the 651 cases, HEMS personnel decided to "treat and leave" the patient. The level of severity of the patient's illness or injuries assessed at the scene was centered around the middle values, NACA levels 2 to 4 (Table 1). Twenty-four patients had the highest NACA score possible, representing lethal injury or disease with or without resuscitation attempts. The proportion of patients with "critical emergencies" (NACA scores 4 to 7) did not seem to differ among patients on offshore island missions compared with patients on mainland missions (risk difference 0.08 [95% CI −0.02 to 0.18]). Advanced out-of-hospital care was administered to 20.1% of all patients (Table 2). Endotracheal intubation and ultrasound examination were the most frequently performed interventions.

Main Results

Hospital diagnoses are presented in Table 3. Half of the patients had a hospital diagnosis within the ICD-10 "Injury" chapter, which includes, besides trauma and

Table 2. Advanced out-of-hospital care for pediatric HEMS patients, administered by either ground or helicopter EMS. No missing data.

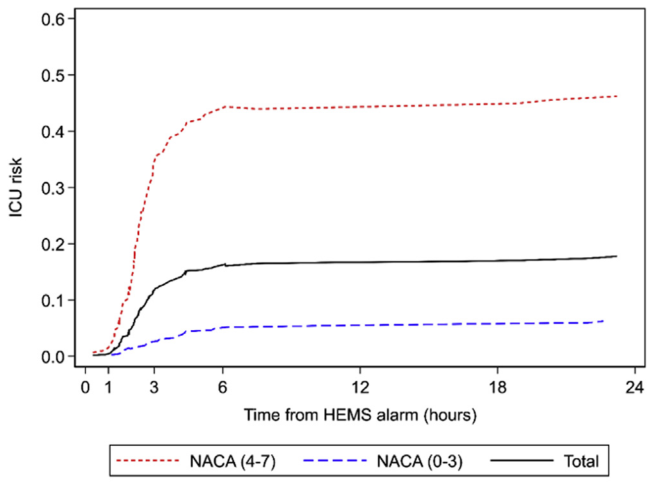
Out-of-Hospital Care	All Patients (N=651) n (%)	Patients Conveyed to Hospital (N=525) n (%)
Patients requiring intervention(s)*	131 (20.1)	100 (19.0)
Intubation	78 (12.0)	57 (10.9)
Surgical airway	0 (0.0)	0 (0.0)
Mechanical chest compressions	10 (1.5)	6 (1.1)
Intraosseous vascular access	41 (6.3)	27 (5.1)
Blood transfusion	5 (0.8)	<5 (<1.0)
Ultrasound examination	74 (11.4)	57 (10.9)
Chest tube insertion or mini-thoracostomy	6 (0.9)	<5 (<1.0)

*A unique patient may have required multiple interventions. Proportions indicate interventions performed divided by all patients at risk and therefore do not add up to a 100%.

Table 3. Hospital diagnosis for patients conveyed to hospital, either by ground or helicopter EMS, listed by frequency with wording accustomed to ICD-10-CM. N=525 patients.

ICD-10 Diagnosis		**n**	**(%)**
Chapter or subchapter level (subordinate rows)			
XIX	Injury, poisoning and certain other consequences of external causes	271	(51.6)
	S00-S19 Injuries to the head and neck	61	
	S20-S39 Injuries to the thorax, abdomen, lower back, lumbar spine, pelvis and external genitals	15	
	S40-S69 Injuries to the upper extremity	16	
	S70-S99 Injuries to the lower extremity	11	
	T00-T14 Injuries involving multiple body regions or unspecified body region	66	
	T15-T19 Effects of foreign body entering through natural orifice	10	
	T20-T32 Burns	59	
	T20-T32 Corrosions	<5	
	T33-T34 Frostbite	0	
	T36-T65 Poisoning by, adverse effect of and underdosing of drugs, medicaments and biological substances / Toxic effects of substances chiefly nonmedicinal as to source	6	
	T75.1 Unspecified effects of drowning and nonfatal submersion	11	
	T66-T78: Any other and unspecified effects of external causes	6	
	T79 Certain early complications of trauma	<5	
	T80-T89 Complications of surgical and medical care, not elsewhere classified	5	
	T90-T98 Sequelae of injuries, of poisoning and of other consequences of external causes	<5	
XVIII	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	60	(11.4)
	DR56 Convulsions	34	
	Any other symptom, sign or abnormal finding	26	
XXI	Factors influencing health status and contact with health services	52	(9.9)
X	Diseases of the respiratory system	41	(7.8)
	DJ05 Acute obstructive laryngitis [croup] and epiglottitis	10	
	DJ00-J06 Any other upper respiratory tract infection	11	
	DJ20 Acute bronchitis	5	
	DJ45-46 Asthma	5	
	Any other disease of the respiratory system	10	
I	Certain infectious and parasitic diseases	21	(4.0)
VI	Diseases of the nervous system	21	(4.0)
	G40-41 Epilepsy	14	
	Any other disease of the nervous system	7	
IX	Diseases of the circulatory system	21	(4.0)
	DI46 Cardiac arrest	14	
	Any other disease of the circulatory system	7	
IV	Endocrine, nutritional and metabolic diseases	9	(1.7)
XI	Diseases of the digestive system	6	(1.1)
II	Neoplasms	5	(1.0)
XVI	Certain conditions originating in the perinatal period	5	(1.0)
	Remaining chapters, each	<5	(<1.0)
	Missing ICD-10 diagnosis	<5	(<1.0)

minor injuries (32.2%), burns, foreign body airway obstruction, drowning, poisoning, and other types of injuries. The ICD-10 chapters representing diagnoses in specific organ systems (respiratory, neurological, and cardiac) all individually contained less than 10% of the patients. This was similar to chapter XVIII (*"Symptoms,*



	Time (hours)	ICU risk	[95%	CI]
NACA score 0-3	1	0.000		
	3	0.027	0.014	0.049
	6	0.053	0.035	0.081
	24	0.064	0.043	0.094
NACA score 4-7	1	0.020	0.006	0.061
	3	0.353	0.283	0.436
	6	0.433	0.359	0.516
	24	0.473	0.397	0.556

Figure 2. Time from HEMS alarm to intensive observation and/or care with a cutoff at 24 hours for the entire population of patients admitted to hospital (black curve, N=95/525 patients). Further, this population is grouped by NACA score assessed at the scene by an HEMS physician; the red curve represents patients with critical emergencies (scores 4-7) (N=73/150 patients) and the blue curve represents patients with noncritical emergencies (scores 0-3) (N=24/375 patients). Cumulative risk estimates for both groups are added below the plot.

signs and abnormal findings"), and more than half of the symptoms were convulsions. The ICD-10 chapters not specifically outlined in Table 3 had less than 5 observations each. Some of the patients were neither admitted to a hospital ward nor an ICU but discharged within 24 hours of arrival at the hospital (77 (14.7%) of 525). Among the patients conveyed to a hospital, 95 (18.1%) of 525 required intensive care within 24 hours of the HEMS mission (Figure 2). Higher levels of NACA score increased the risk of intensive care (0.064 [95% CI 0.043 to 0.094] for NACA scores 0 to 3 versus 0.473 [95% CI 0.397 to 0.556] for NACA scores 4 to 7 at 24 hours). Nonetheless, 24 patients assessed as having "noncritical emergencies" at the scene required intensive care. A third of these patients (8 of the 24) were 2 years old or younger, and two-thirds (16 of the 24) had hospital diagnoses within the "Injury" chapter. Twenty-nine (5.1%) patients out of 565 (95% CI 3.6 to 7.3) died either on or within 1 day of the HEMS mission. The cumulative 30-day mortality was 35 (6.2%) of 565 (95% CI 4.5 to 8.5). Of the 23 cases of immediate deaths (ie, before arrival at the hospital), 19 deaths were among nontrauma patients. Seven patients were considered dead on arrival of HEMS, that is, a NACA score of 7, and no out-of-hospital interventions were performed, neither by ground nor helicopter EMS.

Sensitivity Analyses

The sensitivity analyses presented in Table E1 (available at http://www.annemergmed.com) indicate that the patients without a registered CPR number had a higher level of severity of illness or injuries, assessed by NACA scores and performance of advanced out-of-hospital care. When we calculated mortality on the basis of missions as the event unit, regardless of CPR number, 30-day mortality was 41 (6.3%) of 651 (95% CI 4.7 to 8.5).

LIMITATIONS

The free-of-cost access to EMSs limits selection biases caused by socioeconomic factors. The findings may apply to other highly specialized HEMS systems in countries with similar demographics. However, the study's generalizability is limited by being from a pre–COVID-19 era and by the "Scandinavian" set-up of the out-of-hospital system with physician-staffed HEMS and MECUs. The diagnostic accuracy of the study is restricted to ICD-10 codes at a chapter level. We elaborated to the subchapter level without compromising the risk of identification of the individual patients. Chapter XIX containing injuries is not graduated by the level of severity and does not allow for subdivision into patients with trauma and patients with minor injuries. Despite some level of subjectivity, the ability of the NACA score to predict mortality in a physician-staffed HEMS has been described as reasonably accurate both for trauma and nontrauma patients.[29,30] The outcome of "need for intensive care" may be underestimated. This is because of missing hospital outcomes for patients without a CPR number and the fact that it relies on registration practices. Nonetheless, it is an accepted method in Danish registry-based research. However, patients without a registered CPR number introduce a potential source of selection bias. This is a well-known issue in out-of-hospital research, and they comprise 11% of our study population. Our sensitivity analyses indicate that this subpopulation had higher levels of severity of illness or injuries, and this may have caused us to underestimate mortality. We suggest this bias to be of little consequence because mortality measures based on the variable "Mission outcome" from *HEMSfile*, regardless of registered identity, were similar to the main results.

DISCUSSION

The study's strength is its nationwide and population-based design, covering both urban and rural areas, including numerous islands. A third of the patients had "critical emergencies," and 1 out of 5 patients required advanced out-of-hospital care. According to the inhospital records, injuries and external causes listed in ICD-10 chapter XIX were the most common reasons for the dispatch of the physician-staffed HEMS. They were followed by respiratory, neurological, and cardiac diseases and *"symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified"*. Among hospitalized pediatric patients, 1 out of 5 required immediate intensive care, most within the first 6 hours after HEMS alarm. Thirty-day mortality was 6.2%, with most deaths occurring within 1 day of dispatch. The combination of individual-level data, national registries, and physicians present on all missions allows for extensive and reliable follow-up on survival.

The proportion of injured patients (32.2%) in our study is consistent with the out-of-hospital diagnoses among children for whom a Danish physician-staffed MECU was dispatched.[17] Patients with medical illnesses or symptoms related hereto are generally more frequent than trauma patients in the Danish EMS compared with what is reported from HEMS systems in other countries.[2,11,13,15,31] It has been indicated that HEMSs improve survival for pediatric trauma patients compared with systems with ground-based EMSs only.[1,7,9,10] Every tenth patient in our study population had a hospital diagnosis within the ICD-10 chapter XXI *"Factors influencing health status and contact with health services"*, indicating that their symptoms or signs of acute illness or injuries may have been less severe. Some level of overtriage is inevitable in the pediatric EMS population.[7,8,17] However, appropriate triage was not one of our study objectives. Our study population is restricted to pediatric patients for whom HEMS was dispatched. Consequently, we cannot conclude if there were any pediatric emergencies for which HEMS should have been dispatched. On the other hand, in 7.4% of HEMS missions, the patient was treated and released on scene. In a few cases, despite the patient being labeled as "treat and leave," the patient had a hospital visit within 5 hours from the HEMS alarm. A probable explanation for this could be that HEMS personnel can agree with the parents or caregivers to transport the child to a hospital themselves for a check-up, for example, in cases of minor injuries related to traffic accidents. The finding of approximately one-third of the patients experiencing "critical emergencies" (NACA scores 4 to 7) in our HEMS system is well in line with the patients' level of severity of illness or injuries in some other European HEMSs.[4,13] Nonetheless, 6.4% of the patients initially assessed as "noncritical emergencies" (NACA scores 0 to 3) required intensive care within 24 hours of the mission. A third of them were 2 years old or younger, which emphasizes the challenge of clinical assessment in very young children for nonpediatricians. Two-thirds were patients with various types of injuries, and this subgroup of patients reflects that the severity of the patient's condition may not always be apparent in the out-of-hospital phase. The level of severity of illness or injuries may also be assessed by the administration of advanced care during the HEMS mission for one-fifth of the patients, which is similar to practice in other EMSs.[2,11,17] Ultrasonography is not technically an intervention but rather an extended skill for clinical examination that was exclusive to physicians in Danish EMS settings during the study period. The performance of an ultrasound examination is not as clear evidence of acuity as the performances of an intubation or chest compressions are. An ultrasound examination of the patient may be performed simply because it is available, noninvasive, and inexpensive. Nonetheless, we decided to regard ultrasound examination as an out-of-hospital intervention because it may affect out-of-hospital treatment on scene by quickly diagnosing or ruling out specific life-threatening conditions.

HEMS patients situated on offshore islands are generally older than patients on mainland missions. Conversely, children account for a larger proportion of island missions for tourists than for missions for resident islanders.[21] Including offshore island missions may impact the study outcomes because the Danish HEMS may be dispatched for offshore island missions concerning patients with noncritical emergencies.[32] NACA scores did not seem to differ among pediatric patients on offshore island missions and mainland missions in our study. Accordingly, we regard the dispatch of HEMS to children situated on offshore islands as appropriate because the main concern is to provide a prompt physician-level EMS resource to the patient.

In the pediatric HEMS literature, the ultimate outcome for the level of severity of illness or injuries, mortality, is both sparsely reported and incomparable. Barker et al[3] reported all-cause 30-day mortality of approximately 8% for children conveyed by an Australian HEMS. In this study, as well as in ours, nontraumatic illnesses were proportionally overrepresented among the deceased patients.[3] The majority of deaths in our study population occurred within 1 day of the HEMS mission. This is in accordance with a comprehensive American study among children with major trauma conveyed by HEMS, where close to 80% of deaths occurred within the first 2 days.[1] To identify areas of possible improvement of care, it is imperative to distinguish patients who were declared dead on arrival of HEMS from patients undergoing resuscitation. Most of the deceased patients in our study had received advanced out-of-hospital care. It is worth mentioning that in cases of apparent sudden infant death syndrome, resuscitation may be initiated upon the arrival of the HEMS or MECU physician despite an infant's discrete but irreversible signs of death.

In any case, our findings emphasize the importance of regular training for HEMS crews in pediatric advanced life support. Distinct from HEMSs in other countries, more pediatric patients had medical illnesses or symptoms related hereto than injuries. Among hospitalized patients, 1 out of 5 patients required immediate intensive care and 6 percent of the patients had died within 1 month of the incident that led to the dispatch of HEMS. Some of the patients who required immediate intensive care were assessed as having "noncritical emergencies" by the HEMS physician on scene. Our results highlight the difficulties in determining the patient's subsequent need for care at the moment of dispatch and in the out-of-hospital setting. They also reflect the wide HEMS dispatch criteria used in Denmark. Ideally, future research should include pediatric patients both from ground and helicopter EMS systems and investigate the use of individual criteria to optimize the dispatch of physician-staffed HEMS.

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