Tampere University

HEIDI KANGASNIEMI

Limitations of Medical Treatments in Prehospital Emergency Medicine

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ACADEMIC DISSERTATION
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the Faculty of Medicine and Health Technology
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ACADEMIC DISSERTATION
Tampere University, the Faculty of Medicine and Health Technology
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Finland

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PunaMusta Oy – Yliopistopaino
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To my family

ABSTRACT

As the population ages, the number of people who have chronic illnesses and need assistance in activities in daily living increases. While modern medicine has improved survival rates and found cures for many life-threatening conditions, people in advanced age with severe comorbidities and decreased functional status are less likely to survive critical illnesses, such as cardiac arrest. The global discrepancy of increased possibilities of life-sustaining treatments and restricted societal resources make it essential to target the right treatments for the right patients. In Finland, the emergency dispatch centre dispatches emergency medical service (EMS) units, including helicopter emergency medical service (HEMS) physicians, equally to all patients experiencing similar life-threatening conditions. This includes patients in health care facilities and nursing homes, which will both be referred to as 'nursing homes' in the abstract. HEMS physicians must sometimes treat patients in nursing homes due to the lack of an advance care plan or other deficiencies in end-of-life care. Occasionally, HEMS physicians need to issue a limitation of medical treatment (LOMT) when the situation is futile or if the patient's vital dysfunction is an end stage of a chronic illness rather than an unexpected event. Few studies have examined the decision to limit medical therapies in the prehospital setting, and none have considered Finnish HEMS physicians' end-of-life decision-making regarding patients in nursing homes.

Accordingly, the aims of this thesis were as follows: 1) to analyse Finnish HEMS physicians' experiences and opinions on LOMT and HEMS missions and consultation calls involving patients in nursing homes; 2) to study cardiac arrest patients attended by EMS units in nursing homes; 3) to observe pre-existing and new LOMTs on HEMS missions and consultation calls to HEMS physicians; and 4) to evaluate the information that is available to HEMS physicians when they make decisions on treatment.

Study (I) was a cross-sectional nationwide multicentre study including all HEMS physicians between 20th January and 30th April 2017 in Finland. Fifty-nine (88%) HEMS physicians completed the questionnaire. Observational study (II) was an Utstein report on 65 cardiac arrest patients in nursing homes in the area of Pirkanmaa, Finland, with prospective data collection from EMS records between 1st

June 2013 and 31st May 2014 as well as a post hoc analysis. The data collection for observational multicentre studies (III) and (IV) was prospectively performed in the FinnHEMS database between 6th September 2017 and 6th March 2018. Study III analysed HEMS missions involving LOMTs, and study IV analysed consultation calls involving patients with LOMTs or to whom the HEMS physician issued a new LOMT.

In our survey, 75% of HEMS physicians reported that they are often dispatched to treat patients in nursing homes. In the three prospective studies, 18% of out-of-hospital cardiac arrest patients were in nursing homes, and 11% of HEMS missions and 14% of consultation calls to HEMS physicians involved patients in those. None of the nursing home residents survived cardiac arrest, but two patients (3%) resuscitated in a health care facility were alive 90 days after cardiac arrest with a good neurological outcome; both were <70 years old males, who presented with ventricular fibrillation as a primary cardiac rhythm.

LOMTs are an essential part of HEMS physicians' work in this study. In fact, 85% of HEMS physicians agreed that they are supposed to issue LOMTs. The most common pre-existing LOMT was a do-not-attempt-cardiopulmonary resuscitation (DNAR) order, and all studies showed that information on pre-existing LOMTs is infrequently transmitted to the EMS system. LOMTs in general were involved in 5.7% (n=335/5,895) of HEMS missions and 7.8% (n=478/6,115) of consultation calls. HEMS physicians issued new LOMTs on 2.9% of all HEMS missions. HEMS physicians issued a new LOMT during 3.4% of all consultation calls. The most common new LOMTs were decisions to terminate or not to initiate a cardiopulmonary resuscitation attempt and to withhold intensive care and/or endotracheal intubation. In the survey, 93% of the HEMS physicians claimed they often encounter patients who should already have a LOMT. In 49% of situations when HEMS physicians issued a new LOMT on an HEMS mission and in 67% of consultation calls during which HEMS physicians issued new LOMTs, the HEMS physicians felt that the patient's fragile overall condition should have ethically mandated that the LOMT be issued earlier. The prospective studies found a lack of advance care plans with emergency care plans.

In conclusion, acute EMS missions to nursing homes are common. Nursing home residents are generally old and fragile and their survival from cardiac arrest is poor. LOMTs are an integral part of HEMS physicians' work, and occasionally HEMS physicians also need to make end-of-life care decisions for patients in nursing homes because of insufficient advance care planning. New LOMTs issued by HEMS

physicians mainly relate to cardiopulmonary resuscitation and intensive care. Information on pre-existing LOMTs, such as DNAR, is lacking for EMS personnel.

TIIVISTELMÄ

Väestön ikääntyessä kasvaa myös pitkäaikaissairaiden ja päivittäisessä elämässä apua tarvitsevien ihmisten määrä. Nykyaikainen lääketiede mahdollistaa selviytymisen ja toipumisen monista henkeä uhkaavista tilanteista, mutta ikääntyneiden kroonisesti sairaiden ja toimintakyvyltään heikentyneiden potilaiden todennäköisyys selviytyä vakavasta kriittisestä sairaudesta kuten sydämenpysähdyksestä on huono. Elämää ylläpitävien hoitojen mahdollisuuksien ja yhteiskunnan resurssien riittävyyden välillä on ristiriita, jonka vuoksi on välttämätöntä kohdentaa oikeat hoidot oikeille potilaille. Viranomaisten yhteinen hätäkeskus hälyttää ensihoitoyksiköt mukaan lukien lääkärihelikopterin (HEMS) tasapuolisesti kaikille potilaille, joilla on yhtäläinen henkeä uhkaava tila, myös hoivakoteihin ja hoitolaitoksiin. Joskus ensihoitolääkäreitä hälytetään hoitamaan potilaita näihin yksiköihin, koska potilailta puuttuu ennakoiva elämän loppuvaiheen hoitosuunnitelma. Joskus ensihoitolääkäri rajaa annettavaa lääketieteellistä hoitoa, jos hätätilapotilaan ennuste on toivoton tai kyseessä onkin vaikean pitkäaikaissairauden loppuvaihe. Hoidonrajauksista ensihoidossa on vähän tutkimuksia, eikä suomalaisten ensihoitolääkärien elämän loppuvaiheen päätöksentekoa ole tutkittu koskien hoivakoti- ja hoitolaitospotilaita.

Tämän tutkimuksen tarkoituksena oli 1) analysoida suomalaisten ensihoitolääkäreiden kokemuksia ja mielipiteitä hoidonrajauksista sekä ensihoitotehtävistä ja konsultaatiopuheluista hoivakoteihin ja hoitolaitoksiin; 2) kuvailla ensihoidon kohtaamat sydämenpysähdyspotilaat hoivakodeissa ja hoitolaitoksissa Pirkanmaalla; 3) havainnoida olemassa olevia ja uusia hoidonrajauksia ensihoitotehtävillä ja konsultaatiopuheluissa; 4) arvioida käytettävissä olevat tiedot, kun ensihoitolääkärit tekevät hoitopäätöksiä.

Tutkimuksen I osatyö oli poikkileikkauksellinen valtakunnallinen monikeskustutkimus kaikille HEMS-ensihoitolääkäreille 20.1.–30.4.2017 Suomessa. 59 (88 %) ensihoitolääkäriä täytti kyselylomakkeen. Toinen osatyö oli havainnoiva Utstein-raportti 65 sydämenpysähdyspotilaasta hoivakodeissa ja hoitolaitoksissa Pirkanmaalla. Tutkimusaineisto kahteen havainnolliseen monikeskustutkimukseen (III ja IV) kerättiin FinnHEMS-tietokannassa etenevästi 6.9.2017–6.3.2018. III tutkimuksessa analysoi ensihoitolääkärin tehtäviä, joihin liittyi hoidonrajaus ja IV

tutkimus analysoi konsultaatiopuhelut potilaista, joilla oli hoidonrajaus tai joille ensihoitolääkäri teki uuden hoidonrajauksen.

Tutkimuksessamme 75 % ensihoitolääkäreistä vastasi, että he hoitavat usein potilaita hoivakodeissa ja hoitolaitoksissa. Kolmessa etenevässä tutkimuksessa 18 % sydämenpysähdyspotilaista oli hoivakodissa tai hoitolaitoksessa, 11 % ensihoitolääkärintehtävistä ja 14 % ensihoitolääkärin konsultaatiopuheluista liittyi tällaisiin potilaisiin. Kukaan hoivakodin asukkaista ei selvinnyt sydämenpysähdyksestä, mutta kaksi (3 %) terveydenhuollon laitoksessa elvytettyä potilasta oli elossa 90 päivää sydämenpysähdyksen jälkeen ilman merkittäviä neurologisia oireita; molemmat olivat alle 70-vuotiaita miehiä, joiden sydämen lähtörytminä oli ollut kammiovärinä.

Tässä tutkimuksessa osoitettiin, että hoidonrajaukset ovat olennainen osa ensihoitolääkäreiden työtä. 85 % ensihoitolääkäreistä oli samaa mieltä siitä, että hoidonrajausten tekeminen tarvittaessa kuuluu myös ensihoitolääkärin työhön. Yleisin olemassa oleva hoidonrajaus oli 'ei elvytetä' ja kaikissa tutkimuksissa kävi ilmi, että tiedot olemassa olevista hoidonrajauksista välittyvät huonosti ensihoidon henkilöstölle. Hoidonrajaus liittyi 5,7 %:iin (n=335/5895) ensihoitolääkärin tehtävistä ja 7,8 %:iin (n = 478/6115) konsultaatiopuheluista. Ensihoitolääkärit tekivät uuden hoidonrajauksen 2,9 %:ssa lääkärinyksikön tehtävistä ja vastaavasti 3,4 %:ssa konsultaatiopuheluissa. Yleisimmin uudet hoidonrajaukset olivat elvytyksen lopettaminen, 'ei elvytetä', 'ei tehohoitoa' ja/tai 'ei intubaatiota'. Kyselytutkimuksessa 93 %:a ensihoitolääkäreistä kertoi kohtaavansa usein potilaita, joilla olisi jo pitänyt olla jokin hoidonrajaus tai ennakoiva elämän loppuvaiheen hoitosuunnitelma. Havaintotutkimuksissa ensihoitolääkärit arvioivat, että potilaan kokonaistila olisi edellyttänyt aiempaa hoidonrajausta 49 %:ssa tilanteista, joissa he tekivät uuden rajauksen ensihoitotehtävällä (III), ja 67 %:ssa konsultaatiopuheluista, joiden aikana he rajasivat hoitoa (IV). Ensihoitolääkärit raportoivat, etteivät tutkimusaikana kohdanneet yhtään elämän loppuvaiheen hoitosuunnitelmaa, joissa olisi ollut suunnitelmat perussairauden äkillisen pahenemisvaiheen varalle.

Yhteenvetona voidaan todeta, että kiireelliset ensihoitolääkärin tehtävät hoivakoteihin ja hoitolaitoksiin ovat yleisiä. Hoivakotiasukkaat olivat yleensä vanhoja ja hauraita ja heidän selviytymisensä sydämenpysähdyksestä oli huonoa. Hoidonrajaukset olivat olennainen osa ensihoitolääkäreiden työtä, ja toisinaan heidän on tehtävä elämän loppuvaiheen hoitopäätöksiä hoivakoti- ja hoitolaitospotilaille. Ensihoitolääkäreiden tekemät hoidonrajaukset koskivat lähinnä elvytystä ja tehohoitoa. Tiedot olemassa olevista hoidonrajauksista välittyivät huonosti ensihoidon ammattihenkilöstölle.

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ABBREVIATIONS

ACP	Advance care plan
	Ennakoiva elämän loppuvaiheen hoitosuunnitelma
ADL	Activities of daily living
AED	Automated external defibrillator
AHA	American Heart Association
ALS	Advanced life support
APACHE	Acute Physiology and Chronic Health Evaluation
BLS	Basic life support
CA	Cardiac arrest
CCI	Charlson Comorbidity Index
CoSTR	Consensus on Science and Treatment Recommendations
CPC	Cerebral performance category
CPR	Cardiopulmonary resuscitation
DNACPR	Do not attempt cardiopulmonary resuscitation
ECMO	Extracorporeal membrane oxygenator
ECPR	Extracorporeal cardiopulmonary resuscitation
EDC	Emergency Dispatch Centre
EMS	Emergency medical services
ERC	European Resuscitation Council
FH	FinnHEMS, the radio callsigns for FinnHEMS units
FHDB	FinnHEMS database
FRU	First responding unit
GDP	Gross domestic product
HCF	Health care facility
HEMS	Helicopter Emergency Medical Services
IHCA	In-hospital cardiac arrest
ICU	Intensive care unit
ILCOR	International Liaison Committee on Resuscitation
LOMT	Limitation of medical treatment
LST	Life-sustaining treatment

NGO	Non-governmental organisation
NH	Nursing home
OECD	Organisation for Economic Co-operation and Development
OHCA	Out-of-hospital cardiac arrest
PEA	Pulseless electrical activity
QALY	Quality-adjusted life year
ROSC	Return of spontaneous circulation
SII	Social Insurance Institution of Finland
STEMI	ST-elevation myocardial infarction
ToR	Termination of resuscitation
Valvira	National Supervisory Authority for Welfare and Health Sosiaali- ja terveysalan lupa- ja valvontavirasto
WHO	World Health Organisation
WLST	Withdrawal of life-sustaining treatments

ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, which are referred to in the text by Roman numbers (from I to IV).

I Kangasniemi H, Setälä P, Huhtala H, Kämäräinen A, Virkkunen I, Tirkkonen J, Yli-Hankala A, Hoppu, S. (2019). Limitation of treatment in prehospital care – the experiences of helicopter emergency medical service physicians in a nationwide multicentre survey. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 27,89.

II Kangasniemi H, Setälä P, Huhtala H, Kämäräinen A, Virkkunen I, Jämsen E, Yli-Hankala A, Hoppu, S. (2018). Out-of-hospital cardiac arrests in nursing homes and primary care facilities in Pirkanmaa, Finland. *Acta Anaesthesiologica Scandinavica*, 62,1297–303.

III Kangasniemi H, Setälä P, Olkinuora A, Huhtala H, Tirkkonen J, Kämäräinen A, Virkkunen I, Yli-Hankala A, Jämsen E, Hoppu S. (2020). Limiting treatment in pre-hospital care: a prospective, observational multicentre study. *Acta Anaesthesiologica Scandinavica*, 64,1194–201.

IV Kangasniemi H, Setälä P, Huhtala H, Olkinuora A, Kämäräinen A, Virkkunen I, Tirkkonen J, Yli-Hankala A, Jämsen E, Hoppu S. (2022). Advising and limiting medical treatment during phone consultation: a prospective multicentre study in HEMS settings. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 27, 16.

AUTHOR'S CONTRIBUTION

I	Drafting, methodology, data collection, analysis of the quantitative and qualitative data, writing and visualisation
II	Drafting, methodology, data collection for the post hoc analysis from medical records (the Utstein data on cardiac arrest was collected by PhD Setälä), analysis, writing and visualisation
III, IV	Drafting, methodology, data collection, supervising the accumulation of research data in the FinnHEMS database, analysis, writing and visualisation

Drafting	Idea of the study, formulating the aims of the study, planning the execution, application for research permissions
Methodology	Choosing a suitable design for the study and applying the correct method for the analyses
Data Collection	Planning the research forms, monitoring the implementation of study sheets in the FinnHEMS database, collecting the data
Analysis	Statistical analyses, coding the qualitative data, interpreting the results and synthesising the study data
Writing	Preparation of the initial draft of every manuscript, compiling the proposed changes for manuscripts submitted for review
Visualisation	Preparation of figures and tables for the published studies

1 INTRODUCTION

Emergency medical services (EMS) and Helicopter Emergency Medical Service (HEMS) physicians treat acutely ill and injured patients in prehospital setting with the primary aim to save lives. In Finland, EMS units respond equally to all patients with similar life-threatening conditions, such as out-of-hospital cardiac arrest (CA). EMS is also dispatched to health care facilities (HCFs) and nursing homes (NHs). Sudden CA remains a major public health challenge in Europe (Gräsner et al., 2021). Even with prompt and high-quality cardiopulmonary resuscitation (CPR), survival from out-of-hospital CA has remained poor (Perkins et al., 2021).

As the population ages, the number of older people with chronic illnesses and those who need assistance in activities in daily living increases. Newly developed technologies and therapies have improved survival and provided cures for many life-threatening conditions, but aged people with severe comorbidities and decreased functional status are less likely to survive CA (van de Glind et al., 2013). The global discrepancy in the availability of life-sustaining treatments and restricted societal resources make it essential to target the right treatments for the right patients. Advance care planning is recommended when approaching the end of life. (Mentzelopoulos et al., 2021).

HEMS physicians must sometimes withhold or withdraw medical treatments on-scene if the overall situation is futile or if the patient is in a terminal phase of a chronic illness. Occasionally, EMS is needed in HCFs and NHs because of deficiencies in end-of-life care. Studies on prehospital decisions to limit medical treatments are scarce, and there is no previous research on Finnish HEMS physicians' end-of-life decision-making regarding patients in NHs and HCFs.

Accordingly, the aim of this study was to describe the epidemiology of EMS missions to HCFs and NHS and to determine the frequency and content of limitations of medical treatments in HEMS physicians' work. The study also examined the quality of information that is available to HEMS physicians when they make decisions on treatments. This thesis reflects the current practices in EMS, the values of Finnish EMS culture and current perceptions of sufficient quality of life.

2 REVIEW OF THE LITERATURE

2.1 Finnish Health and Social Care System

According to Finland's Constitution, public authorities must provide all citizens with adequate health care and social welfare services and promote the health and well-being of the population (The Constitution of Finland, 2000). Municipalities are responsible for providing arrangements for health and social care (Health Care Act, 2011; Social Welfare Act, 2014). There are 21 hospital districts, owned by municipalities in the region, which are responsible for coordinating specialised medical care services in their areas. All hospital districts have a central hospital. Hospital districts form five catchment areas for highly specialised medical care, and one central hospital in each catchment area is a university hospital. The Ministry of Social Affairs and Health is in charge of the planning, guidance and implementation of health and social policy.

2.1.1 Emergency Medical Services

EMS is a part of the health care system responsible for treating citizens when they are suddenly ill or injured, primarily outside of a health care unit. The EMS system considers the emergency dispatch centre's (EDC) emergency call handling and EMS units' dispatch process, the first responder system, the primary assessment of need for treatment and implementation of care by EMS personnel as well as transportation to an appropriate hospital if needed. Transfers of suddenly ill or injured patients from one HCF to another for further treatment are included in EMS when the patient needs extensive and continuous follow-up care or treatment during the transfer. EMS also has other tasks related to national security and readiness (Health Care Act, 2011).

According to the Emergency Medical Service Decree, hospital districts determine the EMS service level and coordinate EMS in their area. The Decree also determines EMS vehicles, the management system and educational and other standards for EMS

personnel. The aim of the service-level decision is to provide uniform and equal services to all patients with similar health-related risks in similar geographic risk areas in a similar amount of time within and between hospital districts. When handling an emergency call, the EDC operator analyses the health-related risk of the patient, which is classified into four categories. In category A, the health risk of the patient is considered high, as there is reason to suspect an immediate vital dysfunction. In category B, the patient is likely having a vital dysfunction, but it is not certain based on advance information. In category C, the vital dysfunction is estimated as mild, but quick EMS assessment is needed, and in category D there is no vital dysfunction, but the EMS unit needs to assess the status of the person in need of help. (Emergency Medical Service Decree, 2017).

The Finnish EMS system has three tiers. When a person makes a '112' call to an EDC in need of help from rescue service, health care authorities, social service or police, the EDC operator performs a risk analysis and sends the necessary units according to the dispatch criteria. For medical emergencies, the first tier consists of first-responding units (FRUs) and basic life support (BLS) ambulances. FRUs are generally rescue units, volunteer fire brigade units with rescuers or border patrols that can provide first aid and life support, including the use of an automated external defibrillator (AED). The BLS unit needs to recognise life-threatening vital dysfunctions, start treatments and perform CPR with an AED. One paramedic in the BLS unit needs to be a health care professional with EMS-oriented education, while the other can be a rescuer. The second tier includes advanced life support (ALS) ambulances. ALS units work more independently, have more skills and equipment than BLS units and can provide drug-assisted CPR. In an ALS ambulance, one person must have a bachelor's degree in emergency medicine or be a registered nurse with 30 European Credit Transfer and Accumulation System credits in emergency medicine; the other paramedic can be a rescuer or other health care professional. The EMS field commander is an experienced ALS provider with adequate operational and administrative skills. EMS physicians are the third tier of the EMS system, and their work is described in detail in the Methods section.

In the Finnish EMS system, all EMS physicians are specialised physicians and trained to work in prehospital environments. General practitioners are not part of the EMS response in any part of the country, which is a very different practice than in Norway (Hjortdahl et al., 2018). However, general practitioners may be consulted on EMS-treated patients, for example, in situations when the patient does not require transportation to a hospital (Pekanoja et al., 2018). When planning this study, there were few studies on HEMS in Finland, and there was no literature on consultation

calls to HEMS physicians in Finland. In a Scandinavian study, 23% of HEMS units' events were phone calls (Kruger et al., 2013).

Helicopter-operated Emergency Medical Services

HEMS is a part of the EMS entity defined in the Health Care Act. 'HEMS' refers to physician-staffed and paramedic-only-staffed HEMS units and assistance service facilities, such as ground vehicles, flight operations and bases. Air medical services have a long history. The first air ambulance flight was made in World War I, and helicopters were used for medical evacuation in the Korean War in the 1950s (Nathens et al., 2004). The role model for the Finnish HEMS, London Air Ambulance, was established in 1989 in response to a report by the Royal College of Surgeons that criticised the care of seriously injured patient in the UK (London Air Ambulance, 2021). The first Finnish physician-staffed EMS unit was created in 1971 when The Finnish Heart Disease Alliance tested a 'Heart Ambulance service'. The testing led to the establishment of an all-day and everyday manned Helsinki Doctor Ambulance in 1972 (Nyström, 2006). In 1992, the Association for The Support of Physician Helicopters started HEMS activities in Finland. The first helicopter was rented from Sweden, and the physicians were former Helsinki Doctor Ambulance physicians. The association was soon registered as a non-profit organisation named Pro Medi-Heli, which was later changed to Medi-Heli. For many years, HEMS activities was financed via charity. The employer of HEMS physicians was the EMA (Emergency and Medical Association) Group Ltd. A second Medi-Heli unit was established in Turku in 1998. About the same time, other partly physician-staffed HEMS or search and rescue (SAR) helicopters were established in Finland; 'Sepe' in Oulu in 1995, 'Ilmari' in Varkaus in 1997, 'Aslak' in Sodankylä in 1998 and 'Pete' in Vaasa in 2003. Since the beginning of 2012, FinnHEMS Ltd. has been responsible for all HEMS operations in Finland, while the activities of Medi-Heli and other HEMS support associations were suspended.

FinnHEMS Ltd. is a non-profit corporation possessed equally by all five university health care districts. The government finances and supervises the activity of FinnHEMS, which coordinates HEMS' operational activities and administers bases with assistance service facilities in Finland. The bases in Vantaa (FinnHEMS 10, 'FH10'), Turku (FinnHEMS 20, 'FH20'), Tampere (FinnHEMS 30, 'FH30'), Oulu (FinnHEMS 50, 'FH50') and Kuopio (FinnHEMS 60, 'FH60') are always physician staffed. The HEMS and SAR units in Rovaniemi (FinnHEMS 51, 'FH51') operate with two HEMS paramedics instead of physicians. The operational areas of

HEMS units are shown in Figure 1. Previously, FinnHEMS had chosen two private flight operators to produce the flight activity and to supply a cabin crew: a pilot and an HEMS crew member (HCM, an ALS paramedic or rescuer specialised in flight operations). While writing this thesis, the State decided to designate FinnHEMS Ltd. as a state-owned company that also works as a flight operator, and thus FinnHEMS Ltd. has acquired the business of both flight operators.

The aim of HEMS is to bring the critical emergency team's know-how to the location of the patient as quickly as possible, either by helicopter or ground vehicle. Helicopters are used because of their geographically wide operational range and ability to react fast, which are especially important in sparsely inhabited areas and archipelagos (Kurola, 2014). FinnHEMS states that its units can reach 70% of the Finnish population in 30 minutes from dispatch, thus providing high-quality intensive care-level EMS to citizens equally. As operational readiness requires only 3–5 minutes and the flight time to the destination is 10–12 minutes on average, HEMS physicians usually reach the patient within 15 minutes. The Finnish Parliament approved a supplementary budget in March 2019 that includes state funding for the establishment of two new HEMS bases. FinnHEMS 40 at Seinäjoki will begin to operate on October 1, 2022. Decisions on the location of or timetables for the FinnHEMS unit in the South-Eastern corner of Finland have not yet been made as of the writing of this thesis. In addition to HEMS units, there are EMS physicians in Finland working in ground units that are not part of FinnHEMS Ltd. In Helsinki City, the physician-staffed EMS unit belongs to a fire department and operates at all times. In Pori, Lahti, Lappeenranta, Kouvola, Vaasa and Seinäjoki, the units are parts of the central hospitals' activity and operate part-time (Saviluoto et al., 2020).

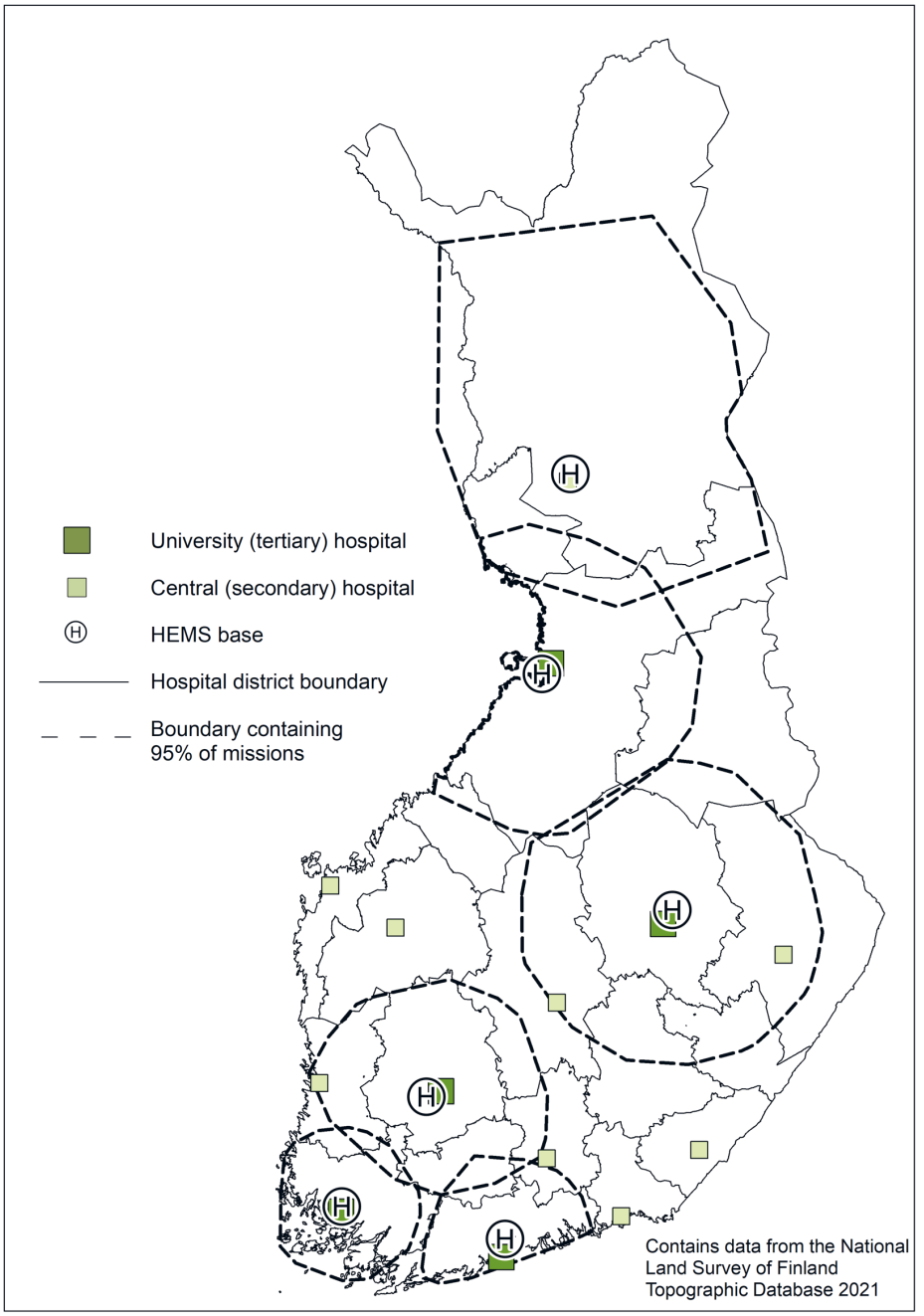


Figure 1. Helicopter-operated emergency medical service units' operational areas and the central hospitals in Finland. The figure is modified with kind permission from Pappinen et al. (2019).

2.1.2 Health Care Facilities

The population of Finland was 5.51 million inhabitants living in 311 communities in the year 2017 (Official Statistics of Finland, 2019b). Basic health care is provided by 544 communal primary HCFs, and specialised medical care is provided in five university hospitals, 16 central hospitals and six district hospitals; many previous district hospitals have been merged with university hospitals (Official Statistics of Finland, 2021). The different types of health and social care facilities in Finland are presented in Table 1.

The primary HCFs are general practitioner-level units with policlinics and wards. In addition to treating patients with common chronic conditions, primary HCFs admit patients with low-risk acute conditions, including patients with infections requiring intravenous antibiotics or those needing rehabilitation after surgery. Patients with terminal conditions or who are queuing for NH residency may stay for months in a primary HCF ward. During office hours, primary HCFs offer physicians and laboratory and basic imaging services, but outside office hours only an on-call general practitioner is usually available for phone consultations.

Secondary hospitals include both district and central hospitals. District hospitals are small public hospitals that provide some medical specialties during office hours and otherwise serve as primary HCF emergency departments, with general practitioners, basic laboratory testing and imaging services. Most district hospitals have a high-dependency unit, and some supply obstetric services, including caesarean sections. Central hospitals offer the most medical specialties and have intensive care units (ICUs).

Tertiary hospitals are the five university hospitals with comprehensive medical services (Figure 1). University hospitals treat patients requiring neurosurgery, cardiac surgery, demanding oncology or with major trauma. Some complex patient groups are treated nationally; Töölö Hospital in Helsinki treats the most severe polytrauma, Jorvi Hospital in Espoo treats the most complex burn injuries, the New Children's hospital in Helsinki treats the most severely ill or injured children and Turku University hospital treats those who need a pressure chamber. Twelve hospitals (the university hospitals and seven central hospitals) have extensive joint emergency services, which means they are always represented by experts on approximately ten medical specialties that can treat the most severely ill or injured patients needing surgery, intensive care (including neonatal and paediatric intensive care) and revascularisation of coronary or cerebral arteries (Finnish Government, 2017b).

Table 1. Care options for different client groups in health and social care in Finland.

Client group	Facility type	Type	Need for medical attention	Dependency	Payment system	Majority of providers
Ill or injured patients, some palliative care patients	HCF acute wards	Health care	High	Varies	Institutional short-term care	Public
	At-home hospitals	Health care	High	Varies	Out-patient care	Public
Aged	HCF long-term care wards	Health care	High	High	Institutional long-term care	Public
	Nursing homes	Social care	Moderate	High	Institutional long-term care	Public
	Assisted living with 24-hour care	Social care	Moderate	High	Home care	Private /Public
	Assisted living without 24-hour care	Social care	Low	Moderate	Home care	Private
	Regular home care	Social care	Low	Low /Moderate	Home care	Private /public
Persons with intellectual disabilities	Institutional care facility	Social care	Moderate	High	Institutional long-term care	Public
	Assisted living with/without 24-hour assistance	Social care	Low	High /Moderate	Home care	Private /Public
	Regular home care	Social care	Low	Low /Moderate	Home care	Private /public
Persons with psychiatric comorbidities	Psychiatric HCF wards	Health care	High	High/ Moderate	Institutional long-term care	Public
	Assisted living with/without 24-hour assistance	Social care	Moderate	Moderate	Home care	Private
	Regular home care	Social care	Low	Low	Home care	Private /public
Persons with disabilities	Assisted living with/without 24-hour assistance	Social care	Moderate	High /Moderate	Home care	Private
	Regular home care	Social care	Moderate	Varies	Home care	Private /public
Persons with substance abuse	Institutions for substance abucers	Social care	Low	Low	Institutional short-term care	Public
Child welfare clients	Child welfare institutions	Social care	Low	High	Institutional care	Public

Modified from the following sources: (Act on Client Charges in Healthcare and Social Welfare, 1992; Mielikäinen & Kuronen, 2019; OECD/European Commission, 2013; Sohlman & Nurmi-Koikkalainen, 2016)

Private clinics and hospitals serve mainly occupational health customers covered by employers' insurance and other citizens with private insurance, but services are available for everyone with a certified identity and funds. In addition to primary HCF-level care, some private clinics also provide multi-level elective surgery and a wide range of imaging and laboratory services. In addition, some communes offer the communal health care services prescribed by the law as purchase services from private providers to whom the customers pay the public rate. Some health care districts purchase the activity of secondary hospitals and EMS units from private for-profit companies. However, all patients needing tertiary hospital-level treatment and extensive emergency medicine services are admitted to public hospitals with public EMS units (Finnish Government, 2017a; Law on Private Health Care, 1990).

2.1.3 Social Care Facilities

The Finnish population is ageing, and the number of the oldest citizens is increasing. People also die older; 40% of those who died in 2018 were more than 85 years old. Major causes of death were cardiovascular diseases (35% of deaths), malignancies (24%) and dementia (19%). The prevalence of dementia (including Alzheimer's disease) as a cause of death has increased in recent years. Of people 65 years of age or older who died in 2018, more than one in five died because of dementia (Official Statistics of Finland, 2019a). Citizens receiving old-age pensions are entitled to social services for the aged (Act on Supporting the Functional Capacity of the Older Population and on Social and Health Services for Older Persons, 2012).

At the time of this study, the local municipalities had the responsibility to arrange social care for citizens (Social Welfare Act, 2014). Social services can be provided by those municipalities where the clients live, or they can be purchased from other municipalities, private for-profit companies or non-governmental organisations (NGOs) (Aaltonen et al., 2014). The linkage of acutely ill or injured long-term care clients/patients, EMS and HCFs is illustrated in Figure 2.

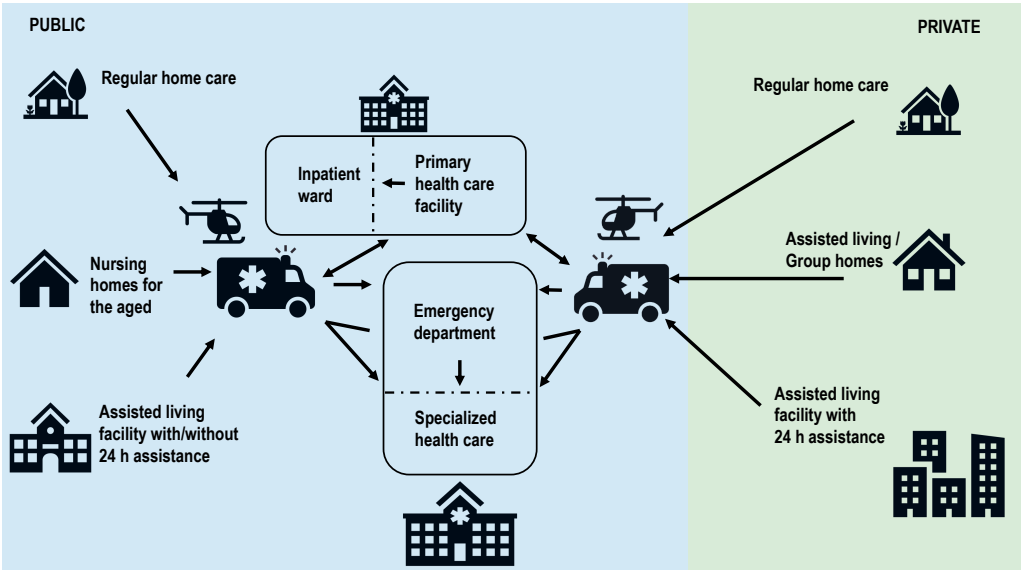


Figure 2. The operational environment and linkage of emergency medical services with health care facilities and long-term care patients in private homes and nursing homes.

Long-term care is defined, in Finland, as care exceeding 90 days, both in health and social care. All social care clients should have an up-to-date client plan (Social Welfare Act, 2014). Long-term care can be arranged in private homes or in long-term care facilities, and the possibilities are shown in the Table 1. If long-term care and assistance in activities of daily living (ADL) is needed, regular home care is primary. Long-term care facilities are divided by the payment system, and they differ notably with regard to providers, funding and customer fees: People living in institutional long-term care facilities are juridically regarded to reside in 'institutional care', whereas people living in assisted living facilities are regarded to reside in 'private homes with home care'. Institutional care is mainly public, and client fees (regulated as 85% of the client's net income) cover residence, medications, care and meal services. Those people in 'home care' pay rent for housing and their own clothes, medications and doctor's visits and, in addition, client fees for care services out of pocket. It is possible to attach auxiliary services (safety, cleaning, meals, transportation etc.) to home care. The care services included in the assisted living facility client fees vary. Private service providers accounted for about half of the assisted living in 2018 (Mielikäinen, 2019). In many long-term care facilities, residents have the opportunity to remain for the rest of their lives, but studies of The Ministry

of Social Affairs and Health have found that clients in private assisted living facilities make more visits to hospital emergency departments than clients in municipal assisted living facilities (Saarto et al., 2019b).

The Finnish government's previous programme was intended to decrease the number of older people in NHs and primary HCF wards and to accelerate the movement of older people in institutional care to home care with adequate services and circumstances. In November 2018, there were 73,563 regular home care clients (≥75 years of age) (Mielikäinen, 2019). They were a heterogenous client group. Some clients were almost totally independent, needing 1–3 visits in a month, while some had continuous care needs requiring multiple visits daily or were in end-of-life care. Round-the-clock care is provided in NHs and in assisted living facilities with 24-hour assistance for the most comorbid and incapacitated people, typically those with cognitive disorders (OECD/European Commission, 2013). The median age of social care clients in 24-hour care facilities for the aged was 84 years in 2018 (Mielikäinen, 2019). Their average need for care was 4.7 on a scale of 1–5, where 1 indicates independent in ADL and 5 indicates a continuous need for round-the-clock care. The proportion of aged citizens living in assisted living facilities with 24-hour assistance was only 1.7% in 2000 but grew to 7.6% by the end of 2018. At the same time, the proportion of aged citizens living in institutional long-term care decreased. Of those people 75 years or older, 20% received home care or lived in a long-term care facility, and in total, 9% of those ≥ 75 years old lived in a 24-hour care facility in 2018. Although the proportion of people in 24-hour care in this age group has decreased, the absolute number of these individuals has increased 23% since 2001 as the number of aged people has increased. (Mielikäinen, 2019).

Subsequently, all social care long-term care facilities are referred to as NHs, while long-term care patients in primary HCF inpatient wards are referred to as HCF patients.

2.1.4 Funding

According to the Finnish Constitution, the sufficiency and quality of health and social care services must be guaranteed to everyone on an equal basis. The main institutional financiers of the health and social care system are the state, communes, the national Social Insurance Institution of Finland, private insurance companies, households and employers. The funding is collected through state and municipal

taxation and tax-like payments, statutory compulsory insurance payments, voluntary health and accident insurance payments and service usage fees or co-payments. In addition, the Finnish Slot Machine Association distributes grants to promote health and well-being. The funding of the health and social care system is collected through multiple channels, and funds are distributed to service providers based on many different principles (Seppälä & Pekurinen, 2014).

Total health care expenditure accounted in 2017 for about 10% of the State's annual budget (Finnish institute for health and welfare, 2019a). In 2017, the current expenditure on health was 20.6 billion euros, while the total cost of FinnHEMS was 24.9 million euros (0.1% of total expenditure). The total cost of long-term care for the aged and disabled was 3.9 billion euros (19% of total expenditure), and the cost of long-term care in primary HCF wards was 0.18 billion (3.7%). These costs were only exceeded by the total cost of specialised health care (7.4 billion euros, 36% of total expenditure on health). The structural change in the service system has led to a reduction in the cost of institutional long-term care and an increase in the cost of assisted living with 24-hour assistance during the last 20 years. Assisted living facilities with 24-hour assistance accounted for 54% of the care for older people expenditure in 2017, almost half of which was for purchases from private service providers (Finnish institute for health and welfare, 2019a). The funding system of assisted living facilities is complex, and client fees have been legally regulated like institutional care fees only since 2021. The social care system reimburses part of the costs (Act on Client Charges in Healthcare and Social Welfare, 1992).

Everyone in the Finnish social security system is covered by national health insurance from the Social Insurance Institution. The insurance reimburses medical costs, such as medicine expenses, partial private health care and travel costs as well as the cost of transportation to a hospital in an ambulance or a taxi (up to 25 euros each time until the yearly limit of 300 euros is reached). The Social Insurance Institution also pays pensions, parental benefits, child benefits, sickness allowances, social assistance and unemployment benefits and many services and supports for the aged and people with disabilities, such as age-related and disability pensions. For example, disability allowances and care allowances for pensioners can be used to cover the cost of living facilities providing 24-hour assistance (European Commission, Directorate-General for Employment & Inclusion, 2018). Social care benefits and services are based on the evaluation of health state and degree of disability, and a certificate for disability benefits is written by a physician (usually a primary HCF general practitioner).

The share of the gross domestic product (GDP) spent on health care was 9.2% in Finland in 2017, which was the lowest rate in the Nordic countries and near the average expenditure of Organisation for Economic Co-operation and Development (OECD) countries (8.8%) (Finnish Institute for Health and Welfare, 2019a). The portion of public financing of current health expenditure was 75.2%, which was also the lowest among Nordic countries (OECD, 2019). The portion of household out-of-pocket payments is high in Finland, mainly because of high co-payments for medicines and dental health care (Seppälä, 2014). The current expenditure on social care was 69.1 billion euros in 2017, which was 30.9% of GDP. Almost half (42%) of the expenditure was related to old age (as pensions and services), and the realistic costs have doubled since 2000 (Finnish institute for Health and Welfare, 2019b).

2.2 Critical Illness and Severe Injuries

When critically ill or severely injured patients need intensive care, they have a vital dysfunction that requires surveillance, support or even replacement (Aarno et al., 2019). The most common reasons for intensive care are troubles with breathing, circulation and/or consciousness (Reinikainen & Varpula, 2018). The aetiologies of these conditions are numerous, including severe infections (sepsis), post-CA state, disturbances of body homeostasis (imbalance of acid-base equilibrium, kidney failure, major bleeding, severe trauma etc.), cardiac failure and major surgical procedures requiring postoperative stabilisation. Advanced cancer therapies are given and their adverse effects are also treated in ICUs (Kuo et al., 2020).

Modern intensive care can replace almost all vital functions temporarily. Ventilators can perform breathing via a tube placed in a trachea through the mouth or tracheostomy, blood can be pumped from the patient to a dialysis machine to replace kidney function, extracorporeal liver assistance devices can replace liver function and an extracorporeal membrane oxygenator (ECMO) (Zapol et al., 1979) can be used to replace the lungs (gas exchange) and/or heart (circulation). In the scope of this thesis, we examine CA treatment, but specific treatment guidelines exist for many other life-threatening conditions, such as trauma (American College of Surgeons, 2018) and sepsis (Evans et al., 2021).

The aim of intensive care is to buy time for the patient's body to recover from the temporary critical illness or until a definitive treatment can be executed (e.g. an organ transplant). Intensive care is heavy, invasive and has many adverse effects, such as infections, delirium, loss of muscular mass, pain and suffering. Intensive care

is mainly offered to those who are believed to be able to recover back to independent life or an otherwise acceptable condition (Aarno, 2019), however some patients who are unlikely to survive are admitted as organ donor candidates. Long physical and mental rehabilitation is often needed after intensive care survival (Needham et al., 2012).

The number of ICU beds in Finland is 6.1 per 100, 000 inhabitants, which is less than the average of 11.5/100,000 in European countries (Rhodes et al., 2012). In a recent Finnish study, the 3-year survival of adult ICU patients was 64% (Jukarainen et al., 2020). The study investigated the costs and cost utility of intensive care and considered approximately 85% of all adult ICU patients admitted in Finland in 2011–2012. During the 3-year follow-up, the observed mean number of quality-adjusted life years (QALYs) gained was 1.49 [95%CI(1.45–1.53)] among all patients. Finnish intensive care was reported to be cost-effective, as the estimated mean total 3-year cost per one QALY was US $46,600, while the GDP per capita in Finland was US $43,433 in 2016 (Jukarainen, 2020). According to the World Health Organisation (WHO), interventions that cost less than three times the GDP per capita in a given country are considered to be cost-effective, and they are considered high-value interventions if they cost less than the GDP per capita (Morris et al., 2018b). The main reason for cost-effectiveness is successful patient selection—patients who are not too healthy or cannot be saved (Ala-Kokko, 2018). High-dependency units are a choice for patients who do not require intensive care or would not benefit from it but still need active treatment. A high-dependency unit is a step-down from an ICU but with more surveillance and staff than general hospital wards (Kelly et al., 2014). High-dependency units improve patient selection and thus may enhance the cost-effectiveness of intensive care.

2.2.1 Cardiac Arrest

CA is defined as the cessation of cardiac mechanical activity confirmed by the absence of signs of circulation (Jacobs et al., 2004). Circulatory collapse leads to a loss of cerebral perfusion and to hypoxic-ischaemic brain injury and death within minutes unless cardiac activity and circulation are restored (Greer, 2006). An Utstein-style report template was created in 1990 to facilitate uniform reporting of data from out-of-hospital CA (OHCA) and to standardise definitions of CPR (Cummins et al., 1991). An Utstein template for in-hospital CA (IHCA) was created in 1997 (Cummins et al., 1997), and the original template has been revised to better describe

OHCA resuscitation performance (Jacobs, 2004; Perkins et al., 2015). According to the template, OHCA occurs outside of a hospital setting that is, at a place of residence, a public place or another place, such as an NH or hotel room. IHCAs are beyond the scope of this thesis, as EMS units are rarely dispatched in such cases except when the patient needs transport to another hospital after a return-of-spontaneous circulation (ROSC). The core data elements and patient-related supplementary data elements of the Utstein template are shown in Table 2.

The causes of CA are categorised as medical, traumatic, drug overdose, drowning, asphyxia and electrocution. Medical causes include both cardiac and non-cardiac conditions, including asthma, anaphylaxis and internal bleeding (Perkins, 2015). Unknown causes should be assigned medical causes. CA is presumed to be of cardiac aetiology if non-cardiac causes cannot be determined (Jacobs, 2004). Sudden cardiac death is defined as unexpected and instantaneous non-traumatic natural death, when a loss of consciousness occurs within one hour from the onset of symptoms. Additionally, patients with pre-existing heart disease may experience sudden cardiac death if the timing and mode of death are unanticipated (Priori et al., 2001). Coronary artery disease has been found in 80% of sudden cardiac death patients (Zipes & Wellens, 1998) and remains the main cause of OHCA in the world (Myat et al., 2018). In a recent European OHCA study, medical causes accounted for 91% and traumatic causes for 3.9% of OHCA (Gräsner et al., 2020).

Resuscitation studies usually report the incidence of EMS-attended OHCA, leaving the true incidence of OHCA unknown; however, sudden CA is the third-leading cause of death in Europe (Gräsner, 2021). Studies show a notable variation in both the incidence and outcome of OHCA in Europe and worldwide (Gräsner, 2021; Kiguchi et al., 2020). In Europe, the incidence of EMS-confirmed OHCA is 89 inhabitants per 100,000 population per year, and resuscitation is attempted in 56 per 100,000 OHCAs (Gräsner, 2020). In a worldwide study, the incidence of EMS-attended OHCA ranged from 30.0 to 97.1 inhabitants per 100,000 population (Kiguchi, 2020). Finland does not have a national CA registry, but the newest studies have reported incidences of EMS-attempted OHCA of 51 (Hiltunen et al., 2012) and 52 (Setälä et al., 2017) per 100,000 inhabitants per year.

Table 2. Utstein reporting template for out-of-hospital cardiac arrest

System	Core	Population served, CA attended, resuscitation attempted/not attempted, EMS system description
Dispatch	Core	Dispatcher identified CA, dispatch-assisted CPR
Patient	Core	Age, gender, witnessed arrest, arrest location, bystander CPR/AED, first monitored cardiac rhythm, assumed aetiology
	Suppl.	Independent living, comorbidities, presence of STEMI, ventricular assist device, cardioverter–defibrillator
Process	Core	EMS response times, defibrillation time, target temp. management, drugs, reperfusion attempted
Outcome	Core	Survived event, any ROSC, 30-day survival/survival to discharge, neurological outcome described with CPC score
	Good outcome	CPC 1: Conscious, alert, able to work CPC 2: Conscious, sufficient neurological function for independent activities of daily living
	Poor outcome	CPC 3: Inability to perform independent activities of daily living CPC 4: Comatose or vegetative state CPC 5: Brain death

EMS: Emergency medical services, CA: cardiac arrest, CPR: cardiopulmonary resuscitation, AED: automated external defibrillator, STEMI: ST-elevation myocardial infarction, ROSC: return of spontaneous circulation, CPC: cerebral performance category

2.2.2 Treatment of Out-of-hospital Cardiac Arrest

While CPR patterns (chest compressions, artificial ventilation and defibrillations) were first presented in the 1950s (Kouwenhoven et al., 1960; Safar et al., 1958; Zoll et al., 1956), prehospital CPR was initiated in 1966 (Pantridge, 1967). The International Liaison Committee on Resuscitation (ILCOR) was formed by the principal resuscitation organisations, including the European Resuscitation Council (ERC) and American Heart Association (AHA), in 1992. ILCOR's aim is to save more lives globally through resuscitation by producing evidence-based recommendations for CPR. The newest ERC guidelines published in 2021 are based on ILCOR Consensus on Science and Treatment Recommendations (CoSTR) from 2020 (Perkins, 2021). The latest Finnish national CPR guidelines were published in November 2021, and they follow the ERC guidelines (working group set up the Finnish Medical Society Duodecim, the Finnish Resuscitation Council, 2021).

CPR is divided into BLS and ALS (Olasveengen et al., 2021; Soar et al., 2021). CPR guidelines for basic life support encourage starting CPR on any person who is not breathing or is breathing abnormally. BLS includes opening the airway, recognition of CA, alerting EMS, chest compressions (compression-only CPR and/or dispatch-assisted CPR when needed), rescue breaths along with the chest compressions in a ratio of 2:30 and administering a shock with an AED when possible. Current ERC guidelines for ALS are shown in Figure 3. Specific guidelines exist for IHCAs, traumatic CAs, paediatric and newborn patients and for many special circumstances with possible reversible causes (Lott et al., 2021).

Modern resuscitation is a short, fast-paced and dynamic process that requires accurate performance of certain roles by the person involved in the treatment, good leadership, timely communication and prompt decisions based on situational awareness. Treatment for individuals with a chance of meaningful recovery is highly active. Many of the latest medical technologies and applications have already been imported from hospitals to the EMS, and the ALS guidelines encourage actively seeking and treating reversible causes (Soar, 2021). Hypoxia and tension pneumothorax can be released on-site, and treatment for severe electrolyte/metabolic disturbance, hypovolemia, catastrophic bleeding and hypo-/hyperthermia and thrombolytic therapy for coronary thrombosis or pulmonary embolism can be initiated during CPR. Mechanical chest compression devices can be used as a bridge when the patient is transported with ongoing CPR to a hospital for a percutaneous coronary intervention or to ECMO (hypothermia, pulmonary embolism or other special circumstance) (Yannopoulos et al., 2020). There are some EMS units in Europe that have portable ECMO machines, allowing extracorporeal cardiopulmonary resuscitation (ECPR) to be initiated prehospitally (Tjelmeland et al., 2020). Guidelines recommend that comatose survivors with a favourable prognosis should be admitted for post-resuscitation care to CA centres (i.e., hospitals) for cardiac revascularisation, targeted temperature management and intensive care (Nolan et al., 2021).

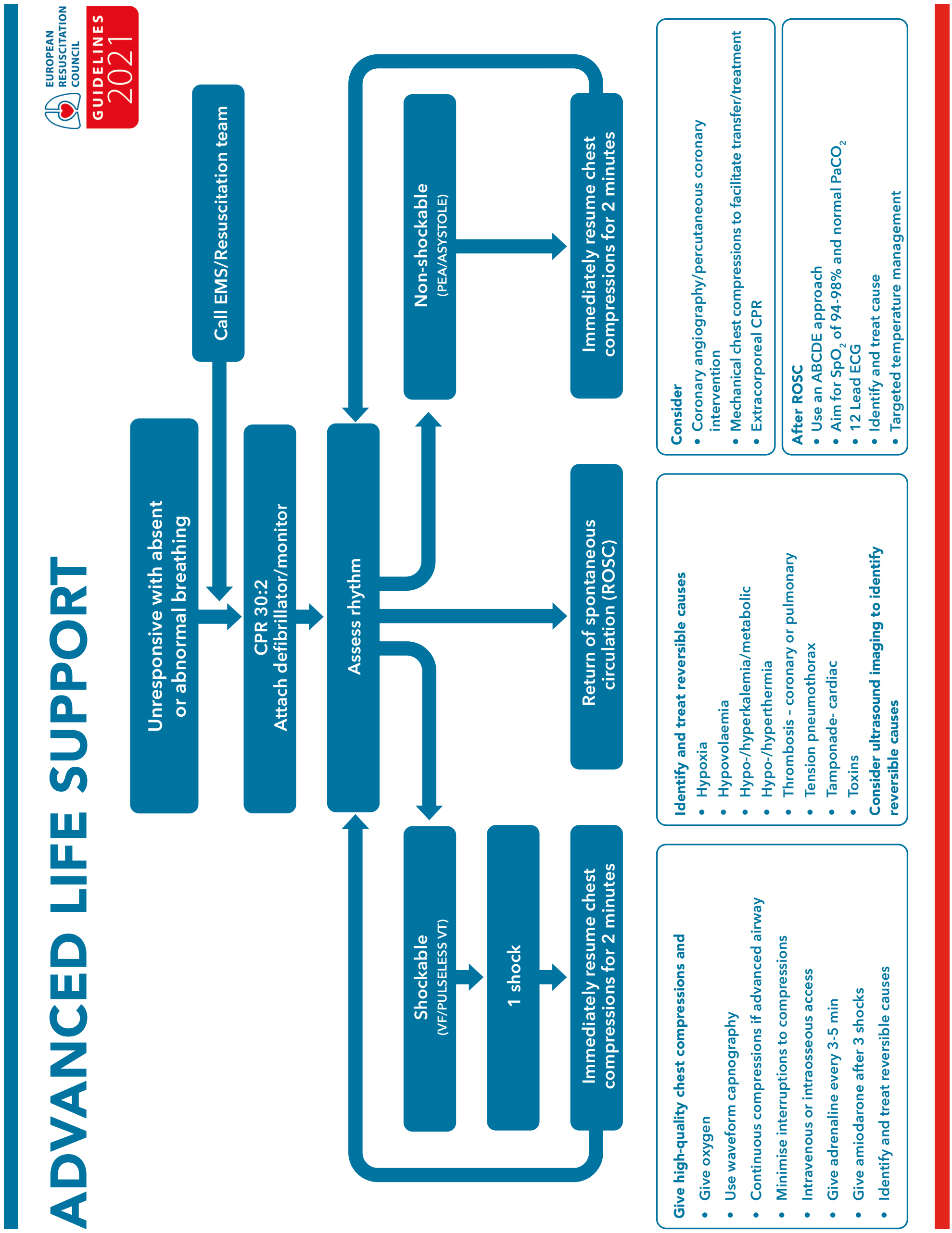


Figure 3. European Resuscitation Council guidelines for advanced life support. Reprinted with the kind permission of the Elsevier (Perkins, 2021).

2.2.3 Outcome of Out-of-hospital Cardiac Arrest

The overall survival rate of hospital discharge after OHCA is 8% (range 0%–18%) in Europe (Gräsner, 2020) and varies between 3.1 and 20.4% of CA registries worldwide (Kiguchi, 2020). In the FINNRESUSCI prehospital study conducted in Finland in 2010, the total number of OHCAs recorded was 1,042. Resuscitation was attempted in 671 cases, 133 (20%) patients survived to hospital discharge and 90 (13%) were alive at one year (Hiltunen, 2012). Setälä et al. (2017) reported that EMS attended 314 OHCAs in the Pirkanmaa area in 2013–2014. Resuscitation was attempted in 280 cases, and 39 (14%) patients survived to hospital discharge. Usually, survival to discharge rates only include cases where resuscitation was attempted by EMS. For comparison, when including cases attended by EMS where resuscitation was not attempted, overall survival to discharge rates of 13% (Hiltunen et al., 2012) and 12% (Setälä et al., 2017) were reported.

In earlier Finnish studies, survival rates were reported to be 17% in 1994 (Kuisma & Määttä, 1996) and 13% in 2004–2005 (Kämäräinen et al., 2007). These studies suggest that survival rates have remained constant over time in Finland, and the same trend has been acknowledged in a global meta-analysis (Sasson et al., 2010). Quite similar survival rates to Finland have been reported in other Scandinavian countries: Sweden 11%, Norway 14% and Denmark 16% (Gräsner, 2021); Australia and New-Zealand 12% (Beck et al., 2018). Meanwhile worse outcomes have been reported in the US (10%) (Virani et al., 2020) and Asia (3.1%) (Ong et al., 2015). The survival rates of paediatric OHCA patients are 5.1–11% depending on age group (Gelberg et al., 2015). The 6.6-fold variation in the overall survival rates between registries (Kiguchi, 2020) is explained by differences between EMS systems (Tjelmeland, 2020), population characteristics, population density, heterogeneity in scientific definitions, different treatment protocols and medical possibilities, the society's ability to tackle challenges related to improving OHCA survival and differences in termination of resuscitation policies (Gräsner, 2021).

The factors associated with good or poor survival after OHCA are presented in Table 3 (Gräsner, 2021; Herlitz et al., 2005; Kiguchi, 2020; Sasson, 2010). The key factor for good long-term survival is survival to hospital discharge with a good neurological outcome, which is defined in the Utstein template using either the modified Rankin scale (van Swieten et al., 1988) or Cerebral Performance Category (CPC) (Jennett & Bond, 1975). The CPC is used in this thesis (Table 2). Survival from OHCA with a good neurological outcome occurs in 2.8–18.2% of cases worldwide (Kiguchi, 2020), 8% in the US (Virani, 2020) and 10% in Finland (Setälä,

2017). EMS system efficacy is usually measured by comparing the survival to hospital discharge of the observed adult CA with ventricular fibrillation or ventricular tachycardia as the first recorded rhythm (Perkins, 2015). 'The Utstein comparator' group has the highest chance for survival after prompt adult life support is provided, with reported rates of 35% (Myat, 2018) and 12–47% in the world (Kiguchi, 2020), 28% (range 0–53%) in Europe (Gräsner, 2020), 33% in the US (Virani, 2020) and 27% (Silfvast, 1990), 35% (Kuisma et al., 2005), 46% (Hiltunen, 2012) and 33% (Setälä, 2017) in Finland.

Table 3. Factors associated with out-of-hospital cardiac arrest survival.

Survival	Non-survival
ROSC on scene	No ROSC
Witnessed arrest	Found in cardiac arrest
Bystander CPR	No bystander CPR or poor quality of CPR
Shockable rhythm (VF, pVT)	Non-shockable rhythms, especially asystole
Early defibrillation	No shock administered
Quick EMS response	Long EMS response time
Cardiac arrest outside home	Cardiac arrest at place of residence
No comorbidities	Comorbidity burden
Dedicated post-resuscitation care	Unavailability of cardiac arrest centre
High socioeconomic status	Low socioeconomic status
Young adult	Adult of high age
Male gender	Female gender

ROSC: return of spontaneous circulation, CPR: cardiopulmonary resuscitation, VF: ventricular fibrillation, pVT: pulseless ventricular tachycardia; EMS: emergency medical services

Modified from the following sources: (Gräsner, 2021; Perkins, 2015; Sasson, 2010)

As the survival from OHCA remains poor, all means to prevent CA are crucial (Gräsner, 2021). The key factors linking CA patients with neurologically favourable survival were described in the 1960s' and termed the 'Chain of Survival' (Nolan et al., 2006). The links are (1) early identification of CA symptoms and rapid EMS dispatch; (2) early BLS to keep up blood perfusion in the brain and heart and thus improve the chances for successful defibrillation; (3) early defibrillation to achieve a

perfusing rhythm; and (4) early ALS to provide good post-resuscitation care for good neurological survival. However, 50–70% of survivors with CPC 1–2 experience long-term fatigue, 40–50% have long-term neurological impairments, such as problems with attention, memory and/or executive functions, and many have emotional and physical problems. Yet, there are many survivors who are able to return to work and to their previous roles in life, and their patient-reported health-related quality of life outcomes do not differ from those of the general population (Gräsner, 2021; Tiainen et al., 2018).

2.2.4 Survival from Critical Illness of Patients with High Age, Comorbidities or Decreased Functional Status

Importantly, in many studies the survival of aged or comorbid patients from a critical illness or hospitalisation is significantly associated with the severity of the acute illness, which always increases the uncertainty of any antecedent prognostication about the survival of any individual patient (Campbell et al., 2004; Ferrante et al., 2015; Guidet et al., 2018). Advanced age is often related to poorer outcomes after critical illness and CA (Campbell, 2004; Deasy et al., 2011; Reinikainen et al., 2007; Terman et al., 2015; Wissenberg et al., 2015), and in a systematic review the pooled survival to discharge rate from OHCA was 4.1% for patients 70 years or older (van de Glind, 2013). However, many aged patients (defined as ≥65 to ≥ 80 years of age depending on the study) have good neurological outcomes after CA (Andersen et al., 2015; Andrew et al., 2018; Beesems et al., 2015; Kitamura et al., 2014; Libungan et al., 2015; Winther-Jensen et al., 2015). In a large study on 101,968 OHCAs in ≥16-year-old US patients, age alone had poor discriminative ability for survival from CA (Andersen, 2015).

Severe chronic illnesses often lowers an individual's functional status and reduces the potential to recover from acute critical illness. In the literature, the comorbidity burden is usually described with the Charlson Comorbidity Index (CCI) (Charlson et al., 1987). CCI is a validated weighted index that predicts one-year mortality and considers the number and seriousness of 22 comorbid conditions (Table 4). The sum of conditions with their weights equals the score, with '0' indicating no comorbidities. A notable comorbidity burden varies between studies but is often defined as a score ≥3. The CCI has been validated in many clinical populations, including acutely hospitalised adults aged ≥ 65 years (Frenkel et al., 2014). The

negative effects of chronic comorbidity on survival from CA (Carew et al., 2007; Dumas et al., 2017; Fabbri et al., 2006; Hallstrom et al., 1996; C.-C. Lee et al., 2011; Stapleton et al., 2014) or other acute critical illnesses (Campbell, 2004; Cardona-Morrell et al., 2016; Esper & Martin, 2011; Jokela et al., 2015; Jukarainen, 2020; Roch et al., 2011) have been reported in many studies. However, in other studies no such association has been found (Beesems, 2015; Soholm et al., 2015; Terman, 2015; Winther-Jensen, 2015). Nonetheless, patients with cognitive impairment have extremely poor survival from critical illness (Beesems, 2015; Cardona-Morrell, 2016; Ebell & Afonso, 2011; Morrison & Siu, 2000; Terman, 2015).

Table 4. Charlson Comorbidity Index. Included comorbidities and their assigned weights.

Weight of the comorbidity	Conditions
1	Myocardial infarction
	Congestive heart failure
	Peripheral vascular disease
	Cerebrovascular disease
	Dementia
	Chronic pulmonary disease
	Connective tissue disease
	Ulcer disease
	Mild liver disease
	Diabetes
2	Hemiplegia
	Moderate and severe renal disease
	Diabetes with end-organ damage
	Any tumour
	Leukaemia
	Lymphoma
3	Moderate and severe liver disease
	Metastatic tumour
6	Acquired immune deficiency syndrome

Recent studies have shown that poor functional status seem to decrease survival from critical illness (Abbo et al., 2013; Campbell, 2004; Ebell, 2011; Krinsley et al., 2017; Narain et al., 1988; Pietiläinen et al., 2018), although no significant association was found when studying the two-year survival of aged ICU patients in France (Roch, 2011). In that study of patients ≥80 years of age admitted to the ICU, hospital mortality was 55%, and the two-year mortality of survivors was twofold to threefold higher than the mortality of the general population of the same age. In a recent Finnish study, 11% of all intensive care patients were over 80 years of age. For non-scheduled emergency patients, the hospital and one-year mortality rates were 28%

and 48%, respectively. For non-scheduled patients with a poor baseline functional status, one-year mortality was 48% for medical admissions and 44% for emergency surgical admissions. Poor baseline functional status was independently associated with one-year mortality (adjusted OR 2.18, 95% CI 1.67–2.85) (Pietiläinen, 2018). Flaatten et al. (2017) found frailty to be a significant factor in increased mortality in 80-year-old or older critical care patients: 30-day mortality was 32% in the whole study population of aged ICU patients and 41% for frail ICU patients specifically. A US study on the effect of premorbid functional status showed that severe disability tripled the risk of death during the first year after ICU admission for critically ill patients >79 years of age (Ferrante, 2015). In that study, 30-day mortality was 24%. In another study of adult patients in a mixed ICU, baseline functional status was a strong predictor of mortality for critically ill patients, and it performed better than the Acute Physiology and Chronic Health Evaluation (APACHE) IV score alone (Krinsley, 2017).

It seems that comorbidities and functional status could be more important to survival than NH residence (Carew, 2007), yet both are usually reasons for residency in a long-term care facility. In a US study, both residential and functional status were important predictors of OHCA, and patients dependent in activities of daily living (regardless of residential status) were less likely to survive (Abbo, 2013). The studies presenting NH residents' survival from OHCA are summarised in Table 5. In some studies, NH residency was found to negatively affect survival from CA (Abbo, 2013; Andrew et al., 2017; Deasy, 2011; Fan & Leung, 2017; Kitamura, 2014; Pape et al., 2018), but often this association was statistically insignificant in an adjusted multivariate analysis (Andersen, 2015; Iwami et al., 2006; Kim C. et al., 2000; Kitamura, 2014; Soholm et al., 2014). In three studies, NH residency did not have an independent negative effect on the outcome (Abbo, 2013; Beesems, 2015; Ghusn et al., 1995). In a systematic review on aged CA patients, NH residency predicted decreased survival to hospital discharge, and absolute survival chances were found to be as low as 0–5.1%(van de Glind, 2013).

When considering studies on intensive care patients, it must be remembered that the patient populations have passed strong selection criteria in preadmission triage, meaning that most old, frail, disabled and dependent patients are excluded from such studies (Ferrante, 2015; Flaatten, 2017; Guidet, 2018; Krinsley, 2017; Pietiläinen, 2018; Roch, 2011; Skjaker et al., 2017). Notably, patients with severe chronic comorbidities (e.g. dementia) often eventually die relatively acutely, for example, from pneumonia (Brunnström & Englund, 2009; Morrison R., 2000).

Table 5. Nursing home residents' survival from out-of-hospital cardiac arrest.

Study	Community and study year	Population	NH resident's survival to discharge
(Applebaum et al., 1990)	USA 1987	705 ≥ 65 years old OHCAs; 117 (17%) in NH	1.7%
(Awoke et al., 1992)	USA 1987–1990	45 OHCAs in NH (42–93 years old)	0%
(Tresch et al., 1993)	USA 1986–1989	196 OHCAs in NH	5%
(Ghusn, 1995)	USA 1990's	114 NH residents with OHCA 228 matched cohort of community-residing older adults	10.5% in NH group 9.2% in matched cohort
(Kim, C 2000)	USA 1987–1998	5,882 OHCAs of cardiac origin; 446 (7.6%) in NH	4.7% in NH
(Iwami, 2006)	Japan 1998–2001	7,540 OHCAs of cardiac origin; 405 (5.4%) in NH	1.5% in NH (to 1-year)
(Deasy et al., 2012)	Australia 2000–2009	30,006 adult OHCAs; 2,350 (7.8%) in NH	2.6% in NH 2.1% >70 years in NH
(Kitamura, 2014)	Japan 1999–2011	10,876 ≥ 65 years old bystander-witnessed OHCA patients; 1,358 (12.5%) in NH	1.3% with CPC 1–2
(Soholm et al., 2014)	Denmark 2007–2011	2,541 ≥ 18 years old OHCAs with resuscitation attempted; 245 (10%) in NH	9%
(Fan, 2017)	China 2012–2013	3,919 ≥ 65 years old nontraumatic OHCAs with resuscitation attempted; 1,506 (38%) in NH	0.3%
(Pape, 2018)	Denmark 2001–2014	26,999 OHCAs 2,516 (9.3%) in NH	1.7% [95%CI:1.2–2.2%]
(Andrew, 2018)	Victoria, Australia 2010–2016	20,103 ≥ 65 years old EMS-attended OHCAs; 2,575 (12.8%) in NH	2.2%

OHCA: out-of-hospital cardiac arrest, NH: nursing home, CPC: cerebral performance category

2.3 Treatment Plans and Limitations of Medical Treatment

In Finland, patients should always be treated in alignment with the Finnish Act on the Status and Rights of Patients (Act on the Status and Rights of Patients, 1992). If patients are unable to express their wishes, the treatment plan should represent their assumed best interests. If a severe condition threatens a patient's health or life, necessary treatment should be given even if the patient's wishes are unknown due to unconsciousness or other reasons. However, if patients have a valid advance directive, they should not be given treatment that is contrary to their will. Patients have a right to refuse an offered treatment, and in that situation they should be offered a medically accepted alternative treatment (lighter, safer etc.) (Mentzelopoulos, 2021). However, the patient or the patient's proxies cannot demand any treatment that is considered unsuitable, ineffective or harmful. Finnish health care professionals are obligated to help patients who are in need of acute care (Health Care Professionals Act, 1994).

According to the legislation, there should always be a plan for implementing health and medical care and rehabilitation, indicating both arrangements for and timing of the treatment (Act on the Status and Rights of Patients, 1992). The Finnish service choices in health include medically or dentally justified disease prevention and treatment, but procedures, examinations and therapies 'that involve an unreasonably high risk for the patient's life or health in view of the health benefits to be gained or whose effect is limited or whose costs are unreasonably high in view of the health benefits to be gained and the therapeutic value' are excluded (Health Care Act, 2011). However, the Act states that they can be included 'if an illness or injury that seriously threatens the life or health of the patient taking into consideration the patient's health state and the expected course of the illness'.

According to the Universal Declaration of Human Rights, everyone has the right to life (United Nations, 1948). The traditional medical principles are beneficence, non-maleficence, autonomy and justice (Beauchamp et al., 1979). The World Medical Association's Declaration of Geneva and the Finnish Medical Oath are similar; in both, physicians swear to serve their fellow humans with respect for life and humanity and not to discriminate any patients (The Finnish Medical Association, 2021a). When treating a single patient, the physician needs to have clinical autonomy to work for what is best for that single patient (Mentzelopoulos et al., 2016). At the same time, physicians need to abide by the principle of solidarity; that is, all patients with a similar need for treatment should receive the same treatment (The Finnish

Medical Association, 2021b). Decision-making in modern medicine has become more patient-centred, and the avoidance of discrimination is essential.

2.3.1 End-of-life Care

The majority of the Finnish population die in the general wards of primary HCFs, where they are transferred during the last weeks of their life (Aaltonen et al., 2010). Planning end-of-life care is an important part of treatment for patients with severe, progressive illnesses. Moving to a long-term care facility is a good time to initiate an advance care plan (Cardona-Morrell, 2016; Pitcher et al., 2017). The Finnish guideline recommends that end-of-life care planning and evaluation of palliative care needs should be established so that the attending physician will not be surprised if the patient dies during the following 6–12 months (Working group set up by the Finnish Medical Society Duodecim and Finnish Association for Palliative Medicine, 2019). Some concepts of end-of-life care related to this thesis are summarised in Table 6. Scientific evidence on advance care planning is novel, and the concept has only been addressed in the latest ERC guidelines (Bossaert et al., 2015; Lippert et al., 2010). However, several studies and meta-analyses from the last two decades have reported encouraging results regarding the effect of advance care planning (Gonella et al., 2019; Houben et al., 2014; Kavalieratos et al., 2016), and there is a strong recommendation in Finland to carry out advance care planning (National Supervisory Authority for Welfare and Health, 2020; Saarto et al., 2022).

The need for palliative care is increasing (Working group set up by the Finnish Medical Society Duodecim and Finnish Association for Palliative Medicine, 2019). The WHO has estimated that oncological patients comprise approximately 40% of all patients needing palliative care, and the majority are patients with other chronic comorbidities, such as cardiac or kidney failure, pulmonary and neurologic illnesses and dementia (Worldwide Palliative Care Alliance, 2014). Most patients approaching the end of life are managed with the simple palliative care measures available in all NHs, HCFs and outreach home hospitals that treat dying patients. Approximately one-third of patients need specialised palliative care interventions that are available mainly in cities with central or tertiary hospitals, palliative care centres and hospice care (Saarto, 2019b). These needs can occur urgently and demand immediate treatment during on-call hours.

Table 6. Some concepts of end-of-life care.

Shared decision-making	Communicative process that includes the patient or their surrogates and, when possible, a multidisciplinary group of health care professionals to reach consensus on which treatment strategies accord with the patient's preferences. [1]
Advance care planning	Advance care planning enables individuals who have decisional capacity to identify their values, to reflect upon the meanings and consequences of serious illness scenarios, to define goals and preferences for future medical treatment and care, and to discuss these with family and healthcare providers. ACP addresses individuals' concerns across the physical, psychological, social, and spiritual domains. It encourages individuals to identify a personal representative and to record and regularly review any preferences, so that their preferences can be taken into account should they at some point be unable to make their own decisions. [2]
Advance directive	Advance care planning generally includes written advance directive forms, statements and wishes that are documented in medical records. An advance directive can be a living will or physician's decision to withhold medical interventions. [3] An advance directive needs to meet the criteria of existence, validity and applicability [1].
Emergency care plan	Emergency care plan is part of an advance care plan indicating actions to be taken in the event of a medical emergency. [4]
Euthanasia	Euthanasia is based on the words 'eu thanatos', meaning 'dying without suffering'. It is defined as actively ending the patient's life by giving medications at the request of a legally competent patient. Euthanasia is illegal in Finland. [5]
Treatment policies for patients with progressive comorbidities: [6]	
Curative treatment	Aims for complete healing.
Slowing the progression of a disease	Treatments that aims to slow the progression of the disease (for example a malignancy or a heart failure), prolong life and improve functional status.
Palliative care	Palliative care is an approach that improves the quality of life of patients (adults and children) and their families who are facing the problems associated with life-threatening illness, through the prevention and relief of suffering by means of early identification and correct assessment and treatment of pain and other problems, whether physical, psychosocial or spiritual. [7] Diagnosis of 'palliative care' (Z51.5) is indicated when treatments no longer affect the prognosis, and the main goals of care are to relieve symptoms and the maintain quality of life.
End-of-life care	End-of-life care supports the patient and the proxies during the last days or weeks of life. End-of-life care is the phase of palliative care when the patient is dying. The decision to enter to the end-of-life care includes a decision to withhold CPR in case of cardiac or respiratory arrest, although that can be documented separately.

[1] (Mentzelopoulos, 2021); [2] (Rietjens et al., 2017); [3] (Andreasen et al., 2019); [4] (Pitcher, 2017);

[5] (The Finnish Medical Association, 2021c); [6] (Working group set up by the Finnish Medical Society Duodecim and Finnish Association for Palliative Medicine, 2019); [7] (Worldwide Palliative Care Alliance, 2020)

The working group studying the status of palliative care and terminal care in Finland identified deficiencies in the availability of palliative care resources and competence, leading to abundant admissions to emergency departments and hospitals. This was found to be true for all aged patients in long-term care, but especially those in homecare. During the last 90 days of the patients' lives, 89% of homecare patients had received some treatment in a hospital compared to 49% of those patients in long-term care facilities with 24-hour assistance. Correspondingly, the proportions or patients being admitted to a hospital emergency departments were 70% and 43% (Saarto, 2019b). Although end-of-life care of the aged has improved (Visapää, 1998), 10% of long-term care residents with dementia experience burdensome end-of-life transitions (Aaltonen, 2014). Importantly, palliative care consultations are not available during on-call hours (Saarto et al., 2019a).

In 2012, chief physicians responsible for the EMS of the university hospital districts sent a memorandum to the Regional State Administrative Agencies indicating their concerns about the increased use of EMS units to treat patients in NHs because of end-of-life care challenges due to the lack of advance care plans. In 2015, the National Supervisory Authority for Welfare and Health 'Valvira' published a guide on treatment plans and DNAR decisions in long-term care facilities and the use of EMS (National Supervisory Authority for Welfare and Health, 2015). The guide clearly stated that all patients with comorbidities in long-term care should have an advance care plan, with an adequate emergency care plan easily available when needed. The guide also acknowledged that in some long-term care units the staffs' education, competence and number of personnel have been inadequate in relation to the number of residents or the residents' functional status, leading to EMS dispatch even when there is no actual need for it. This guide was removed from Valvira's website in 2020 and replaced with more general guidance on end-of-life care directed to health care professionals (National Supervisory Authority for Welfare and Health, 2020). In an European multicentre study of NH residents with 24-hour assistance, 40% of those who deceased in Finland in 2014 had some written advance directive (Andreasen, 2019). In a survey conducted in Western Finland in 2019, only 20% of NHs indicated that they have an advance care plan for all residents, and more than one-third reported that none of their residents have an advance care plan. Many of the residents are too deteriorated or demented for such discussions when they arrive at an NH (Saarto, 2019b).

2.3.2 Limitation of Medical Treatment

Limitation of medical treatment (LOMT) is a decision to withdraw or withhold medical treatments or interventions based on medical causes or the patient's preferences. The principle of limiting medical treatment is that treatment would cause more harm than benefit to the patient. Often the justification for LOMT is medical futility, but futility is a controversial concept that requires consideration of the context (Mentzelopoulos, 2016). Regarding clinical outcome, it has been proposed that treatment could be considered futile if the chance of the treatment being successful is less than 1%, or if it would only preserve a state of permanent coma or dependence in intensive care (Schneiderman et al., 1990). This approach has been widely questioned, and as medicine has shifted towards more individual and patient-centred care, it has been suggested that futility should be assessed based on the treatment's impact on the patient's life and quality of life (Helft et al., 2000; Mentzelopoulos, 2021).

LOMTs are categorised as 'withholding', that is, not to initiate or increase the activity of treatment, and as 'withdrawing', meaning to actively cease an intervention that has already been initiated. LOMT practices vary remarkably between regions and countries because of cultural, societal, legislative, religious and economic reasons (Curtis et al., 2017; Mark et al., 2015; Santonocito et al., 2013; Sprung et al., 2003; Tjelmeland, 2020). LOMTs are common in North Europe and the US but rarer in East and South Europe, Latin-America and Asia (Bae et al., 2008; Gonella, 2019; Gräsner, 2021; Guidet, 2018; Mark, 2015; Morgan, 2015; Tanaka et al., 2020). In countries where withholding or withdrawal of intensive care are not common practices, there are more OCHA survivors with poor neurological statuses, such as a persistent vegetative state (Gräsner, 2021). In Italy, 50% of OHCA survivors were found to have poor neurological outcome at six months (Scarpino et al., 2019). In comparison, in Finland, where LOMTs are common, over 91% of OHCA survivors were independent in ADL at one year (Tiainen, 2018).

In Finland, a licensed physician alone can decide to limit medical treatments according to the law, but local guidelines set more precise frameworks such that the decision should be made by an appropriate medical specialist (HUS, 2017; PSHP, 2019). The decision to withdraw intensive care is made in a treatment group during office hours, and it requires a unanimous decision of at least two specialists (HUS, 2019). While LOMT decisions are medical decisions made by physicians, they should be made in agreement with the patient or, if that is not possible, with the patient's proxies. All LOMTs and their reasoning are documented in medical records along

with the name of the decision-maker, details of the consultation with the patient and the proxies and their opinion on the LOMT, resulting in an LOMT being issued either based on mutual understanding with the patient/proxies or on medical grounds (Hirvonen & Pöyhiä, 2016; HUS, 2017; National Supervisory Authority for Welfare and Health, 2020; PSHP, 2019). LOMTs need to be based on a comprehensive evaluation of the patient's health, functional capacity and resources for recovery, and blanket or categorical criteria (e.g. age thresholds) should not be used to determine the appropriateness of a treatment for a patient (Mentzelopoulos, 2021). If the patient's condition improves or if the patient changes their preferences and wishes treatment they have previously refused, the LOMT decision can be cancelled.

Withholding and Withdrawal of Life-sustaining Treatments (WLST)

Life-sustaining treatment (LST) is defined as any intervention that serves to prolong life without reversing the underlying medical condition, such as CPR, mechanical ventilation, haemodialysis, left ventricular assistance devices, antibiotics and artificial nutrition and hydration (Ko & Blinderman, 2015). There have been many studies on withholding or withdrawing CPR attempts after OHCA, but studies on other LOMTs from the perspective of EMS personnel were scarce while planning this thesis. The key aspects of WLST are presented below as well as topics to consider when talking about LOMTs in prehospital settings.

DNACPR (do not attempt CPR) is a decision to withhold CPR (chest compressions, defibrillation and artificial ventilation) in the event of cardiac or respiratory arrest, and it does not consider any other medical treatments. Although DNACPR orders have been documented since the 1970s, there are still misunderstandings due to inconsistencies in decision-making, communication and documentation (Fritz & Fuld, 2010; Pitcher, 2017; Sundar et al., 2015). Systematic reviews show significant variability in DNACPR practices between countries and cultures (Mockford et al., 2015), and the most promising intervention for improving DNACPR decision-making involves linking those decisions to discussions about overall treatment goals (Field et al., 2014). While European physicians are encouraged to discuss DNACPR as a part of advance care planning (Slowther et al., 2017), for physicians in Asia WLST may be illegal and regarded as euthanasia (Morgan, 2015). Nonetheless, a DNACPR order affects decision-making on treatments and may also reduce the therapies that patients with DNACPR orders are entitled to, such as prompt aggressive treatment of sepsis or even palliative care

(Mockford, 2015; Moffat et al., 2016). This reduces physicians' willingness to issue DNACPR orders in Finland, although practical criteria for initiating discussions on advance care planning and LOMTs exist (Hirvonen, 2016).

DNACPR orders are general practice in hospitals in Europe (Gräsner, 2021) and have become more common in NHs and home care due to increasing advance care planning (Visapää, 1998). Twenty years ago in Finnish secondary hospitals, 85% of patients for whom CPR was not attempted after CA had a DNACPR order in place, and the remaining 15% had either a terminal illness or suffered an unwitnessed CA in general wards (Skrifvars et al., 2003). Laakkonen et al. (2004) studied the prevalence of advance orders to limit therapies in 5,654 NH residents in Finland in 2002. The prevalence of DNACPR orders was 13% and that of do-not-hospitalise orders was 0.6%, and the prevalence of these orders varied significantly between NHs. The local caring cultures explained LOMTs more than patient-related factors, such as functional status or impaired cognition (Laakkonen et al., 2004). For EMS-attended OHCA patients, the prevalence of DNACPR orders was reported to be 6.2% in the UK (Rajagopal et al., 2016) and 9.9% in the US (Counts et al., 2020), while the prevalence of advance directives was 7.5% in France (Reuter et al., 2017). Most (89%) German prehospital physicians had encountered out-of-hospital emergency patients with advance directives (Wiese et al., 2011).

Termination of resuscitation (ToR) in prehospital settings is often strictly regulated, but practices vary (Gräsner, 2021; Tjelmeland, 2020). Guidelines on ToR are based on studies on resuscitation-related factors that are associated with a minimal chance for survival with an aim to reduce futile hospital transportations. Several individual ToR rules have been developed and implemented in prehospital settings around the world. For example, Morrison et al. (2009) validated a universal ToR rule for EMS systems with BLS and ALS units. ToR is recommended if there is no ROSC, if the arrest is not witnessed by prehospital providers and if no shock has been delivered during the CPR, and it has 100% specificity and a positive predictive value of 100% (Morrison L. et al., 2009). ILCOR conducted a systematic review of 34 studies addressing the use of ToR rules, conditionally supporting the use of ToR rules, although there was very low-certainty evidence. However, none of the existing ToR rules should be the lone decisive factor in ceasing resuscitation (Greif et al., 2020). In some countries in Europe and throughout the world, prehospital providers need to initiate treatments for all OHCA patients, and the patients need to be transported to the hospital with ongoing resuscitation if ROSC does not occur. ToR is possible in prehospital settings in some countries, and transport to the hospital is only possible after ROSC. However, most countries allow

transport with ongoing CPR in specific situations. Studies have reported that resuscitation is ceased in about 40–50% of OHCA cases attended by EMS and considered for resuscitation in Europe (Gräsner, 2021). In Finland, resuscitation was withheld in 51% of OHCA cases in one study (Kämäräinen, 2007) and in 36% in another (Hiltunen, 2012). Setälä (2017) found that CPR was ceased in 34% of OHCA cases (withholding in 10.8% of cases and withdrawal in 23.6% of cases).

In Finland, CPR can be withheld or withdrawn at the scene in the event of OHCA, and in specific circumstances transportation with ongoing CPR is permitted. Finnish guidelines follow ERC guidelines for ToR. EMS paramedics can always stop CPR if their safety cannot be adequately assured (i.e. communicable diseases, scene safety), if they perceive obvious mortal injury or secondary signs of death or if a valid and relevant LOMT (e.g. a DNACPR or advance directive) becomes available (Perkins, 2021). EMS paramedics can withhold CPR based on a physician's consultation or the hospital district's permanent instruction if the patient has been drowned for more than 30 minutes, is in the process of dying from a terminal illness, has an unwitnessed CA with asystole as a first monitored rhythm or if there is a non-shockable rhythm with a long time delay from CA to EMS arrival without bystander-administered CPR (the exact time is not defined in the guidelines, but in practice this means delays exceeding 15 minutes). ToR is considered after 20 minutes of ALS in cases of persistent asystole or pulseless electrical activity (PEA) in the absence of any reversible cause if the patient is not hypothermic. In the event of shockable rhythms, ToR needs to be considered after 40 minutes of ALS without ROSC if the patient is not eligible for transport to the hospital with ongoing resuscitation or if there is no opportunity for transport and/or emergency intervention at the receiving hospital. Transport with ongoing resuscitation should be promptly assessed if any of the following criteria are met: EMS-witnessed CA, ROSC is achieved, shockable rhythm or CA from a reversible cause (cardiac, toxic, hypothermia) (Working group set up the Finnish Medical Society Duodecim, the Finnish Resuscitation Council, 2021). However, the decision should not be made solely based on pupil size, CPR duration, end-tidal carbon dioxide level or suicide attempt. These criteria are the same for children, although health care staff tend to attempt futile CPR longer if the patient is a child (Mentzelopoulos, 2021).

The incidence of decisions to limit LSTs is increasing (Prendergast & Luce, 1997; Sprung et al., 2019). There are few studies on the reasons for WLST in prehospital settings, but studies from ICUs exist. The severity of the acute disease on admission is usually the main reason for hospital mortality and treatment restrictions after admission to the ICU (Ferrante, 2015; Flaatten, 2017; Guidet, 2018; Hoel et al., 2014;

Roch, 2011; Skjaker, 2017). In addition, factors affecting the decision to limit treatments of ICU patients include older age (Adamski et al., 2020; Guidet, 2018; Hoel, 2014; Skjaker, 2017), frailty (Adamski, 2020; Flaatten, 2017; Guidet, 2018; Pietiläinen, 2018), acute admission (Adamski, 2020; Guidet, 2018; Pietiläinen, 2018), comorbidity burden (Adamski, 2020; Hoel, 2014; Skjaker, 2017) and NH residency (Adamski, 2020; Reignier et al., 2008). In non-scheduled patients, 33% of medical admissions and 25% of emergency surgical admissions had LOMTs in Finland (Pietiläinen, 2018). Reignier et al. (2008) conducted the first prospective study analysing reasons for ICU refusal rather than admission. The reasons for the decision to limit LST and refuse ICU admission were higher age, underlying disease, NH residency, pre-existing cognitive impairment, admission for medical reasons, and a diagnosis of sepsis, acute cardiac failure or acute central neurologic illness. In that study, 59% of the decisions to withhold LST for ICU-refused patients were made via phone (Reignier, 2008). While LOMTs are generally common in Finland and Northern Europe (Guidet, 2018; Mark, 2015), some critically ill patients with LOMTs survive. In 2016, 14% of all ICU patients had limitations of LST in Finland, yet 24% of them survived for one year after ICU admission (Adamski, 2020).

Recently, an increasing number of studies have been published on end-of-life decision-making in prehospital settings. The first study on prehospital WLST was conducted in France in 2003 (Ferrand et al., 2006). It showed that 76% of prehospital physicians had made prehospital end-of-life decisions. Withholding was more common than the withdrawal of LST. These decisions concerned intubation/extubation, vasopressor therapy and fluid resuscitation, and the withdrawal decision also concerned ventilation. Waldrop et al. (2019) studied end-of-life decision-making in a prehospital setting in the US. In their qualitative study on prehospital providers, end-of-life situations were divided into four groups based on the patient's and proxies' awareness of dying and the availability of documentation of wishes or LOMTs. Four categories of situations were recognised (aware-documented, aware-undocumented, unaware-documented and unaware-undocumented), which differed in nature, reasons to call 911, treatments, help and support provided by the prehospital providers and the types of conflicts encountered (Waldrop et al., 2019). In cross-sectional studies based on qualitative data analysis, 43 prehospital providers were interviewed on how they manage emergency calls at the end of life in general (Waldrop et al., 2015) and emergency calls to NHs at the end of life (Waldrop et al., 2018). Reasons to activate the EMS system to NHs included the increasing care needs of the dying resident leading to an imbalance with other residents' needs, distress related to the dying process, a fear the facility would

be cited if a resident were to die, low staffing ratios compared with the number of residents and organisational protocols that required transfers of declining NH residents to emergency departments.

There are multiple challenges in LOMTs and end-of-life decision-making. The varying circumstances and dynamic situations in prehospital settings make these choices even more complex. EMS personnel can experience end-of-life situations as confusing and ethically challenging (McGinley et al., 2017; Waldrop, 2019). Conflicts may arise at the end of life even when LOMTs exist (Kim K. et al., 2017; Mirarchi et al., 2015; Waldrop, 2015). There has been scepticism about the notion that WLST could cause the deaths of potential survivors (Chen et al., 2008; Elmer et al., 2016) or a loss of potential organ donors (Sairanen et al., 2014; Sandroni & Taccone, 2016), while other have argued that WLSTs in prehospital settings may be made hastily (Rocker, 2006). In the UK in 2014, the Court of Appeal ruled that a patient's human rights had been violated when a DNACPR order was placed without informing the patient, as the decision about the patient's CPR status engages Article 8 of the European Convention of Human Rights (the right to private and family life). The severely ill patient was intubated and ventilated in an ICU, and the previous extubation attempts prior to the DNACPR decision had failed (Fritz et al., 2014). The Parliamentary Ombudsman of Finland have given decisions on DNACPR order that was deficient in both the decision-making process and the grounds for the decision (4072/4/09) and on cases of maltreatment of dying patients (1552/4/05 and EOAK/3110/2019). The Ombudsman emphasised that no patients with a particular illness or any other group of patients should be discriminated against (1863/4/11, 3624/4/07). There is also no justification for not providing particularly expensive therapy because resources are limited or because other patients would be left without treatment (921/4/04) (Parliamentary Ombudsman of Finland, 2022). In addition, the assessment of the cost-effectiveness of treatments is not systematic in Finland, and unlike other countries, such as the UK, there is no threshold for how much a therapy or care for one person or illness can cost (Morris, 2018b).

3 AIMS OF THE STUDY

The purpose of this thesis was to investigate EMS and HEMS missions to NHs and HCFs and LOMTs in HEMS physicians' work with the following specific aims:

1. To describe Finnish HEMS physicians' experiences and opinions on LOMTs and on HEMS missions and consultation calls involving patients in NHs and HCFs (I)

2. To investigate the characteristics and prognosis of CA patients attended by EMS in NHs and HCFs in Pirkanmaa according to an Utstein template (II)

3. To determine the prevalence and content of pre-existing LOMTs on HEMS missions and on consultation calls and investigate new LOMTs issued by HEMS physicians (III, IV)

4. To evaluate the information available when HEMS physicians make decisions on treatment and LOMTs (III, IV)

4 MATERIALS AND METHODS

4.1 Study Setting

4.1.1 Emergency Medical Service Dispatch and Study Setting in Pirkanmaa

The Emergency Response Centre Agency is a national organisation that operates six EDCs around the country. The EDC in Pori is responsible for the Pirkanmaa and Satakunta areas (Figure 1). EDC operators work both as call handlers and dispatchers for EMS, rescue, police and social units. The degree of Emergency Response Centre Operator (90 European Credit Transfer and Accumulation System credits) takes 1.5 years to complete in Emergency Services Academy Finland and can be accomplished after upper secondary education. Importantly, EDC operators are not licensed health care professionals, and they are unable to perform medical health care assessment during the call. Instead, call processing is based on strict protocols and algorithms. The operator inputs the required data to the EDC information system, and the system generates a proposal for a task code and suitable units to dispatch. The task code defines the leading authority of the dispatch (rescue services, EMS or police). The response, that is, the type and number of suitable units for each dispatch, is pre-defined, but the actual response depends on the location of the patient, the time of the day, risk assessment of the situation and the geographical location of the units at that moment in time. The dispatch protocol does not take into account whether the patient is located in an NH or HCF, and it does not include questions on LOMTs or advance care plans.

Of the 5,534,000 population in Finland, 522,852 inhabitants lived in the Pirkanmaa area, which is 15,550 square kilometres (Official Statistics of Finland, 2019b). There were 5,485 clients in NHs in Pirkanmaa in 2013, and 98 private NHs for the aged were provided by for-profit companies in Pirkanmaa in 2016. During the study (II), there were 45 FRUs, 10 BLS and 25 ALS units, one field commander and one HEMS base with HEMS physicians operating 24 hours in a day in the

Pirkanmaa area. FinnHEMS 30 is always dispatched on missions concerning patients with CA. Patients who need assessment in the emergency department of a tertiary hospital are transported to Tampere University Hospital.

4.1.2 Helicopter Emergency Medical Service (HEMS) Physicians

The EMS Decree stipulates that all catchment areas for highly specialised medical care shall organise 24-hour EMS physician services on premises in at least one base. Those are the five HEMS bases. The on-call HEMS physician, together with the field commander, manages the situation-specific medical activities of the EMS system and is responsible for providing care instructions to other prehospital providers in their area of responsibility. The physician-staffed HEMS units can operate by car or helicopter depending on the situation, for example, based on the location of the patient or the weather. The HEMS unit is automatically joined to some high-risk (category A) EDC task codes, such as CA, unconsciousness, bleeding, drowning, high-impact road-traffic accidents or other major trauma and pre-hospital labour. In addition, HEMS physicians can decide to join any other mission if they consider it necessary or if EMS personnel or the EMS field commander request support. After the HEMS dispatch, the HEMS physician gathers information on the mission by radio from the EDC operator and by radio or phone from EMS units on-site with the patient. HEMS physicians can cancel their participation in a mission if they determine that there are adequate medical resources at the site, if there is a weather obstacle or the patient is too far to reach in a meaningful time or if a concurrent mission occurs that the HEMS unit decides to join instead. Adequate medical resources mean that either the patient is well enough for a BLS/ALS unit to handle the situation or the patient has an LOMT and is not eligible, for example, for intubation, mechanical ventilation or vasopressor therapy provided by an HEMS physician and adequate comfortable measures can be provided by BLS/ALS units.

EMS physicians have important tasks to direct and organise EMS patient flows to the right hospitals for admission, to perform patient triage during concurrent missions or in multicausal accidents and to support and advise paramedics when needed. HEMS physicians can make diagnostics and initiate a vast array of LSTs at the site of a patient, such as identifying and treating reversible causes of CA.

(Bjornsen et al., 2018; van Schuppen & Bierens, 2011). In addition to other ALS procedures and basic clinical examination, an EMS physician can place intra-arterial cannulas, analyse blood gases, electrolytes and acid-base balance, perform ultrasound examination, secure the airway, induct and maintain general anaesthesia, use drugs demanding intensive-care level surveillance, perform emergency surgery in the field and perform blood transfusion. Surgical procedures include surgical airway, thoracostomy and pleural drainage, placing an endovascular resuscitative balloon in the aorta (FH30 in Pirkanmaa), emergency thoracotomy and post-mortem caesarean section. HEMS physicians assess the health risk and determine the appropriate vehicle for transportation and suitable destination for further treatment.

HEMS physicians also provide guidance and support for EMS personnel on the phone. Consultation practices vary between areas, as protocols are defined by local health care districts. Generally, an HEMS physician is consulted on critically ill or injured patients with a vital dysfunction if an HEMS unit is not dispatched to the scene. The HEMS unit can decide to join the mission because of the consultation call. In addition, EMS personnel consult a physician when a medical intervention following the standard protocol has been given on the scene but the patient's condition does not improve. In situations where EMS personnel have given sufficient medical treatment to the patient and transportation to a hospital is not needed, a physician needs to be consulted to obtain a permission to leave the patient at the scene. The latter calls are occasionally directed to HEMS physicians but also to physicians in emergency departments. Based on treatment protocols for certain patient groups, EMS personnel primarily call a cardiologist or neurologist for consultation regarding further treatment.

According to the EMS Decree, every hospital district should have a responsible EMS physician who is a specialised physician with good familiarity and experience in EMS. Generally, this competence is shown by completing a supplementary training programme on EMS in a medical faculty. Only physicians specialised in emergency medicine or anaesthesiology and intensive care can enrol in the additional EMS training programme. This programme requires two years of full-time service as an EMS physician, at least one of which should be served in an HEMS unit. The programme has physical, psychological, skill and knowledge standards for trainees. Universities' medical faculties launched these additional professional training programmes in 2014. Prior to this, the Finnish Medical Association organised and granted special competences in medical subspecialties. At that time, a special competence in EMS was available for specialised physicians regardless of the specialty.

4.1.3 The FinnHEMS Database and Medical Records in HEMS Settings

FinnHEMS Ltd. has an electronic database called the FinnHEMS database (FHDB). The FHDB is used on HEMS bases, but it can also be used online via a secured internet connection. FHDB includes data on HEMS missions that are used for daily reporting, but it also contains data on phone consultations and medical records on encountered patients. Additionally, the database is used for administrative and scientific purposes. The data inserted in the FHDB are mainly structurally recorded. While the variables in the documentation sheets are primarily derived from guidelines, there is a space for free writing on every documentation sheet. HEMS physicians record their missions in the FHDB, but when appropriate they also provide documentation to the university hospital's medical records because other hospital physicians do not have access to FHDB (Heino et al., 2019).

Documentation of consultations calls varies between HEMS bases. Physicians in FH20, FH30, FH50 and FH60 document consultation calls to FHDB. Meanwhile, in FH10 (at Helsinki-Vantaa Airport) the consultation calls are documented in Merlot Medi, another EMS software application that is used by all EMS units in the Helsinki area, including the physician-staffed ground unit in Helsinki City. Merlot Medi is not intended for scientific purposes, and data on consultation calls concerning only HEMS physicians cannot be derived from that database.

Kanta Service is a national archive of health and social welfare information. It contains up-to-date health care records from both the private and public sectors and social care records from the public sector. The users of Kanta Service include citizens, health care services, social welfare services and pharmacies. HEMS physicians have access to university hospital medical records and other national health care records via Kanta Service while they are on the HEMS base, but they are usually unavailable while on the scene. If information from medical records is needed while on-scene, the HEMS physicians can contact the on-call physicians in the hospitals.

4.2 Study Design and Data Collection

This thesis was planned to study two topical phenomena of EMS work that are often invisible but still strongly present in practical work: EMS missions to NHs and HCFs and LOMTs in HEMS physicians' work. We hypothesised that these are linked to each other, that is, that LOMTs would be more common on EMS missions to NHs

and HCFs. The hypothesis was approached with four studies with different materials, and both qualitative and quantitative analysis methods were used to triangulate these phenomena. These were prospective, observative and open studies based on registries and survey data from HEMS physicians. There were no interventions, and no patients were contacted for the research. A summary of studies included in this thesis is presented in Table 7.

Table 7. Summary of the studies.

	Study I	Study II	Study III	Study IV
Design	Cross-sectional	Prospective observational + post-hoc analysis	Prospective, observational	Prospective, observational
Study setting	Nationwide	Pirkanmaa	Nationwide	FinnHEMS bases FH20, FH30, FH50 and FH60
Data Collection	Jan 20 – April 30, 2017	Jun 1, 2013 – May 31, 2014	Sep 6, 2017 – Mar 6, 2018	Sep 6, 2017 – Mar 6, 2018
Main objective	HEMS physicians' experiences on LOMTs, and EMS missions to NHs and HCFs	Utstein report on OHCAs in NHs and HFCs	All HEMS missions associated with LOMTs	All consultation calls to HEMS physicians associated with LOMTs
Cohort	59/67 (88%) HEMS physicians	65 OHCA patients	335 HEMS missions	478 consultation calls

4.2.1 HEMS Physicians' Experiences and Opinions (I)

This cross-sectional nationwide multicentre study was designed around ethical challenges arising from previous studies (Becker et al., 2013; Mockford, 2015; Nordby & Nøhr, 2012). As the literature search did not reveal any validated questionnaires assessing physicians' attitudes or behaviour regarding LOMTs in an EMS setting, a new questionnaire was created. The feasibility of the questionnaire was evaluated by an independent senior physician. The study was conducted among

all HEMS physicians in Finland between 20th January and 30th April 2017. There were 67 HEMS physicians in the country, of whom 31 were working full-time as HEMS physicians, and each HEMS base had a pool of 12–15 physicians working regular on-call shifts. The data were mainly collected on HEMS bases during training days when most HEMS physicians were present. HEMS physicians were informed about the study with a personal or recorded video presentation and written information. The Finnish laws and existing guidelines on LOMTs were not presented to the physicians as part of this information. Participation was voluntary, and returning a completed questionnaire was considered as an agreement to participate. HEMS physicians who were absent on training days were contacted via email with a printable version of the questionnaire and posting instructions.

The questionnaire included 38 questions exploring HEMS physicians' opinions, attitudes and experiences with prehospital LOMTs in general, HEMS missions designated to HCFs and NHs and the LOMTs established in those places. The closed questions and claims were answered with five-point Likert-type scale choices, with a sixth response choice being 'I do not wish to answer this question'. The open questions addressed the features and challenges of LOMTs in prehospital settings. Demographic data on the HEMS physicians' unit, gender, age, medical specialty and previous work experience within the medical field were collected.

4.2.2 Cardiac Arrests in Health Care Facilities and Nursing Homes (II)

This was an observational study based on prospective data collection and post hoc analysis. The study was conducted between 1st June 2013 and 31st May 2014 in the Pirkanmaa area. Utstein data concerning EMS missions for all OHCA patients were collected prospectively by EMS personnel. This study was a subgroup analysis of CA patients in HCFs and NHs. Patients located in a private residence, workplace, recreational place, public place and EMS transport were excluded. Author Kangasniemi collected the additional data on the patients' backgrounds, pre-existing DNARs and outcomes from EMS datasheets and primary HCFs' and university hospitals' medical records retrospectively. The weighted CCI was used to evaluate the patients' prior health. Information from Social Insurance Institution was collected regarding whether the patient had received a care allowance for pensioners due to impaired baseline functional status and regular need of assistance. The

neurological status of the survivors before CA and at hospital discharge was characterised based on the Cerebral Performance Category as either favourable (CPC 1-2) or unfavourable (CPC 3-5). Survival was described with the Utstein template as survival to hospital admission, survival to hospital discharge and 90-day survival based on the date of death requested from Statistics Finland. A resuscitation attempt was considered to be futile if it was performed on patients with dismal chances of survival, including those with prolonged downtime, end-stage terminal illness, multiple traumas or unwitnessed asystole as the primary rhythm.

4.2.3 HEMS Missions (III) and Consultation Calls to HEMS Physicians (IV) Associated with Limitations of Medical Treatment

LOMTs in HEMS settings and the quality of information available when HEMS physicians make treatment decisions were studied in two separate observational multicentre studies (III, IV). The data for both studies were prospectively collected from the FHDB between 6th September 2017 and 6th March 2018. LOMTs on all HEMS missions were studied in a nationwide study (III), and all five physician-staffed HEMS bases in Finland were included. Another study (IV) examined consultation calls to HEMS physicians, and it involved four physician-staffed HEMS bases that used FHDB to document consultation calls. FH10 was excluded from this study (IV) because consultation calls were documented in another information system. The catchment areas for highly specialised medical care of the included bases served approximately 3.78 million inhabitants (70% of the Finnish population).

The primary object was to identify pre-existing and/or new LOMTs and their content. Secondary outcome variables were the reasons for a new LOMT, the quality of information the HEMS physicians had available when making treatment decisions and, in study IV, survival measured as the number of days from the consultation call. For the purposes of these studies, a questionnaire (study sheet) was created in the FHDB, and HEMS physicians completed the study sheets. The physicians were informed verbally and through an information letter about the study, and their participation in the data collection was voluntary. However, completion of normal mission reports and medical records on encountered patients and consultation calls was obligatory according to the standard operating procedures. HEMS missions and consultation calls to HEMS physicians were defined to be associated with an LOMT

if the HEMS physicians 1) identified that the patient had a pre-existing LOMT, 2) issued a new LOMT or 3) identified the patient as having a pre-existing LOMT and issued a new one. In the study on HEMS missions (III), missions in which the HEMS unit's participation was cancelled after it was dispatched were included. In that study, phone consultations were excluded. The study on consultation calls (IV) focussed on LOMTs made by phone when the HEMS physician did not encounter the patient in person. However, phone consultations associated with HEMS missions were included (this means that due to the consultation call, the physician decided to join the HEMS unit on the EMS mission or the HEMS unit was cancelled after dispatch due to a call from on-scene EMS personnel).

In this study setting, situations in which HEMS physicians pondered but did not issue a new LOMT were not documented and thus were excluded. In addition, HEMS missions and consultation calls without a (or with an incorrectly completed) study sheet were excluded from the analyses. The patient's civil registration numbers were obtained and documented in the FHDB whenever possible. The mortality rate of all patients with civil registration numbers available up to 6th November, 2018 was retrieved from The Finnish Population Register Centre. The patient's civil registration number was obtained for only approximately one-half of the HEMS missions, and so a valid survival analysis could not be performed in that study (III). However, the patient's civil registration number was available in 87% of documentations of consultation calls to HEMS physicians, allowing survival analysis to be performed. If multiple consultation calls were observed regarding a unique patient, the first call was included in the survival analysis.

4.3 Definitions

Although the term 'HCF' refers to all kinds of HCFs, EMS and HEMS are mainly dispatched to municipal primary health care centres and occasionally to secondary hospitals. HEMS physicians are not dispatched to or consulted by tertiary hospitals. In this thesis, the term 'NH' refers broadly to various public and private NHs, institutions and to assisted living facilities providing 24-hour assistance. Where comparisons between 'patients in HCFs/NHs' and 'patients in other locations' were made, the 'other locations' meant private homes, workplaces, public places and transport.

In the survey study (I), no definitions of 'LOMT' were given so that the HEMS physicians would answer based on how they understood LOMTs. In the prospective studies on LOMT (II, III, IV), the following definitions were provided. 'DNACPR' was a decision to withhold further CPR attempts, including situations in which ROSC had been achieved after a CA but a decision to withhold further CPR attempts in case a rearrest was made. A decision to discontinue an ongoing resuscitation attempt was defined as 'ToR'. 'No intensive care' meant withholding all interventions that the HEMS physician perceived as intensive care, such as endotracheal intubation, mechanical ventilation, invasive monitoring or drugs that are comparable to those administered in ICUs. The decision to withhold endotracheal intubation was coded as 'no intubation'. 'No tertiary hospital transfer' meant that the patient could be moved from an NH or private residence to a municipal primary HCF. Meanwhile, 'no transfers' meant that the patients would be treated in their current location: a private residence, NH or primary HCF's inpatient ward. The term 'other LOMT' concerned all other LOMTs that HEMS physicians issued that were not suitable for the categories listed above. The pre-existing 'other LOMT' patients had prior to the EMS mission contained restrictions on invasive procedures (i.e. dialysis, percutaneous coronary intervention or elective surgery for brain tumour or abdominal aortic aneurysm), the use of intravenous drugs, fluids or nasogastric nutrition as well as on admission to palliative or end-of-life care or the decision to allow natural death, which is mainly made by general physicians.

4.4 Data Handling, Analysis and Statistics

The paper questionnaires (I) were sealed in envelopes and delivered to statistician Huhtala, who recorded the data from the questionnaires in Microsoft Word and SPSS files. The anonymous data were then sent to Kangasniemi for analysis and interpretation of the results. The Utstein data (II) were delivered to Kangasniemi as a Microsoft Excel file, and she manually completed the data for post hoc analysis from medical records. These data were merged with data from Social Insurance Institution and Statistics Finland. Anonymous data of HEMS missions (III) and consultations calls (IV) from the study period together with the completed study sheets (III, IV) were extracted from the FHDB to a Microsoft Excel file by FinnHEMS information and communication technology personnel. FinnHEMS Ltd.'s Research and Development Unit applied the dates of death from the Finnish

Population Registration Centre to all patients with known identities (III, IV) and gave the anonymised data to Kangasniemi to connect with previously extracted anonymous data by research number.

For the quantitative data, statistical analyses were performed using SPSS software (IBM SPSS Statistics for Macintosh, Versions 24.0 to 27.0 Armonk, NY: IBM Corp). The demographic data were presented with frequencies and percentages (I, II, III, IV) and with medians and quartiles (Q1–Q3) (I, II, III, IV), as appropriate. Differences in the answers of HEMS physicians were compared in the following demographic groups: men and women, HEMS bases, the age of the physician and work experience in years (I). The Likert-type scale answers were analysed with contingency tables, the Chi-Square or Fisher's exact test and Spearman correlation (I). In other studies (II, III, IV), binary categorical variables were compared with the Chi-square or Fisher's test, and numerical variables were compared with the Mann–Whitney U-test and Kruskal–Wallis test, as appropriate. In the study on consultation calls to HEMS physicians (IV) the survival between independent and mutually exclusive groups was described with a Kaplan–Meier curve and tested with a log-rank test. In all analyses, statistical significance was defined as a p-value < 0.05, and all tests were two-sided.

For the qualitative data (I), a content analysis was used to evaluate the information in the material and to quantify the most commonly occurring reduced expressions. In addition, practical situations and ethical dilemmas the HEMS physicians encountered or reported during this study period were described with directs quotes from their answers (I, III, IV).

4.5 Ethical Considerations

The studies were conducted according to Finnish legislation and the principles of the Declaration of Helsinki (World Medical Association, 2013). The Ethics Committee of the Tampere University Hospital reviewed the study protocol on 17th March 2015 (Approval no: R15048). This study was approved by the National Institute for Health and Welfare (THL/861/5.05.00/2015 on 11th November 2015) and by all five Finnish university hospitals (TAUH R15048 on 9th April 2015, KUH Medical Superintendent's Decision 9/2016 on 17th January 2016, TUH T14/2016 on 18th January 2016, OYS on 15th December 2016 and HUS HUS231/2016 on 14th

November 2016). In addition, study permissions were retrieved from Social Insurance Institution (KELA/61/522/2015 on 14th October 2015) (II), FinnHEMS Ltd. (on 20th November 2015) (I, III, IV), Statistics Finland (TK53-884-5 on 14th December 2015) (II, IV) and Tampere and Kangasala Cities for primary HCF medical records (on 7th November 2016) (II).

Due to the observational and register-based design of the study, the need for informed consent was waived, as these studies were not medical trials and the patients were not contacted by the researchers. Following the Personal Data Act (523/1999), the description of the privacy policy of the study register was sent and registered with the Data Protections Ombudsman (151/4225/16 on 1st March 2016). All data collection was performed before the General Data Protection Regulation came into force in 2018. The participation of the HEMS physicians in the study was voluntary, and individual physicians cannot be identified from the study reports.

The study was partly conducted in the employment of FinnHEMS Ltd.'s Research and Development Unit, Helsinki University Hospital and Tampere University Hospital. The FinnHEMS Ltd.'s Research and Development unit determined it would be the first affiliation in all publications produced or mainly promoted during the employment relationship. The employment relationships with the university hospitals were financed by State Research Funding (TYH2018317 and Grant 9S009). In addition, the author received personal scientific grants from the Finnish Medical Association, the Finnish Medical Foundation, the Finnish Society of Anaesthesiologists and the fund of Doctor Uulo Arhio. The funding organisations were not involved in the conceptualisation, execution, analysis or reporting of any part of the studies.

5 RESULTS

5.1 Demographic Data

5.1.1 HEMS Physicians and HEMS Events (I, III IV)

Fifty-nine (88%) HEMS physicians participated in the survey (I), and the demographics of the respondents are shown in Table 8. The response rates by base varied between 69 and 100%, and there were respondents from all physician-staffed HEMS bases. The HEMS bases did not differ by physicians' age, gender distribution or work experience.

Table 8. Sociodemographic data of Helicopter Emergency Medical Service (HEMS) physicians in Finland in 2017.

Demographics of the respondents	N= 59	%
Male gender	39	66
Age		
Median, years (Q1–Q3)	43	(38–47)
Min – max, years	31–59	
First specialty		
Anaesthesiology and Intensive Care	53	90
Internal Medicine	3	5
Emergency Medicine	2	3
General Medicine	1	2
Completed specialisation	52	91
Second specialty; Emergency Medicine	9	15
Completed Specialisation	5	8
Medical subspecialty (MS)[a]	37	63
1 MS, Emergency medical services (EMS)	26	44
1 MS, other than EMS	4	7
2 MS, EMS and some other	5	8
2 MS, both other than EMS	1	2
3 MS, EMS and two other MSs	1	2
Work experience in EMS, median, years (Q1–Q3)	10	(6–16)
Work experience as physician, median, years (Q1–Q3)	15	(10–20)
Work experience as EMS physician, median, years (Q1–Q3), (n=55)	8.5	(5–13)

[a] Medical subspecialties refer to both special competences granted by the Finnish Medical Association and the additional professional training programmes completed in medical faculties. Q1–Q3 indicates the 25th–75th percentile.

During the study period of studies III and IV, there were 5,895 HEMS missions (mean number of 6.5 missions/base/day) and 6,115 consultation calls to HEMS physicians (mean number of 8.4 calls/base/day) on the included bases, and these events are summarised in Table 9. HEMS mission reports were documented by 68 different HEMS physicians, and 60 physicians (corresponding to 88% of all HEMS physicians) completed study sheets during the study period (III). Consultation calls were documented by 57 different HEMS physicians, and 52 of these physicians (corresponding to 91% of all HEMS physicians working in the included HEMS bases) completed study sheets (IV).

Table 9. HEMS events during the six-month study period 2017–2018.

HEMS events included in the studies	HEMS missions (III)		Consultation calls to HEMS physicians (IV)	
	N	%	N	%
Total number of events	5895	100	6115	100
Events per HEMS base				
FH-10	1304	22	Excluded	
FH-20	1038	18	1639	27
FH-30	1439	24	1575	26
FH-50	894	15	1087	18
FH-60	1220	21	1814	30
Events regarding patients in HCF or NH	644	11	833	14
Events associated with LOMT	335	5.7	478	7.9
FH-10	75	5.8	Excluded	
FH-20	56	5.4	94	5.7
FH-30	81	5.6	114	7.2
FH-50	35	3.9	60	5.5
FH-60	88	7.2	210	11.6

5.1.2 Patient Characteristics (II, III, IV)

For study II, there were 355 EMS-attended OHCA missions in Pirkanmaa during the study period. For 65 (18%) of the missions, the patient was in an HFC/NH. The data collection for study II is presented in Figure 4. The demographic data on the OHCA patients are presented in Table 10, and the data regarding EMS situations are shown in Table 11.

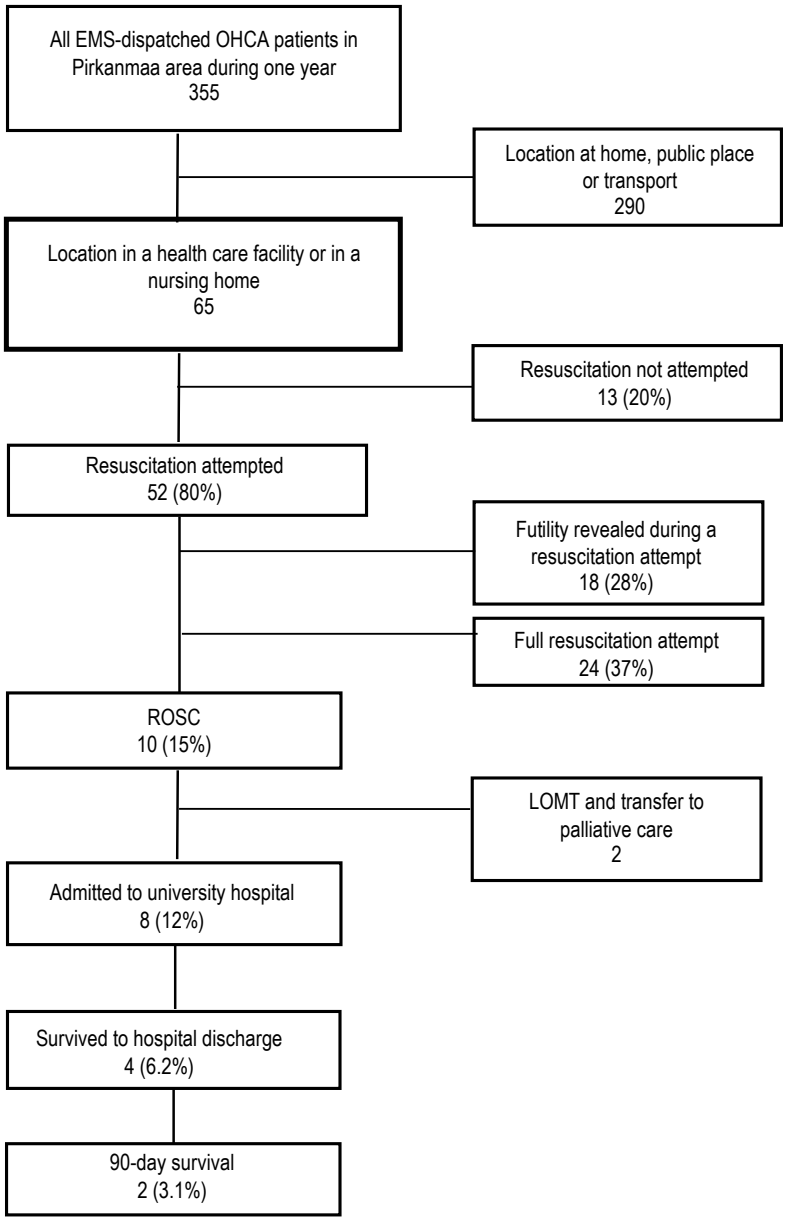


Figure 4. The data collection and survival of cardiac arrest patients in Pirkanmaa (II).

Table 10. The demographic data for out-of-hospital cardiac arrest patients in health care facilities and in nursing homes in Pirkanmaa in 2013–2014 (II).

Patient demographics	All		Survived to hospital		Deceased on scene		
	n=65	%	n= 8	%	n=57	%	p
Age, median (Q1-Q3)	82	(68–90)	70	(62–82)	84	(70–90)	0.03
Male gender	36	55	6	75	30	53	0.28
Physical performance[a]							0.33
Outdoor independence	16	29	1	13	15	32	
In-house independence	26	47	6	75	20	43	
Dependent on assistance	13	24	1	13	12	26	
Impaired Cognition[b]	28	51	4	57	24	50	1.00
CCI score[c], median (Q1-Q3)	4	(3–6)	3	(2–4.8)	4	(3–6)	0.25
CCI ≥ 3	46	78	5	63	41	80	0.36
Independent living[d]	21	34	2	25	19	35	0.71
Resides in long-term care facility[d]	23	37	0		23	43	0.02
Days spent at current location prior CA[e]							0.04
0–1	15	28	5	63	10	22	
2–7	16	30	3	38	13	28	
8–90	10	19	0		10	22	
over 90	13	24	0		13	28	
Received care allowance for pensioners from SII	46	71	5	63	41	72	0.683
Arrest location							0.002
Primary HCF policlinic	7	11	4	50	3	5	
Primary HCF ward	37	57	4	50	33	58	
Nursing home	21	32	0		21	37	
Existing DNAR	19	29	0		19	33	0.09
DNAR, resuscitation attempted	10	53	0		10	53	

Q1−Q3 indicates the 25th−75th percentile; OHCA: out-of-hospital cardiac arrest, CA: cardiac arrest, SII: Social Insurance Institution, HCF: health care facility, DNAR: do-not-attempt-resuscitation order

[a]Last week before CA, observed from patient records, data missing n=10, [b] Patients with diagnosed dementia of any cause, Mini-Mental State Examination score < 24, moderate or severe intellectual disability or severe schizophrenia with residence in NH, data missing n=10, [c]Charlson Comorbidity Index score, data missing n=6, [d]data missing n=3, [e]data missing n=11

Table 11. The situation-related data according to the Utstein reporting template on out-of hospital cardiac arrests in health care facilities and nursing homes in Pirkanmaa in 2013–2014 (II).

Utstein situation data	All		Survived to hospital		Deceased on scene		
	n=65	%	n= 8	%	n=57	%	p
Witnessed arrest	53	82	8	100	45	79	0.33
EMS witnessed	12	18	3	38	9	16	0.16
Bystander CPR[a]	43	81	5	100	38	79	0.57
No DNAR, no bystander CPR	2	4	0		2	5	
Presumed cardiac aetiology	53	82	5	63	48	84	0.16
First monitored rhythm							0.16
Shockable	13	20	3	38	10	18	
PEA/AED non-shockable	22	34	3	38	19	33	
Asystole	26	40	1	13	25	44	
Other	4	6	1	13	3	5	
Time intervals, median, minutes (Q1–Q3)							
Collapse-to-call[b]	2	(0–8)	2	(0.5–15.5)	2	(0–8)	0.46
Call-to-EMS arrival	7	(5–10.5)	4	(1.75–7)	7	(5–11.5)	0.006
Collapse-to-ROSC	15	(7–33.5)	17	(7–39.8)	13	(13–13)	0.89
Beginning-of -to-end-of EMS CPR	9	(1–19)	9	(3.3–22.8)	9	(0–19)	0.82
Any ROSC	23	35	8	100	15	26	<0.001
HEMS on scene	13	20	6	75	7	12	<0.001
LOMT							<0.001
On field	31	48	1	13	30	53	
In hospital emergency department	3	5	3	38	0		
No LOMT	31	48	4	50	27	47	

Q1–Q3 indicates the 25th–75th percentile; OHCA: out-of-hospital cardiac arrest, CPR: cardiopulmonary resuscitation, HEMS: Helicopter Emergency Medical Services.

[a]Among not EMS witnessed CA cases, [b]witnessed cases only (EMS-witnessed cases excluded), n=32.

The data collection for studies III and IV is presented in Figure 5. The characteristics of patients with LOMT are shown in Tables 12 (III) and 13 (IV). 'Dual LOMT' refers to a situation when the patient had a pre-existing LOMT and the HEMS physician issued a further LOMT during the mission or the consultation call.

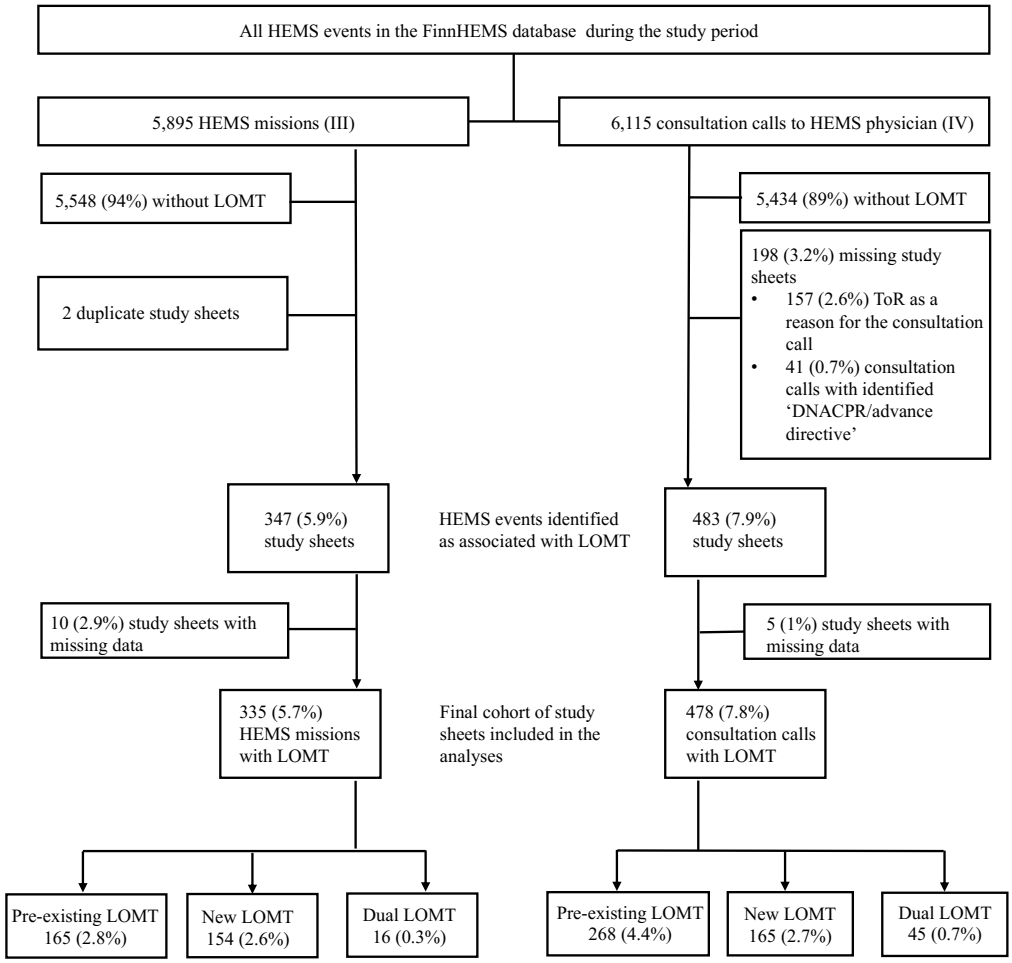


Figure 5. The data collection for studies III and IV on HEMS missions and consultation calls to HEMS physicians during the six-month study period.

Table 12. The demographic data on HEMS missions that were associated with limitations of medical treatment.

HEMS missions associated with LOMT (N=335)	Pre-existing LOMT N= 165	%	New LOMT N= 154	%	Dual LOMT N= 16	%	P
Time of the call							
Day (8 AM–4 PM)	82	50	85	55	9	56	0.877
Evening (4 PM–12 PM)	46	28	36	23	4	25	
Night (12 PM–8 AM)	37	22	33	21	3	19	
Dispatch code[a]							0.028
Cardiac arrest	67	41	82	53	8	50	
Unconsciousness	71	43	45	29	7	44	
Airway obstruction	6	3.6	9	5.8	0		
Dyspnea	5	3	2	1.3	1	6.3	
Falling (not dropping)	6	3.6	0		0		
Hypothermia	1	0.6	4	2.6	0		
Male gender[b]	42	48	45	53	10	63	0.547
Age median (Q1–Q3)[b]	81	(73–88)	81	(71–87)	81	(69–86)	0.929
Location of the patient							<0.001
Home/public/work	57	35	112	73	7	44	
Nursing home	97	59	30	20	7	44	
Primary health care facility	10	6.1	7	4.5	2	13	
Hospital	1	0.6	3	1.9	0		
Other	0		2	1.3	0		
HEMS unit cancelled from mission[c]	118	72	86	56	10	63	

Q1–Q3 indicates the 25th–75th percentile

[a] Only the 6 most common codes out of the 22 codes observed in the study material are shown.

[b] Missing data n = 147 (44%), analyses made for cases with data available.

[c] EMS code 'X-9' = unit cancelled from the mission because it is not needed on-scene

Table 13. The characteristics of patients on consultation calls to HEMS physicians associated with limitations of medical treatment.

Consultation calls associated with LOMT (N=478)	Pre-existing LOMT		New LOMT		Dual LOMT		
	N= 268	%	N= 165	%	N= 45	%	P
Time of the call							0.02
Day (8 AM–4 PM)	116	43	87	53	21	47	
Evening (4 PM–12 PM)	104	39	44	27	10	22	
Night (12 PM–8 AM)	48	18	34	21	14	31	
Reason for consultation							< 0.001
Treatment instructions	178	66	106	64	34	76	
Destination of further admission	43	16	8	4.8	4	8.9	
Pain medicine	10	3.7	0		0		
ECG interpretation	10	3.7	0		0		
Non-conveyance	12	4.5	1	0.6	1	2.2	
End of resuscitation attempt	12	4.5	47	29	3	6.7	
Other	3	1.1	3	1.8	3	6.7	
Dispatch code[a]							< 0.001
Dyspnea	76	28	33	20	11	24	
Cardiac arrest	11	4.1	66	40	5	11	
Arrythmia	51	19	12	7.3	9	20	
Unconsciousness	23	8.6	27	16	9	20	
Chest pain	29	11	2	1.2	2	4.4	
Stroke	18	6.7	5	3	1	2.2	
Other onset of illness	21	7.8	1	0.6	0		
Convulsions	14	5.2	2	1.2	4	8.9	
Other code	25	9.3	17	10	4	8.9	
Male gender[c]	106	41	83	55	20	44	0.015
Age Median (Q1–Q3)	84	(75–90)	80	(70–89)	85	(78–92)	0.006
Location of the patient							< 0.001
Home/public/work	95	35	96	58	11	24	
Nursing home	150	56	50	30	23	51	
Primary HCF	18	6.7	13	7.9	8	18	
Hospital	4	1.5	6	3.6	3	6.7	
Other	1	0.4	0		0		

Q1–Q3 indicates the 25th–75th percentile

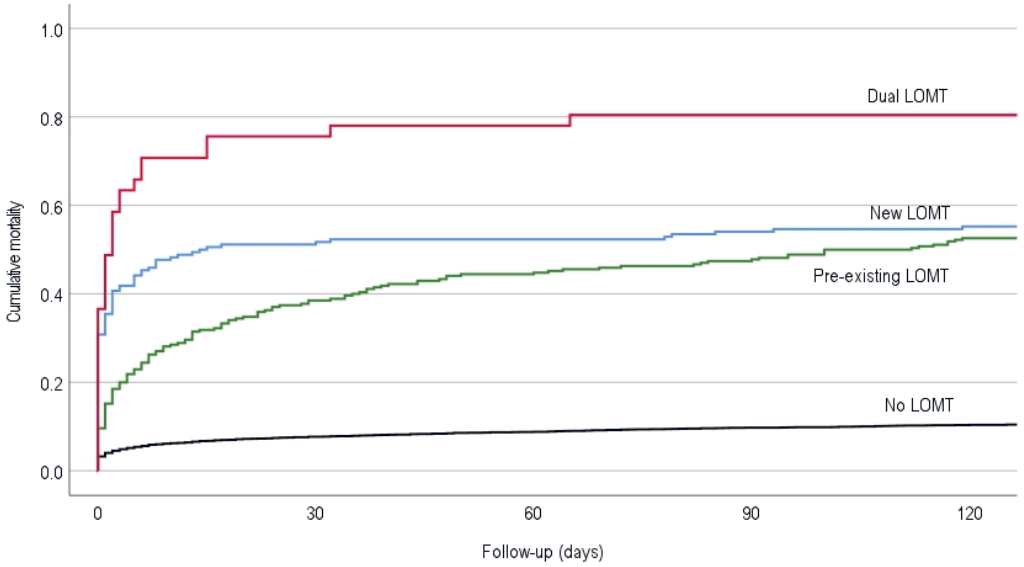
[a] Only the 8 most common codes out of the 24 codes observed in the study material are shown.

[b] Missing data n = 22 (4.6 %)

Patient Outcomes (II, IV)

Patient outcomes were available for studies II and IV. The outcomes for the patients in study II are presented in Figure 4 and Table 10. None of the OHCA patients in NHs survived to hospital. Compared to patients who survived the event, the patients who died on-scene were older, resided more often in long-term care facilities, were located in an NH or HCF inpatient ward instead of a primary HCF outpatient clinic and had longer admissions in the unit where the CA happened and longer EMS response times (Tables 10 and 11). In addition, LOMTs were made on-scene for over half (53%) of OCHA patients who died on the scene, and the HEMS unit was often cancelled from these missions (Table 11). Four patients (6% of all 65 patients) survived to hospital discharge, one with a poor neurological outcome (CPC 4) and three (4.6%) with the same CPC as before the CA. There were two (3%) patients alive 90 days after the CA, both with good neurological outcomes (CPC 1–2). The patients were < 70-year-old men who had had a ventricular fibrillation as the first monitored cardiac rhythm and had briefly been in a primary HCF due to an acute illness with a cardiac cause.

In study IV, there were 6,115 consultation calls to HEMS physicians. In 5,330 (87%) calls the patient's civil registration numbers were recorded, and these calls concerned 5,061 unique patients. The survival rates of these patients are presented in Figure 6 in four groups (no LOMT, pre-existing LOMT, new LOMT and Dual-LOMT). In cases where a new LOMT was issued by an HEMS physician, 32% of patients died the day of the consultation call, while 34% survived for one week following the consultation call ($p<0.001$) (Figure 6).



In the groups of 5,061 patients with known civil registration numbers, there were 4,671 (92%) patients without limitations of medical treatment (LOMTs), 233 (4.6%) patients with pre-existing LOMTs only, 119 (2.4%) patients to whom HEMS physicians issued new LOMTs and 38 (0.8%) patients in the 'dual LOMT' group, that is, patients having pre-existing LOMTs but to whom HEMS physicians issued further LOMTs.

Figure 6. Kaplan–Meier survival curve of patients about whom HEMS physicians were consulted during the six-month study.

5.2 HEMS Physicians' Opinions and Experiences (I)

HEMS physicians had varying opinions and experiences regarding LOMTs, and there were some differences between the physicians concerning missions to HCFs/NHs and consultation calls regarding patients in those facilities. The distributions of answers on LOMT practices are presented in Figure 7. Opinions and attitudes on LOMT in HEMS physicians' work are presented in Figure 8, and answers related to patients in HCFs and NHs are presented in Figure 9.

The figures show variation between physicians. This heterogeneity was mainly perceived as differences between individuals and to some extent as differences between the working cultures of HEMS bases (Figure 10). The differences in HEMS physicians' responses were only slightly explained by age and years of experience. The Likert-type scale answers were tested with a Spearman correlation. When '1' indicated 'totally agree' and '5' indicated 'totally disagree', a positive correlation

coefficient meant that with increasing physician age or experience the physician's disagreement with a claim increased. Physicians with longer experience as a physician more often agreed with the claims 'we have good guidance on LOMT situations' (r_s -0.311, p=0.0017) and 'the situations in which I issue LOMTs are generally clear to me' (r_s -0.276, p=0.0034). Experienced physicians were more likely to disagree with the claims 'I have a phone conversation with a proxy in LOMT situations' (r_s 0.29, p=0.0026), 'I would like to have more training on LOMTs' (r_s 0.281, p=0.0032) and 'I have encountered emergency care plans made for patients in long-term care' (r_s 0.269, p=0.041). Older HEMS physicians more often agreed that 'the patients' advance directives are useful' (r_s -0.336, p= 0.0016), but they were less likely to 'respond to a (phone) consultation concerning a patient in a HCF or NH' (r_s 0.349, p=0.0010) compared to younger HEMS physicians.

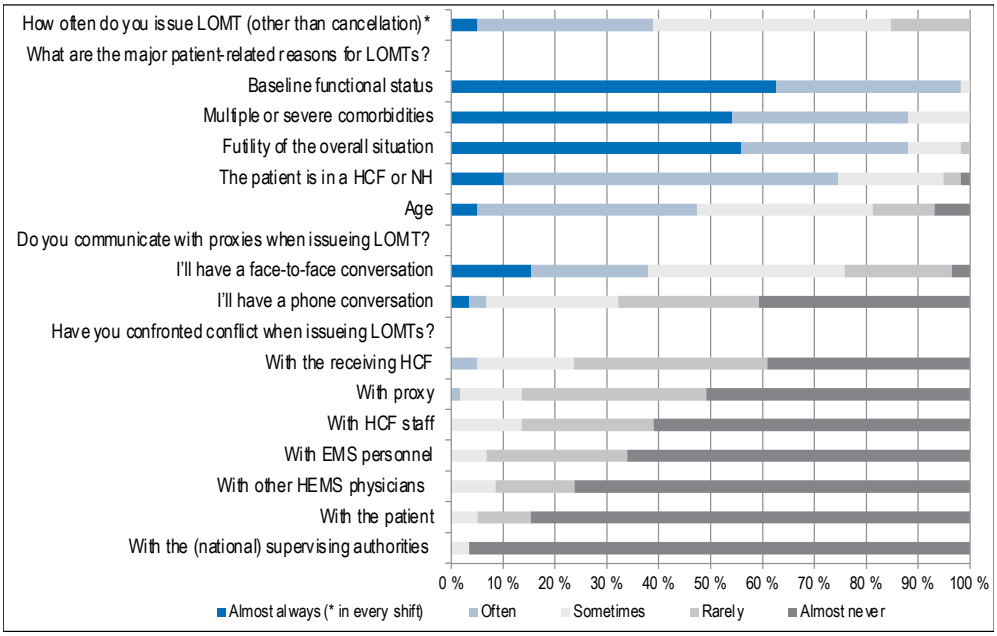


Figure 7. HEMS physicians' limitations of medical treatment practices.

Many of the HEMS physicians (n=31, 53%) felt that the LOMTs they issue are valid until the next physician's evaluation (e.g. in the hospital emergency department), but other types of responses were also received: 'throughout the whole adjacent (hospital) admission period' (n=13, 22%), 'only in the current situation' (n=9, 15%); 'permanently' (n=2, 3%) and 'other' (n=1, 2%); 3 (5%) respondents did not reply at

all. Half of the HEMS physicians (n=28, 49%) had sometimes decided not to issue a medically justifiable LOMT because they wanted to avoid a conflict with the patient, the proxies or HCF/NH staff. In total, 17 (30%) physicians indicated they 'always issue the necessary LOMTs regardless of the possible discordance', two (4%) stated that they 'never issue an LOMT if there is a conflict', 12 (21%) answered that they 'had never encountered that kind of situation' and two (3%) did not respond to the question. While 32 (54%) physicians found it more challenging to issue an LOMT via phone without meeting the patient personally, some (n=2, 3%) found those situations easier or reported that there was no difference (n=6, 10%).

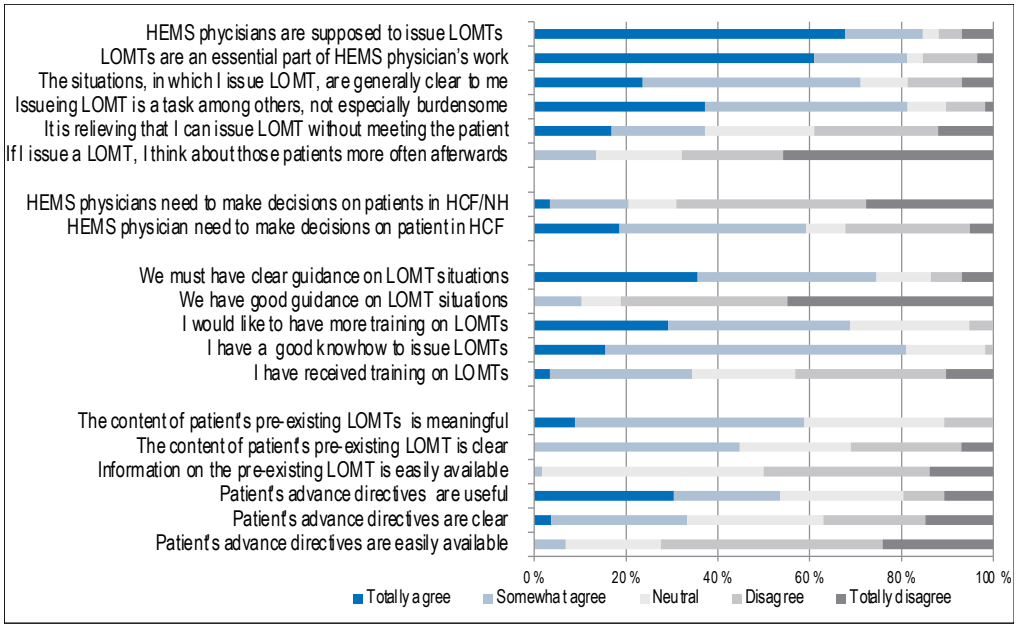


Figure 8. HEMS physicians' opinions on limitations of medical treatments.

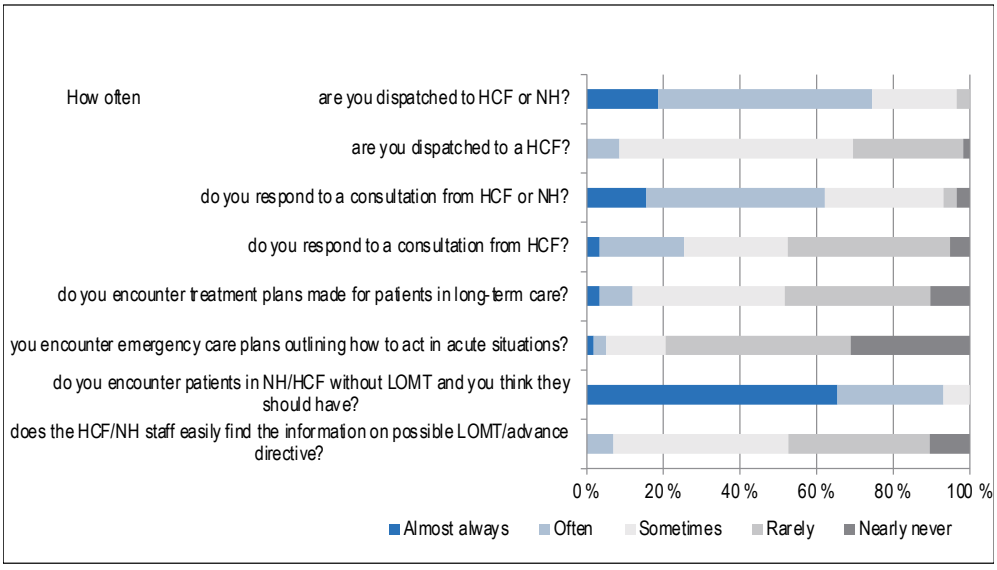


Figure 9. HEMS physicians' experiences with missions to health care facilities and nursing homes.

5.2.1 Qualitative Data

The open questions addressed the diversity of EMS situations and limited resources in prehospital settings. The HEMS physicians were asked if there are any groups of patients for whom it is challenging to issue LOMTs in their work. Forty-one (69%) respondents named the following patient groups: children and adolescents (n=26, 44%), patients with severe comorbidities (n=16, 27%), especially those with cancer (n=5, 8%), patients in HCFs/NHs (n= 11, 19%), disabled or mentally retarded patients (n=11, 19%), old patients (n=10, 17%), patients with an impaired cognitive status (n=4, 7%) and those with a pre-existing DNAR but without other LOMTs (n=2, 3%). In their answers regarding the characteristics of LOMT situations in their work, the HEMS physicians indicated that limited data are used in prehospital settings (n=31, 53%), they find it important to address the baseline functional status of the patient (n=17, 29%), the situations are often sudden and tragic (CA, trauma, drowning etc.) (n=17, 29%), there is often interaction with the proxies (n=15, 25%), the treatment plans for patients in HCFs/NHs are often deficient or missing (n=5, 8%) and the resources of the EMS or health care systems are limited (n=4, 7%) as is the time available in the situation (n=3, 5%).

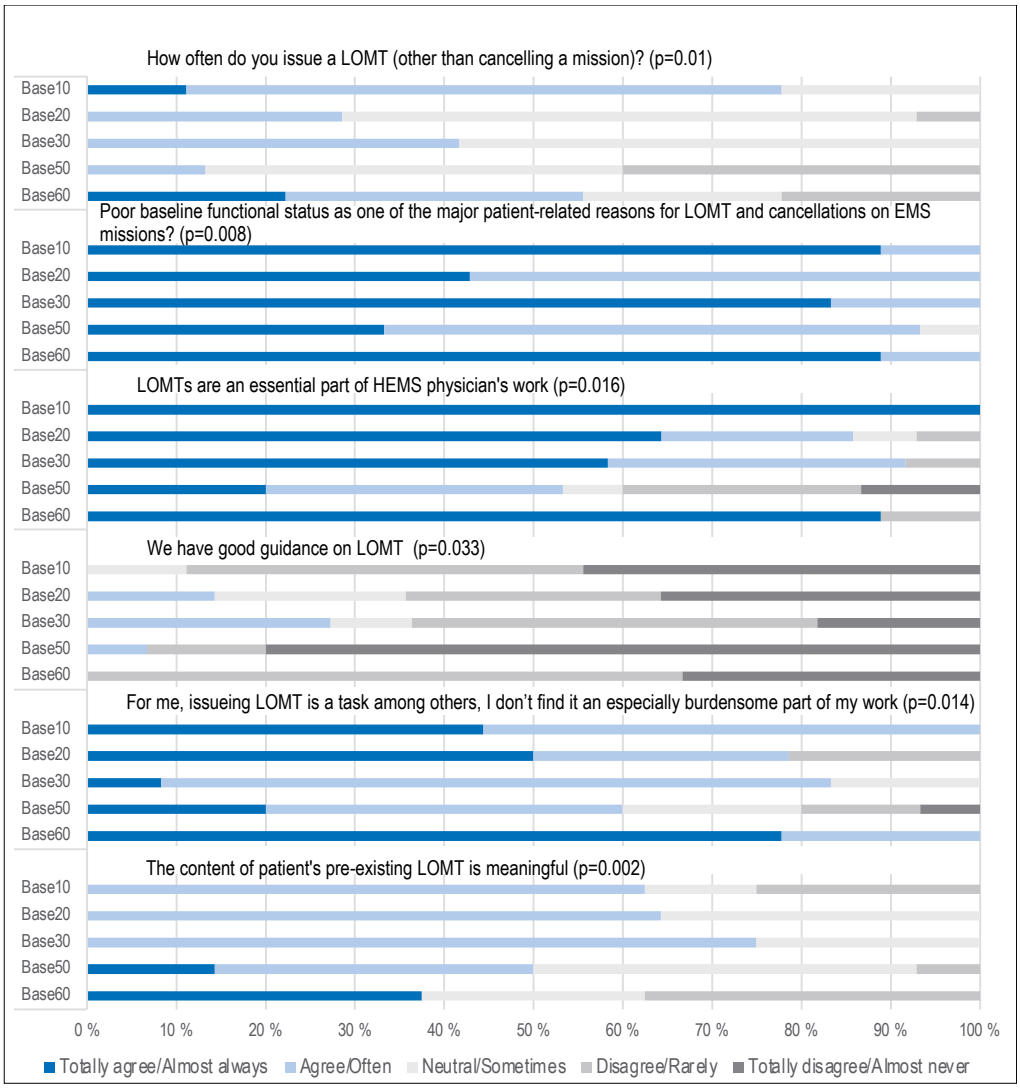


Figure 10. Differences in claims based on the respondents' working base.

The HEMS physicians indicated that the LOMTs they issue usually concern CPR, intensive care or other LSTs, and some felt uncomfortable issuing other LOMTs, such as 'no transportation'. Although the questionnaire did not ask the respondents to define the term LOMT, many physicians spontaneously described their LOMT decision-making. Many (n=22, 37%) physicians reported their personal practices or

main principles regarding how they issue LOMTs, 14 (24%) expressed an opinion on LOMTs or how they should be issued and 7 (12%) gave some definition for the term LOMT. In the definitions, it was controversial whether or not the decision to cancel an HEMS unit's participation in a certain mission should be regarded as an LOMT. If HEMS physicians wanted more education on LOMT, they most often desired training on juridical issues. Most physicians (n=43, 73%) suggested a need for more training for HCF/NH staff on LOMTs and end-of-life care issues, and some (n=16, 27%) physicians indicated that EMS personnel should have more training on LOMTs.

5.3 Limitations of Medical Treatment in HEMS Settings (III, IV)

In the prospective studies, 5.9% of HEMS missions and 7.9% of consultation calls were associated with LOMTs (Figure 5 and Table 9). LOMTs were especially common on HEMS missions and consultation calls regarding patients in HFCs and NHs. HEMS mission associated with LOMT were seven times more common on missions to HCFs/NHs (n=158/644, 25%) compared to HEMS missions to other locations (n=177/5251, 3.4%) (statistical test unavailable). At the same time, 276/833 (33%) of consultations calls regarding patients in an HCF/NH were associated with an LOMT compared to 202/5282 (3.8%) of consultation calls concerning patients in other locations ($p<0.001$).

5.3.1 Pre-existing Limitations of Medical Treatment

The pre-existing LOMTs observed in the prospective studies are presented in Table 14. There were 181 (54%) missions with pre-existing LOMT in all 335 HEMS missions with LOMTs, and 34 (19%) patients had multiple pre-existing LOMTs (III). Of the 478 consultation calls associated with LOMTs, 313 (65%) concerned patients with pre-existing LOMTs, and 64 (20%) of those patients had multiple pre-existing LOMTs (IV). Because there were patients with multiple LOMTs, the sums are not 181 or 313, and the proportions exceed 100% (Table 14).

In both studies, the majority of patients with pre-existing LOMTs were in an HCF or NH (n = 117/181 (65%) in study III and 207/313 (66%) in study IV). Usually, the situation was that the patient had a DNACPR only (n = 133/181, 74% and n=236/313, 75%, respectively). The category 'other pre-existing LOMT' was

varied. On HEMS missions, this category included three patients with an advance directive, two end-of-life care patients, one admitted for palliative care and one with 'no LSTs'. In consultation calls, there were five palliative care patients, three patients with an advance directive, two with a 'no elective operation', one with a 'no dialysis' and one patient with an 'allow natural death' decision.

On the study sheets on HEMS missions (III), physicians spontaneously reported six cases in which pre-existing LOMTs were discovered only after the CPR attempt. Physicians reported two cases where the HEMS physicians were dispatched to an NH for acute end-of-life care regardless of reasonable LOMTs. One HEMS physician reported having a mission to a private home for a patient in end-of-life care.

Table 14. The frequency and content of pre-existing limitations of medical treatment on HEMS missions and on consultation calls to HEMS physicians.

Pre-existing LOMT	On HEMS missions (III)		On consultation calls (IV)	
	N=181	%	N=313	%
DNACPR	167	92	300	96
No intensive care	37	20	59	19
No tertiary hospital admission	2	1.1	2	0.6
No transfers	1	0.6	4	1.3
Other	11	6.1	16	5.1
	218	120	381	122

5.3.2 New Limitations of Medical Treatment Issued by HEMS Physicians

The new LOMTs issued by HEMS physicians are shown in Table 15. Withholding or withdrawing a CPR attempt only comprised half of the new LOMTs on HEMS missions, and other new LOMTs were rare (1% of all HEMS missions and 2.2% of all consultation calls to HEMS physician). In study III, of 335 missions with LOMTs 170 (51%) included a new LOMT, and in study IV, of 478 consultations with calls with LOMTs 210 (44%) included new a LOMT. When HEMS physicians issued a new LOMT, they often issued multiple LOMTs for the same patient; for 64/170 (38%) patients on HEMS missions (III) and for 108/210 (51%) patients during consultation calls to HEMS physicians (IV).

However, the most common situation in which a new LOMT was issued was when the HEMS physician decided only to terminate ongoing CPR. Such situations accounted for 61/170 (36%) of new LOMTs on HEMS missions (III) and for

49/210 (23%) of new LOMTs during consultation calls (IV). The second most common new LOMT was 'DNACPR+ no intensive care + no intubation' in the studies on HEMS missions (n=20/170, 12% of) and consultation calls (n=32/210, 15% of).

The median age of patients to whom new LOMTs were issued was 80 years or higher, and new LOMTs were often made on CA missions (Tables 12 and 13). All patients with new LOMTs were adults during the study period. Unlike with pre-existing LOMTs, new LOMTs were issued more often for patients in private homes and public places (in 70% of cases on HEMS missions and on 51% cases on consultations calls). In study IV, new LOMTs were issued more often during office hours (Table 13). When HEMS physicians issued new LOMTs to patients without any pre-existing LOMTs, the physicians were asked, in their opinion, if the patient should have had an LOMT before the current situation. In study III, the physicians thought there should have been a pre-existing LOMT in half (n=75/153, 49%; data on one patient missing) of the cases, while the other half of cases concerned trauma or an unexpected onset of a critical illness. Similarly in study IV, in many consultation calls (n=108/165, 66%) in which an HEMS physician issued a new LOMT during the call, the HEMS physician thought that the patient should have already had an LOMT. In the remaining cases (n=57/165, 35%), the patients were younger (median 74 vs. 84 years, $p<0.001$), more often in a private home or in a public location (n=49/57, 86% vs. n=47/108, 44% in an HCF/NH, $p<0.001$) and the reason for consultation was most commonly ToR (n=30/57, 53% vs. n=17/108 16%, $p<0.001$).

Table 15. The frequency and content of new limitations of medical treatment issued by HEMS physicians.

New LOMT	On HEMS missions (III)		On consultation calls (IV)	
	N=170	%	N=210	%
DNACPR	69	41	122	58
Termination of a CPR attempt	66	39	54	26
No intensive care	63	37	96	46
No intubation	46	27	67	32
No transfers	4	2.4	12	5.7
No tertiary hospital admission	2	1.2	12	5.7
Other[a]	12	7.1	24	11
	262	155	387	184

[a]The category 'other new LOMT' considered 3 (1.8%) + 10 (4.8%) decisions to transport the patient to another HCF than a university hospital, four documented decisions where the HEMS unit did not join the mission (study III) and one decision not to initiate prehospital blood products (study IV).

Justification for new limitations of medical treatment

Typically, the reason for issuing an LOMT in HEMS settings was the futility of the overall situation. In fact, it was the only reason for a new LOMT in 29% of the cases in study III and 18% of the cases in study IV. The reasons for new LOMTs are presented in Table 16. HEMS physicians selected multiple reasons for LOMTs on 110/170 (65%) missions and on 159/210 (76%) consultation calls with new LOMTs.

Table 16. The reasons for new limitations of medical treatment issued by HEMS physicians.

Reasons for new LOMT	On HEMS missions (III)		On consultation calls (IV)	
	N=170	%	N=210	%
Futility of the overall situation	125	74	150	71
Multiple/severe comorbidities	84	49	118	56
Old age	73	43	103	49
Poor baseline functional status	72	42	117	56
Pre-existing LOMT or advance directive	11	6.4	33	16
Other	10	5.9	14	6.7
	375	220	535	255

5.4 Quality of the Information Available When Making Decisions on Treatment (III, IV)

The HEMS physicians often needed to make decisions on treatment, including new LOMTs, without medical records available (Table 17). While making decisions on patients with pre-existing LOMTs, the medical records were available on 37/181 (20%) HEMS missions and 146/313 (47%) consultation calls to HEMS physicians. The information on these pre-existing LOMTs was available on 154/181 (85%) HEMS missions and 290/313 (93%) of the consultation calls.

The HEMS physicians did not report on any advance care plans, including emergency treatment plans, during the study period. If the patient was in an HCF or NH, the physician was asked to assess whether the HCF/NH staff could answer the HEMS physicians' or EMS personnel's questions about the patient's previous health. In study III, the staff was familiar with the patients' baseline functional status in 43% (n=68/158) of cases, comorbidities in 38% (n=60) of cases and possible pre-existing LOMTs in 54% (n=85) of cases. Similarly in study IV, the staff was familiar with the

patients' baseline functional status in 46% of cases (n=128/276), comorbidities in 39% (n=108) of cases and possible pre-existing LOMTs in 48% (n=132) of cases.

Table 17. The types of information available when making decisions on treatment and issuing new limitations of medical treatment in HEMS setting.

Quality of information available when issuing new LOMT	On HEMS missions (III)		On consultation calls (IV)	
	N=170	%	N=210	%
Information from EMS situation	154	91	206	98
Anamnesis via EMS personnel	152	89	206	98
Measured vital parameters	90	53	160	76
Clinical examination by HEMS physician	57	34	-	
ECG	28	16	45	21
Information from a person other than the EMS personnel[a]	90	53	79	38
A relative/proxy	47	28	22	10
Nurse familiar with the patient	30	18	39	19
Nurse unfamiliar with the patient	3	1.8	8	3.8
Attending physician in nursing home	2	1.2	4	1.9
Another physician	8	4.7	10	4.8
Information on any pre-existing LOMTs	13	7.6	35	17
Medical records	38	22	60	29
Tertiary hospital medical records	25	15	57	27
Primary health care facility medical records	8	4.7	0	0
Nursing home client's medical records	4	2.4	3	1.4
Emergency care plan	0	0	0	0
Kanta Service[b]/National electronic medical records	0	0	1	0.5
Medication list without medical records	19	11	17	8.1
Information relayed by emergency dispatch centres only	7	4.1	-	
Information available only from paramedics on-scene[c]	-		82	39

[a] Someone other than EMS personnel, i.e. a proxy, NH staff member or physician in a tertiary hospital.

[b] Please see the Methods section 4.1.3

[c] Information on medical records, medication lists, pre-existing LOMTs or from any person other than EMS personnel on-scene was not available.

HEMS physicians discussed the new LOMT with proxies on 28 (16%) HEMS missions with new LOMTs (in 27 cases the proxies were on scene) and on two (0.5%) consultation calls with a new LOMT. The HEMS physicians mainly made decisions regarding new LOMTs without a second opinion (n = 147/170, 87% on mission and n=186/210, 89% on consultation calls). If the HEMS physician discussed the new LOMT with another physician, he or she was usually a specialist in a tertiary hospital who also had access to medical records. Discussions with NH physicians were rare (n=4, 2%/n=3 1%, study III/IV).

5.5 Ethical and Practical Challenges Observed

The most prominent ethically challenging topics arisen from all four studies' materials were that the need for advance care planning had not been identified or that the patient had a DNACPR order without a sufficient treatment plan. Those situations were also common when there was a pre-existing LOMT but information on it was not available or it was not complied with. Difficult patient groups were encountered, especially those with impaired cognition or malignancies. Conflicts were also recorded with health care staff members and proxies. In addition, some cases highlighted inadequate resources or know-how to treat patients in end-of-life care or with deteriorating chronic comorbidities in NHs. Some quotes from the study materials that illustrate these ethical and practical challenges are presented in Table 18.

Table 18. Ethical and practical challenges in HEMS physicians' work concerning limitations of medical treatment.

Ethical challenges in clinical work
Patient does not have a sufficient treatment plans
Unconsciousness. EMS personnel calls for treatment instructions. The patient is a 65-year-old woman in an NH who has an end-stage gynaecologic malignancy and schizophrenia and has just been in the hospital ward because of pneumonia. No pre-existing LOMT. The internal medicine physician has been called, who asked to transport the patient to the hospital. EMS personnel would like to leave the patient on-scene for end-of-life care. New LOMTs issued: DNACPR, no intensive care and no intubation. Transportation at recovery position. The patient survived 15 days. (Study IV)
Dyspnoea. A 62-year-old patient at a private home. Pulmonary carcinoma with radiotherapy and cytostatic therapy, has also received radiotherapy for brain metastases. On the last control the disease was progressing. No LOMT. Now the general condition has decreased, and 112 was called because of dyspnoea. The patient is septic, 40 °C fever, hypotensive. Decreased consciousness, not reacting. New LOMTs issued by HEMS physician: DNACPR, no intensive care and no intubation. The patient survived 0 days. (III)
Transportation from one HCF to another. EMS unit is at primary HCF policlinic. The patient is an NH resident, 78 years old, has coronary syndrome, previous stroke and one leg amputated due to arteriosclerosis obliterans, nutrition via a percutaneous endoscopic gastrostomy tube. Pre-existing LOMT DNACPR. Now symptoms of upper respiratory tract infection, transferred to primary HCF and then referred to a central hospital. Restless and agonised. EMS personnel calls to HEMS physician for treatment instructions. Survived two days. (IV)
Patients with an altered mental status
The challenge is an intellectually disabled critically ill child whose prognosis is pessima, but there are no LOMTs. (I)
Dyspnoea. A 71-year-old NH resident with a DNACPR. Bedridden, does not communicate. Profound mental retardation on background. Now has fever and lots of mucus for two days. Today difficulties with breathing. New LOMT issued by HEMS physician: no intensive care, no intubation. Survived 6 days. (III)
Dyspnoea. A 68-year-old NH resident with mental retardation. No somatic comorbidities, no LOMT. Bedridden, occasionally eats. Does not move, occasionally fed. Last night mucus in airways and wheezing. In the morning the dyspnoea is getting worse. Has told the nurse about stomach pain. New LOMT issued by HEMS physician: DNACPR. Survived 8 days. (III)
Other physicians are not instructing for end-of-life care
Dyspnoea. EMS unit calls to ask for treatment instructions at 1.37 a.m. The patient is an 87-year-old NH resident, who is bedridden but communicates normally. DNACPR as pre-existing LOMT. Today the patient has been tired, and general condition has decreased. Now the staff can't wake her up. The patient is totally unconscious. EMS personnel has called a physician in the hospital emergency department who has refused to make decisions on treatment and said to call someone else. No new LOMT issued during the call. Survived 117 days. (IV)
Arrhythmia. EMS unit calls to ask for treatment instructions at 7.15 p.m. The patient is 93 years old and had a hip fracture operated a week ago. Now transferred to a primary HCF with increasing C-reactive protein. Wheezes. Decreasing consciousness and low saturation. DNACPR exists but no other LOMT. HEMS physician issues further LOMT as DNACPR + no intensive care, no transfers. Survived 1 day. (IV)

6 DISCUSSION

This thesis studied LOMTs in prehospital settings and on EMS missions to HCFs and NHs. The thesis included a survey on Finnish HEMS physicians' opinions and practices regarding LOMTs in their work and their experiences on missions and consultation calls involving patients in HCFs/NHs (I). The three prospective studies examined EMS-attended CA missions in HCFs and NHs in Pirkanmaa (II) and HEMS missions and consultation calls to HEMS physicians in which HEMS physicians issued a new LOMT or the patient had a pre-existing LOMT (III, IV).

The main findings are as follows: 1) EMS and HEMS missions to HCFs and NHs are common (I, II, III, IV); 2) survival from CA in HCF/NHs was 4.6% in general, but there were no survivors in NHs (II); 3) all Finnish HEMS physicians issue LOMTs, but LOMT practices and opinions differ between physicians (I); 4) LOMTs were involved in 5.7% of HEMS missions and 7.8% of consultation calls to HEMS physicians. The most common pre-existing LOMT was DNACPR only. The most common new LOMTs issued by HEMS physicians were ToR, DNACPR and withholding intensive care and/or endotracheal intubation (III, IV); 5) EMS personnel and HEMS physicians have limited information available while making decisions in prehospital settings. Information on patients' possible pre-existing LOMTs is infrequently available in EMS situations (I, II, III, IV); and 6) EMS units are dispatched to treat patients because of insufficient advance care planning (I, III, IV).

6.1 (H)EMS Missions to Health Care Facilities and Nursing Homes

In the survey, 75% of HEMS physicians indicated that they are often dispatched to treat patients in NHs or HCFs. This was confirmed in the three other studies, where 18% of all EMS-attended OHCAs in Pirkanmaa occurred in HCFs/NHs and 11% of all HEMS missions in Finland and 14% of consultation calls to HEMS physicians involved patients in HCFs/NHs. Interestingly, 65% of HEMS physicians disagreed with the claim 'HEMS physician need to make decisions on patients located at an

HCF/NH'. In the Utstein study (II), the proportion of OHCA patients in HCFs/NHs was high compared to the other studies presented in the Table 5. A probable explanation for this is that this study included patients in HCFs as well as patients for whom resuscitation was not attempted, contrary to many other studies (Table 5). A study from Australia that also included all OHCA patients reported that the proportion of OHCA patients in NHs was 12.8% (Andrew, 2018). Similarly, a Danish study reported that the proportion of OHCAs in NHs was 16.5% in 2014 (Pape, 2018), which was the same year when the material for our study II was collected.

None of the NH residents survived from CA in this small study, contrary to other recent bigger studies, which reported survival rates of 1.3–2.6% (Andrew, 2018; Deasy, 2012; Kitamura, 2014; Pape, 2018). However, long-term survival with good outcome was poor in those studies. Pape et al. 2018 reported that the one-year survival for the NH group was 1.2% but did not provide information on neurological or functional outcomes. In the study of Andrew et al. 2018, the one-year survival was 1% for NH residents, and none of the patients were reported to have a good functional outcome. The poorer survival rates in our study may be an incidental finding related to the small study cohort or due to the demographics of our study cohort as well as challenges in adhering to the resuscitation protocol (Perkins, 2021); strikingly, 53% of those with a pre-existing DNACPR received CPR, while two patients without a DNACPR did not receive bystander CPR in HCFs/NHs. Although CPR attempts were futile for patients in NHs in the current study, some patients (3% of the whole study group) resuscitated at HCFs demonstrated a favourable 90-day outcome after CA. The longer EMS response times, more frequent cancellations of the HEMS unit and decisions to withdraw treatments on-scene may explain the differences between those who died on the scene and those who survived the event. However, the EMS response was generally successful in this study, and the differences could be interpreted to mean that the EMS system was able to recognise patients with an assumed favourable prognosis and focus resources on their treatment.

The population of clients in 24-care facilities in Finland is remarkable and consists mainly of old people with severe cognitive disorders, other comorbidities and extremely decreased functional status (OECD/European Commission, 2013; Saarto, 2017; Vanttaja et al., 2015). The case-mix of clients in NHs with 24-hour assistance varies between countries and in a large comparison of nine countries the NH residents in Finland had high burden of physical and cognitive impairments (OECD/European Commission, 2013). Accordingly, the survival of these patients

from acute critical illness is poor (Ibrahim et al., 2015; Morrison R., 2000), which was also seen in this study. The differences in the demographics of NH populations can explain the varying survival rates of this study and other studies presented in the Table 5.

NHs are not obligated to have an on-call physician available, but 'sufficient health care services' need to be offered to clients (Social Welfare Act, 2014). In addition, many primary HCFs have abandoned their on-call physician arrangements due to the centralisation of acute health care services. Thus, acute deterioration in HCFs/NHs often results in a call to 112 to get the patient assessed by EMS personnel or transported to an emergency department for a physician's assessment. The EDC dispatch protocol is unchangeable whether the patient is in an NH or elsewhere, and juridically NHs are equivalent to private homes. The dispatched EMS resources are the same regardless of the location of the patient. Private for-profit NHs and HCFs may save on financial costs when acute health problems are treated in public health care, but this practice burdens the EMS system. In this study, this was most obvious in situations where EMS units were dispatched to NHs/HCFs because of deficient advance care planning, which is discussed in more detail below. However, the current international trend is that EMS units increasingly treat patients in NHs and transport them to hospitals for further treatment (Deasy, 2012; Dwyer et al., 2014; Kitamura, 2014; Pape, 2018). Based on these observations and the increasing number of EMS missions in Finland and developed countries (HUS, 2021b; Lowthian et al., 2011), it is fair to wonder whether the health care system or EDC dispatch protocol require modification.

6.2 Limitations of Medical Treatment in HEMS Physicians' Work

The studies in this thesis show that LOMTs are common in prehospital settings. In the survey (I), 39% of HEMS physicians indicated that they often issue LOMTs (other than cancellation of HEMS mission). In the Utstein study (II), 29% of OHCA patients in HCFs/NHs had a pre-existing DNAR, and a new LOMT was issued for 48% of OHCA patients on-scene. The prospective studies of LOMTs in HEMS settings found that LOMTs were involved in 5.7% of HEMS missions (III) and 7.8% of consultation calls to HEMS physicians (IV).

In the survey, all Finnish HEMS physicians stated that they issue LOMTs, and 85% physicians agreed that HEMS physicians are supposed to issue LOMTs.

However, the issuance of LOMTs varied between physicians. Indeed, the physicians raised concerns about whether their practices might differ significantly from those of other physicians, and they also wondered about their legal status when they issue LOMTs at the scene or by phone. The different personal practices, experiences, opinions and LOMT definitions could not be fully explained by the responding physicians' sociodemographic or professional backgrounds. Rather, the differences were mainly explained by variations between individual physicians and only to a lesser extent to differences in working cultures between HEMS bases. Experienced physicians had greater confidence in issuing LOMTs, and they found situations in which they needed to issue LOMTs clearer than less experienced physicians. This likely reflects the experienced physicians' repeated exposure to LOMT decision-making in their work history. Such remarkable heterogeneity in end-of-life decision-making was reported 20 years ago in a Finnish study of Nordic intensivists (Pettilä et al., 2002). A study by Guidet et al. (2018) similarly reported that the variation in attitudes toward withholding or withdrawing LST in ICUs is mainly due to differences between individual physicians (Guidet, 2018). In fact, it has been found that the practices of physicians vary in terms of why or how actively they issue LOMTs (Curtis, 2017; Garland & Connors, 2007; Mark, 2015).

A similar questionnaire survey to this study was conducted at the same time in Shanghai (So et al., 2019). In that study, emergency physicians were asked about attitudes, ToR practices and medical futility related to OHCA. The physicians' experience, attitudes and knowledge were not associated with the aggressiveness of resuscitation behaviour. Instead, having the status of a fellow of the Hong Kong College of Emergency Medicine or an advanced cardiac life support instructor was significantly related to earlier ToR in medically futile patients with OHCA. This finding was explained by these physicians' higher confidence in terminating resuscitation and their awareness of the futility and maleficence of prolonged resuscitation attempts (So, 2019).

In study I, the physicians from base FH50 seemed more reluctant to limit therapies in prehospital settings compared to physicians from bases FH10 and FH60, while physicians from bases FH20 and FH30 were more neutral in their approach. Expectedly, this difference was seen in prospective studies of clinical work, as HEMS events associated with LOMT were less common in base FH50 (III, IV) and most common in bases FH10 (III) and FH60 (III and IV). The clinical significance of this observation is difficult to assess, but one natural explanation for the difference might be that in some working cultures ToR is considered an LOMT, whereas in other working cultures it might be perceived as stopping a futile therapy after all efforts

have been made instead of issuing an LOMT. Another possible explanation is that the operating environments of HEMS units are different. In the area of FH10, the HEMS unit is not primarily dispatched to NH/HCF missions unless the patient is a visitor or a staff member, and this practice contains an allusion of an LOMT. Units FH10 and FH30 have advanced protocols for the transportation of suitable patients with ongoing CPR to in-hospital ECMO prior to immediate percutaneous coronary intervention or endovascular resuscitative balloon occlusion of the aorta (REBOA; in FH30 only), which require strict patient selection, while patients who are not expected to benefit from these treatments have dismal prognoses. Thus, these protocols may increase the incidence of LOMT decisions and make LOMT decision-making more routine. Local caring cultures have been found to affect individuals' advance orders to limit medical therapies (Laakkonen, 2004), and working cultures in general strongly regulate such individual decisions, especially in ethically or cognitively challenging situations (Fritz, 2010; Schein, 2004).

6.2.1 Pre-existing Limitations of Medical Treatments

Pre-existing LOMTs were mostly (65–66%) related to (H)EMS missions to HCFs and NHs and were often (74–75%) DNACPR only (III, IV). The incidence of LOMTs has increased (Kane & Burns, 1997; Sprung, 2019). As a result, the prevalence of DNACPRs on OHCA missions in general has been reported to be 6–10% (Counts, 2020; Rajagopal, 2016; Reuter, 2017), and it was 16% among CA patients in an NH in Australia (Andrew, 2018). The prevalence of DNACPR orders has also increased in Finland from 13% in long-term care facilities in 2002 (Laakkonen, 2004) to 67% in NHs in Tampere in 2011 (Vanttaja, 2015). The study of Andreasen et al. 2019 showed that the prevalence of written advance directives on deceased NH residents was 33% in general in the six studied European countries in 2014. However, the prevalence of advance directives varied significantly (0 –77%) between countries and was only slightly above the mean prevalence in Finland (40%) (Andreasen, 2019). This finding supports our results as in this thesis, the prevalence of pre-existing LOMTs on EMS missions to HFCs/NHs was 29% in study II, 18% in study III and 24% in study IV. However, these studies were not designed to evaluate the true prevalence of LOMT on EMS missions to HCFs/NHs, and likely advance directives are more general. Many patients with LOMTs and sufficient treatment plans do not need HEMS physicians if they deteriorate, and yet

information on pre-existing DNACPRs is poorly transmitted to EMS personnel (Andrew, 2018; Reuter, 2017). This study and other recent studies suggest that the possibility of a pre-existing LOMT is high on missions to HCFs/NHs, but it should be considered on all OHCA missions.

6.2.2 New Limitations of Treatment Issued by HEMS Physicians

The HEMS physicians indicated that the new LOMTs they issue usually concern only life-sustaining therapies, such as CPR and intensive care (I), which was supported in the prospective studies. HEMS physicians issued new LOMTs on approximately 3% of all HEMS missions and consultation calls (III, IV). In both studies, the majority of new LOMTs were ToR, DNACPR, withholding intensive care and/or endotracheal intubation. It seems that these LOMTs were rarely made according to the national and local instructions presented in Chapter 2.3. (National Supervisory Authority for Welfare and Health, 2020). On the other hand, the new LOMTs the HEMS physicians issued were often prompt decisions to withhold or withdraw a resuscitation attempt in clearly futile situations and according to the resuscitation protocol (Working group set up the Finnish Medical Society Duodecim, the Finnish Resuscitation Council, 2021). Other new LOMTs were rare. The new LOMTs were often followed by the cancellation of the HEMS unit from the mission (III). In the study of new LOMTs issued during consultation calls, 66% of patients with new LOMTs died within a week from the consultation call.

Presumably, new LOMTs are more common than reported in this study. Decisions to terminate resuscitation are common. In approximately 35% of all EMS-attended OHCAs in Finland, the CPR attempts are withheld or withdrawn after the on-scene arrival of EMS personnel (Hiltunen, 2012; Setälä, 2017). It is likely that all ToR cases are not recorded in this study material since ToR after a futile resuscitation attempt is not considered a new LOMT by all physicians or in every situation. Yet, cancellation of the HEMS mission is not generally considered to be a new LOMT, even if the reason for cancellation is that the patient would not benefit from the presence of HEMS physician. In such situations, there is no legal patient–physician relationship. Thus, there is seldom any documentation of those decisions, and often the patient's personal identity number is not even recorded.

An interesting finding was the importance of baseline functional status when making decisions on new LOMTs (II, III, IV). This reflects our society's valuing of

overall independence, especially independence in ADL, but as discussed in Chapter 2.2.4, the recent evidence supports the association between frailty and poor functional status, with poorer outcomes related to critical illness (Krinsley, 2017; Pietiläinen, 2018). However, defining a critically ill patient's 'baseline' functional status and prognosis of chronic comorbidities and then adjusting the goals of care may be challenging in an acute EMS situation. Patients tend to evaluate their quality of life better than their physicians, and when physicians estimate the quality of life as poor, they are more inclined to withhold LST (Ibrahim, 2015).

The reasons and situations for new LOMTs change over time and geographically. For example, since the time this thesis was planned the resuscitation protocol for traumatic OHCA patients has become more aggressive in Finland (Working group set up the Finnish Medical Society Duodecim, the Finnish Resuscitation Council, 2021). Otherwise, physicians' reasons for withholding and withdrawal of LST were generally the same as in previous studies in prehospital settings (Ferrand, 2006; Horsted et al., 2004) and on ICUs (Hoel, 2014; Pettilä, 2002; Reignier, 2008). In a French study, 59% of the decisions to forego LST for ICU-refused patients were made via phone, meaning that issuing LOMTs by phone is not a new practice (Reignier, 2008).

Prognostication of an outcome is difficult, and LOMT as well as all medical decision-making is prone to biases (Christakis & Asch, 1993). Moreover, in this study there were extremely ill or injured patients with a new decision to withhold LST in a prehospital setting who surprisingly survived at least the whole follow-up period. The patient groups that Finnish HEMS physicians identified as challenging in terms of end-of-life decision-making were the same as described in other studies. Especially challenging were children and adolescents (Mentzelopoulos, 2021), patients with disabilities (McGinley, 2017; Werth, 2005) and patients with malignancies (Nordby, 2012) or in palliative care (Kim K. et al., 2017). The many challenges related to issuing LOMTs for patients with dementia are detailed in an Australian study (Ibrahim, 2015). The appropriateness of CPR attempts for aged patients and NH residents was studied in Belgium, revealing marked variability between physicians (Druwe et al., 2020). A Danish study suggests that ethical considerations should be documented more often in situations concerning prehospital life-and-death decision-making (Mikkelsen et al., 2017).

6.3 Information Available When Making Decisions on Treatment in Prehospital Settings

In all of the studies in this thesis, it was alarming how rarely the information on pre-existing LOMTs was transmitted to the EMS system, and EMS units were dispatched to treat OHCA patients with a DNACPR. The inaccessibility of advance directives has been reported previously (Morrison R. et al., 1995), and the problem persists internationally (Andrew, 2018; Reuter, 2017). The results of this thesis suggest that information on LOMTs issued in tertiary hospitals is also infrequently transmitted to NHs or even primary HCFs. Another interesting but concerning result was that medical records were only available in 22%/29% of cases when new LOMT was issued on HEMS missions/consultation calls. A literature search did not reveal any other relevant studies to compare this result. The reason for this finding is probably that HEMS physicians often make decisions while they are in the field, and they do not have access to mobile medical records. Another reason is that the operational environment is geographically wide and exceeds the boundaries of hospital districts; different hospital districts have separate medical records that the HEMS physicians are unable to access. It was expected that the national archive of health care information (Kanta) would solve some of these problems, but some challenges remain. HEMS physicians have a working interface to Kanta while they are at base, but there are delays in the data transfer from other hospital districts' medical records to the Kanta Service. In addition, Kanta is a huge pool of unorganised data, and finding specific information (e.g. pre-existing or previously considered LOMT) rapidly may be impossible. In the future, increasing the availability of mobile medical records could ease these problems, but physicians still do not have access to NH client records or other social care data.

In general, data in prehospital settings are scarce. If the situation is not obviously futile or there is a lack of sufficient information, HEMS physicians reported that they usually proceed with full LST. Physicians also reported that it is difficult to determine whether a patient with a malignancy is in curative or palliative treatment. This information is sometimes difficult to get from the patient/proxy, from medical records and even from an oncologist. Yet, the EDC dispatch algorithm does not include compulsory questions about LOMTs or treatment plans. HEMS physicians may have some time to study the patient's medical history while travelling to the scene, but the patient's civil registration number is often unknown at this point of a mission. Perhaps it would help if the EDC dispatcher could ask the patient's name

and civil registration number during the emergency call and transmit it to the EMS unit, thus allowing more time to study the patient's previous medical records.

Finnish HEMS physicians rarely consult other physicians while issuing new LOMT. For comparison, in an ICU study another physician was consulted in 43% of LOMT decisions (Hoel, 2014), while in a prehospital setting another physician was consulted in 57% of decisions to withdraw or withhold LST (Ferrand, 2006). Interestingly, in the latter study 30% of patients to whom the prehospital physicians issued new LOMTs were in palliative care (Ferrand, 2006). Discussions with NH physicians were rare. Probably there are problems with information transmission in another direction as well: from HEMS physicians to NHs and primary HCFs. When an HEMS physician issues a new LOMT, the information on it should be transmitted to the patient's attending physician to ensure good continuity of care and complete an advance care plan.

6.4 Deficient Treatment Plans

This study shows that the EMS system and HEMS physicians need to make medical decisions repeatedly in situations where there is a rapid deterioration in the well-being of a patient with a serious long-term illness, for which there is insufficient advance preparations. In the survey, 93% of HEMS physicians claimed they often encounter patients who should have already had an LOMT. In 49% of situations when HEMS physicians issued a new LOMT on an HEMS mission and in 67% of consultation calls during which HEMS physicians issued new LOMTs, the HEMS physicians recognised the patient's frail condition, suggesting the LOMT should have been issued earlier. One reason may be that there is a LOMT but information on it or an advance care plan is not available (Reuter, 2017). Either there is no access to medical records, or the family or nursing staff are unable to share information on them. Another reason is that that advance care plans that include emergency care plans are still rare (Mentzelopoulos, 2021; Pitcher, 2017). The recommended national quality criteria for end-of-life require that updated advance care plans should be available for all health and social care staff participating in the patient's care regardless of the time of the day so they would know how to treat acute symptoms (Saarto, 2019b, Saarto et al,. 2022). It seems clear that advance care plans should be made in a timely manner, and there should be an emergency care plan regarding concrete actions to be taken, at least in case of CA, unconsciousness or severe dyspnoea. The high number of patients with DNACPR with attempted CPR in these

studies indicates that the staff in HCFs and NHs need education not only on the CPR protocol in general but also on how to act when treating a patient with an LOMT who needs palliative care.

A DNACPR is not a treatment plan. HEMS physicians received multiple consultations asking for further treatment instructions for patients with DNACPRs only. HEMS physicians receive more consultation calls in Finland than reported in a Scandinavian study (Kruger, 2013). In Finland, a physician is consulted on 24% of non-conveyed patients (Paulin et al., 2020), and the number of EMS missions has recently increased remarkably (HUS, 2021b). Frequent consultation calls may burden HEMS physicians. Interestingly, half of the new LOMTs issued during consultation calls involve patients in HCFs/NHs and occur partly during the day, when there should be an attending physician who could make decisions on treatments and who has access to the patient's medical records and/or client files. EMS and HEMS missions resulting from deficient treatment plans increase the risk of concurrent EMS missions, which may result in excess suffering and healthcare costs (Mentzelopoulos et al., 2018; Osteras et al., 2018).

From HEMS physicians' perspective, it may seem that they need to make decisions on LOMT because other physicians are unwilling to do so. One reason for this is that general practitioners at HCFs and NHs may overestimate the prognoses of their patients and fail to identify approaching death (Morrison R., 2000). In addition, the protocol for advance care planning is rigid and demands time and personal resources, which the health care system cannot afford (National Supervisory Authority for Welfare and Health, 2020). However, procrastinating about end-of-life decisions based on the stereotypes that NH residents are not willing to or they lack the capacity to discuss these matters does not seem justified (Fritz, 2014; Ibrahim, 2015; McGinley, 2017). It is also possible that primary health care and/or social care do not communicate with specialised health care, and no one is responsible for the overall situation of the patient. It is likely that the problems experienced by the EMS system are not passed on to those responsible for the primary care of the patients. In addition, all physicians need more education on advance care planning and LOMTs. It has been shown that communication skills training interventions increased health care professionals' comfort, self-efficacy and preparedness in the delivery of end-of-life care. (Walczak et al., 2016).

The Ministry of Social Affairs and Health's report on the status of palliative care in Finland acknowledges that EMS often responds to the sudden care needs of patients in end-of-life care (Saarto, 2019b). HEMS physicians feel frustrated when dispatched to treat dying old patients in NHs with already-existing LOMTs. It is

considered unethical if no one else can give instructions for end-of-life care other than an HEMS physician and/or the dying old patient is transferred to a hospital emergency department in vain (Aaltonen, 2014). There are care-related, psychological and organisational reasons why EMS personnel are called to NHs and private homes at the end of life (Waldrop, 2018). When advance care planning is focussed mainly on treatment restrictions without emergency care plans, EMS participation is usually needed to take the responsibility for clinical decision-making about when to proceed to palliative care (Pitcher, 2017). As the patient's family members or NH staff are typically not familiar with seeing or treating critically ill or end-of-life patients, they usually need both diagnostic measures and support (Counts, 2020; Reuter, 2017). In addition, calling 112 in case of an acute deterioration in an NH can be a part of the caring culture or a juridical act. Instructions may obligate informing an on-call physician about sudden death even though the patient is only declared dead by a physician in the following office hours.

Importantly, there are challenges in the organisation of care for end-of-life care patients in both private homes and NHs. Who prescribes new medications needed acutely? Who can get them from the pharmacy? Who dispenses medications for pain, nausea or dyspnoea, and are there skilled NH staff who can give such strong medications? There are also issues with the availability of medications needed in end-of-life care in NHs. They are not juridically considered HCFs, and thus they are not allowed to have medicine cabinets, which limits their ability to provide palliative medication (Saarto, 2019a). The EMS system may need to solve these practical arrangements, provide palliation to ease the distress of the NH staff or organise and execute transfers to a hospital emergency department or primary HCF palliative inpatient ward (Waldrop, 2018). In addition to either offering or withholding LST while on the scene, HEMS physicians also provide their competence in clinical decision-making on critically ill patients (Fritz, 2010; van Schuppen & Bierens, 2015; Waldrop, 2019). However, the situation is always challenging when HEMS physicians need to issue LOMT on-scene for patients who—and whose proxies—have not previously understood the severity of the overall situation (Waldrop, 2015). The EMS system covers many deficiencies in end-of-life care planning and capabilities in society. However, the biggest clinical problem resulting from the lack of treatment plans is the absence of good palliative care when, surprisingly, it is needed (Aaltonen, 2014; Saarto, 2017).

6.5 Ethical and Practical Challenges

Ethically challenging situations were recorded in all of the studies in this thesis, but these considerations are rarely documented (Milling et al., 2021). In the survey, half of HEMS physicians had sometimes decided not to make a medically justifiable LOMT to avoid a possible conflict with the patient, proxy or HCF/NH staff. This conflict has been reported in other studies as well (Sandman & Nordmark, 2006; Waldrop, 2019). Although the solution to withhold LOMT decision-making might not reflect the patient's best interest, prolonging the time spent on-scene should be avoided.

In health economics, there is a principle of equity. It does not mean that the therapies offered to patients should be evaluated based on their productivity, expense or impact on quality of life. Instead, it means, for example, equally assessing the chances of survival from a critical illness. Economic studies estimate that attempted CPR for OHCA is expensive. For instance, an international multicentre trial from the 1990s estimated the cost to be approximately US $406,605 per life saved and US $225, 892 per QALY (K. H. Lee et al., 1996). The monetary value of a human life is difficult to define. However, our perception of a life worth saving can be consciously or unconsciously influenced by numerous factors, such as the perception that housing and care in an NH with 24-assistance is too expensive for the client, the family or the society, as the costs can exceed 4,000–5,000€ per month (Kokko, 2018).

Recent studies emphasise that hasty LOMTs as an early withdrawal of LST may lead to excessive mortality (Elmer, 2016). In the meta-analysis of Nas et al. (2020), it was found that the specificity of ToR rules was worse in Asian than in Western countries. In Asian regions, where all OHCA patients need to be transported with ongoing CPR, the pooled specificities of the BLS and ALS rules were 0.84 and 0.94, respectively. Hence, 16 and 6 out of every 100 survivors would fulfil these TOR criteria. In Western countries, where CPR attempts are often withdrawn on-scene, there is a possibility for bias, and new LOMTs may be issued to as many as 6 out of 100 possible survivors (Nas et al., 2020). Issuing new LOMTs in acute situations requires know-how on both the possibilities of medicine and the general prognosis of critically ill patients. If physicians lack experience in intensive care and do not realise that ICUs also admit aged people with comorbidities, they might be too eager to issue new LOMTs, and some possible candidates would not be sent to intensivists. The situation of Finnish HEMS physicians is good in that they are mainly experienced anaesthesiologists who have work experience in ICUs.

As the field of medicine evolves, the ethically accepted practices change. Ethical review has traditionally evaluated the treatment of a single patient. Today, there is also a need to evaluate the care and best practices for patient groups and the general population (The Finnish Medical Association, 2021b). All those in the same situation should be able to receive the same treatment, and there should be no significant geographical differences within the country. HEMS dispatch cannot be excluded solely based on the location of the patient in an HCF/NH for ethical and juridical reasons (Pape, 2018). However, when evaluating the whole situation, if the person is over 80 years old, resides in an NH, needs help or support to be eligible for Social Insurance Institution pensioner care allowance and a DNACPR decision could have been made on either a discussion or medical basis, serious consideration should be given to whether the patient is still eligible for intensive care. This relates to the majority of Finnish nursing home residents with 24-hour assistance (Mielikäinen, 2019; OECD/European Commission, 2013). If a person needs care with 24-hour assistance, would it be ethically correct for there to be a treatment plan stating that most treatments should be carried out in a place of residence?

Developments in medicine have led to new advanced technologies and expensive therapies. This could lead to differences between private and public health care if further treatments are offered in private health care. Private cancer clinics already offer therapies to patients whose public health care treatment has been discontinued as unsuccessful. Private clinics also perform surgeries in situations in which public health care has refused to. Does this mean that in case of severe pneumonia or surgical complications requiring intensive care that these patients have a passing lane to enter ICUs despite the public health care treatment restrictions? In addition, the EMS system and HEMS physicians would need to treat these patients prior to their arrival to the hospital. Should there be some regulation for private health care to at least pay for all costs of the complications it causes to balance the costs of public health care? There are no bounds on how many services people might want from the health care system. If there were no payment restrictions for an individual or society, there would be no upper limit on the consumption of health care services (Morris et al., 2018a).

The main problem with the current system is that the decision may not always be made equally. Another problem is that (H)EMS physicians need to be responsible for prehospital prioritisation. Public authorities, and the democratic decision-making system, are ultimately responsible for the fairness of public health care (The Finnish Medical Association, 2021b). Political decision-makers should define the principles on what kinds of treatments and care are offered, to whom and for how long in

public health and social care, even though physicians have the ultimate decision-making power and responsibility for individual patients. This conversation is yet to come and is not clearly addressed in current legislation or in the Council for Choices in Health Care in Finland, which issues recommendations on what should be included in the range of public health services (COHERE Finland, 2022).

6.6 Strengths and Limitations of the Study

This was the first nationwide multicentre study of prehospital LOMTs and decisions on other LOMTs beyond withholding or withdrawing CPR. The participation rates in the studies on HEMS physicians were high, and the data collection on OHCAs in Pirkanmaa was comprehensive. The internal validity of this study was good because the survey was conducted in the same year that the prospective recording of LOMTs in prehospital settings was initiated. The decision was made to not provide any definitions of LOMTs in survey (I) because that would have constituted an intervention, and the aim was to record all possible heterogeneity in the HEMS physicians' answers. Data were collected for studies III and IV from the same FinnHEMS database that HEMS physicians use to document missions and consultation calls, which probably affected the participation rates positively.

This thesis has several limitations. First, the observational study design makes it impossible to draw causal conclusions from the associations. However, the thesis focussed on sensitive end-of-life situations. The study population contained plenty of vulnerable or incapacitated patients (the critically ill, demented, intellectually disabled, children and those with severe psychiatric conditions), and clinical trials requiring informed consent would be extremely difficult to accomplish. Thus, registry studies were reasonable. Second, the results from this thesis cannot be applied to other countries with different clinical practices or EMS, healthcare and social care arrangements. However, the professional backgrounds of the HEMS physicians in Finland were fairly similar to those of other HEMS physicians in Europe (Bjornsen, 2018; Guidet, 2018; van Schuppen, 2011). Third, the prospective study cohorts were generally small in studies II, III and IV. They were not random samples extracted from a larger population but rather included almost all consecutive cases within the study periods, and power calculations were not needed. Moreover, when a statistically significant association is found within a small study cohort, it is often relatively strong. In study III, there were at least eight cases in which data were

missing because HEMS physicians did not complete the study sheet. In those cases, the HEMS physicians stated that the mission was involved with an LOMT on the compulsory page of the FinnHEMS database, but the study sheet was not completed. While the FinnHEMS database contains reliable data on HEMS events and is used for other scientific studies as well (Saviluoto et al., 2020), there is individual variation in the documentation habits of physicians. In addition, the database has not been externally validated (Heino et al., 2019).

In study II, the total number of beds in all HCFs and NHs was unknown, and the incidence of CA was not available for this population. The study was limited in explaining whether the low survival rates in HCFs and NHs were due to deficiencies in treatment or to the patients' overall poor prognosis. The HEMS unit was cancelled in most of the cases, which might have caused selection bias, as the same reasons that led to the HEMS cancellation often led to the poor survival of the patients.

It must be remembered that studies IIII and IV were not designed to identify all patients with deficient advance care planning; patients were not included in the study if they did not have pre-existing LOMTs or if a new LOMT was not issued. As discussed earlier, the number of new LOMTs issued in prehospital settings may be even higher than found in this study. It should also be noted that if the patient had a clear pre-existing LOMT or a sufficient treatment plan there might not be a need for HEMS dispatch or a consultation call to an HEMS physician—or even a need for EMS at all—and thus those patients were not part of this study. Unfortunately, studies III and IV were not completely symmetric because HEMS unit FH-10 was unable to participate in study IV. Moreover, due to the high number of cancelled HEMS missions in study III, the patient's civil registration number was missing in approximately half of the cases, and thus survival could not be analysed. In study IV, the patient's civil registration number was missing in 13% of consultation calls.

It is important to understand that the results of studies III and IV only represent the situations in which the HEMS physicians issued a new LOMT or identified a pre-existing LOMT. All situations in which a new LOMT was considered but not issued were not recorded in this study. However, from a clinical perspective, HEMS physicians automatically engage in a short internal decision-making process regarding the possible prognosis of almost every critically ill patient, and LOMTs are pondered on many missions and consultation calls to some extent. To keep the definitions simple, studies III and IV were designed to include only the issued LOMT.

6.7 Future Implications

As the possibilities of emergency medicine develop, decisions must be made about to whom will be offered new treatments in prehospital settings. It is also possible that the number of LOMTs imposed by EMS physicians will decrease in the future if advance care planning improves and some patients are transported to hospitals with ongoing CPR. In addition, the number of potential organ donors will increase as the organ donation protocol changes, which may reduce the number of prehospital LOMTs issued in acute situations (HUS, 2021a; Manara et al., 2012). Along with the new protocol, many critically ill patients could be transported to a hospital's emergency department, and the assessment of the patient's ability to survive or, conversely, to serve as an organ donor, would only be assessed in the hospital.

Currently, there is room for improvement in advance care planning in Finland. Considering the increased workload of the EMS system, decision-makers in the health care system should actively consider the organisation and accessibility of end-of-life care services in acute situations. In addition, EDC's dispatch protocol could acknowledge the increasing prevalence of advance care plans and advance directives.That would also require a chance to transmit patients' civil registration numbers to EMS as soon as possible. There are promising local inventions for responding to increasing end-of-life care needs. In Western Finland, there is an EMS unit called 'Combilanssi', which is staffed with one EMS paramedic and one geriatric nurse. The unit is dispatched to NHs and to other suitable aged patients and aims to treat many problems on-scene to reduce transportation to emergency departments. The unit can consult with the home hospital physician or EMS physician (Aalto, 2021). North-Carelia in Eastern Finland has implemented a treatment protocol for patients in end-of-life care in their own private homes. EMS plays an important role in the protocol, responding to the acute care needs of these patients (Saarto, 2019b). However, as the responsibilities of the EMS system increase, there also needs to be enough educated EMS personnel, vehicles and agreed courses of action to have sufficient resources to carry out the EMS system's basic activities. The Ministry of Social Affairs and Health recommends to develop the palliative at-home hospitals and their collaboration with EMS to better address the acute needs of end-of-life care patients (Saarto, 2019b). In addition, further studies are recommended on the continuity of care of patients with a prehospital LOMT. Information is needed on how the information about prehospital LOMTs and/or admission to palliative care

should be communicated to the NH physicians and what happens to patients with LOMTs after they are admitted to hospital emergency departments.

In this thesis, the HEMS physicians suggested a need for more education on LOMTs for the health care staff in HCFs and NHs. General practitioners play an essential role in advance care planning, especially for long-term care patients and patients with acute admissions to hospital emergency departments and primary HCF wards. In some hospital districts, general practitioners already receive consultation calls from EMS personnel involving patients in HCFs and NHs. It would be useful to increase the awareness of modern intensive care and CPR in general, particularly regarding their possibilities and adverse effects. Systemic and routinised advance care planning is welcomed, especially when it focusses on the goals of care and the treatments that will be offered. Decisions on LOMT are linked to the overall treatment plans (Hirvonen, 2016). There are also positive effects of structured discussions about the goals of care on acute hospital admission and assessments by specialist teams upon acute patient deterioration (Field, 2014). In addition, education on end-of-life care practices and tools for LOMT decision-making could also be provided to HEMS physicians to harmonise the LOMT practices. The training could be arranged on each HEMS base on local training days or at national congresses for anaesthesiologists, intensivists and emergency physicians.

Other means to increase advance care planning and data transmission in health care systems exist. Almost all HCFs use electronic medical records, and health and social care systems are obligated to collect data for huge national registries in Finland. Data mining is already possible in health care data, but as information technologies develop, they could be used not only for medical research but also to build tools that support clinical decision-making. For example, the programme could determine the best probability of survival in cases in which the patient had CA (witnessed CA with shockable monitored primary rhythm), or it could assess the severity of comorbidities with age. When the probability of survival decreased below a pre-defined level, the programme would indicate when it could be time to consider advance care planning. In addition, administrative incentives could be used to increase advance care planning. A condition for the care allowance from Social Insurance Institution (or at least for the middle and highest care allowance rates) could be that there is a sufficient treatment plan that covers the intensity of treatments in the event of acute critical illness. A similar condition already exists in Social Insurance Institution allowances: The maternity allowance is only granted after the mother has registered to the maternity clinic. To facilitate the transmission of information on possible pre-existing LOMTs to the EMS system, EDC operators

could ask about them during the call or at least attempt to get the civil registration number of the patient when available.

7 SUMMARY AND CONCLUSION

The conclusions of this thesis are as follows:

1. Acute EMS missions to NHs and HCFs are common in Finland.
2. The residents in NHs are generally old and represent a comorbid and frail portion of the aged population. Their survival from CA is dismal.
3. EMS units are also dispatched to treat and transport CA patients in HCFs when there are possible survivors.
4. LOMTs are an integral part of HEMS physicians' work, but LOMT practices and opinions differ between physicians. LOMTs are involved in 5.7% of HEMS missions and 7.8% of consultation calls to HEMS physicians in Finland. Pre-existing LOMTs are usually DNACPR only, and patients with a pre-existing LOMT are more commonly encountered on EMS missions to HCFs and NHs. New LOMTs issued by HEMS physicians mainly concern life-sustaining treatments only. The most common reason to issue a new LOMT in prehospital settings is to terminate a futile CPR attempt. Other new LOMTs include DNACPR, withholding intensive care and/or endotracheal intubation.
5. The data available in prehospital settings are scarce, and information on pre-existing LOMTs (e.g. DNACPR) are inadequately transmitted to the prehospital personnel and HEMS physicians.
6. EMS units and HEMS physicians are also dispatched to treat patients because of insufficient advance care planning in HCFs and NHs.

The findings of this thesis cannot be generalised to end-of-life care in Finland, but it is undeniable that the EMS system's expertise and preparedness are employed to support the health and social care systems in responding to acute end-of-life care challenges.

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PUBLICATIONS

PUBLICATION I

Limitation of treatment in prehospital care – the experiences of helicopter emergency medical service physicians in a nationwide multicentre survey.

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ORIGINAL RESEARCH Open Access

Limitation of treatment in prehospital care – the experiences of helicopter emergency medical service physicians in a nationwide multicentre survey

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Abstract

Background: Making ethically sound treatment limitations in prehospital care is a complex topic. Helicopter Emergency Medical Service (HEMS) physicians were surveyed on their experiences with limitations of care orders in the prehospital setting, including situations where they are dispatched to healthcare facilities or nursing homes.

Methods: A nationwide multicentre study was conducted among all HEMS physicians in Finland in 2017 using a questionnaire with closed five-point Likert-scale questions and open questions. The Ethics Committee of the Tampere University Hospital approved the study protocol (R15048).

Results: Fifty-nine (88%) physicians responded. Their median age was 43 (IQR 38–47) and median medical working experience was 15 (IQR 10–20) years. All respondents made limitation of care orders and 39% made them often. Three fourths (75%) of the physicians were often dispatched to healthcare facilities and nursing homes and the majority (93%) regularly met patients who should have already had a valid limitation of care order. Every other physician (49%) had sometimes decided not to implement a medically justifiable limitation of care order because they wanted to avoid conflicts with the patient and/or the next of kin and/or other healthcare staff. Limitation of care order practices varied between the respondents, but neither age nor working experience explained these differences in answers. Most physicians (85%) stated that limitations of care orders are part of their work and 81% did not find them especially burdensome. The most challenging patient groups for treatment limitations were the under-aged patients, the severely disabled patients and the patients in healthcare facilities or residing in nursing homes.

Conclusion: Making limitation of care orders is an important but often invisible part of a HEMS physician's work. HEMS physicians expressed that patients in long-term care were often without limitations of care orders in situations where an order would have been ethically in accordance with the patient's best interests.

Keywords: Emergency medical services, Treatment limitations, Ethics, Nursing home, DNAR, Decision-making

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Introduction

Physician-staffed helicopter emergency medical service (HEMS) generally represents the highest level of care available in the prehospital setting. HEMS physicians have advanced experience in initiating a vast array of life-sustaining therapies at the site of the patient [1, 2]. HEMS units are dispatched to all high-risk medical situations based on the provision of medical equality in Finland, therefore they are also dispatched to healthcare facilities (HCFs) and nursing homes (NHs) [3]. However, an acute critical illness may be a manifestation of the terminal phase of the chronic condition rather than an unpredictable event among the patients in HCFs and NHs [4, 5]. Often the same factors that have led to the need for 24-h care and dependence in activities of daily living may lead to the withholding or withdrawing of life-sustaining therapies in acute situations [6].

There are numerous reports on ethical issues concerning withholding cardiopulmonary resuscitation (CPR) [7–10], but studies on limitation of care orders (LCO) beyond 'do not attempt resuscitation' (DNAR) are scarce, especially in the prehospital setting [11–13]. As far as we know, there are only a few studies on prehospital providers' end-of-life decision-making in HCFs and NHs [14, 15]. Here we describe the HEMS physicians' experiences with the LCOs they make in HCFs, NHs, and prehospital settings.

Methods

Design and ethics

We conducted a cross-sectional nationwide multicentre study among all HEMS physicians in Finland between 20th January and 30th April 2017. We designed the study survey around ethical dilemmas described in the recent literature [16–19]. An independent senior physician evaluated the feasibility of the questionnaire and appropriate revisions were conducted. The Ethics Committee of the Tampere University Hospital approved the study protocol (Approval no: R15048). The study was accepted by all Finnish university hospitals, the National Institute for Health and Welfare, and FinnHEMS Ltd. Participation was voluntary. We informed the physicians about the study with a personal or recorded video presentation and written information. The existing LCO guidelines weren't presented while giving this information. Absent respondents were contacted via email with a printable version of the questionnaire.

Setting

The Finnish emergency medical service (EMS) system has been previously described in detail [20]. In short, a HEMS unit is dispatched to all severely ill or injured patients alongside an advanced life support (ALS) unit by a national emergency dispatch center. The HEMS crew consists of a HEMS physician, a pilot, and a HEMS nurse-paramedic. HEMS services are coordinated by FinnHEMS Ltd., which is a publicly financed, non-profit corporation jointly owned by all Finnish university hospital districts. HEMS bases operate 24 h a day. There are six HEMS bases of which five are physician-staffed and one is HEMS-paramedic-staffed. Most HEMS physicians are specialists in anaesthesiology and intensive care medicine.

The Finnish healthcare system with HCFs, NHs, and care for the aged in general has also been described in the literature [21, 22]. In this study, the term 'HCF' included municipal health centers, hospitals, and private clinics. The term 'NH' refers to all the various housing services, which include residential homes for older people, sheltered housing with and without 24-h assistance, institutions for people with intellectual disabilities, institutions for substance abusers, rehabilitation institutes, and hospice units. Many NHs are private, whereas most of the HCFs providing institutional long-term care are public. Both HCFs and NHs usually have skilled healthcare staff, and both can utilise the public EMS system for the treatment and/or transportation of patients in acute situations. All patients with chronic illnesses should have a treatment plan according to the national guidance [23, 24]. If a patient is admitted to 24-h care, the attending physician should draft an emergency care plan and/or an anticipatory end-of-life care plan [3, 24–26].

Limitation of care orders

Finnish legislation emphasises that the patient's wishes should always be respected when planning his/her treatment and when this is not possible, the plan should represent the patient's assumed best interests [23, 27]. A senior physician may limit any medical treatment considered futile, and the patient has the right to refuse any treatment offered. Ineffective or harmful therapies may not be provided even if they are demanded by the patient or relatives. The patient can create an advance directive (AD) to limit his/her treatment. All LCOs and ADs should be clearly stated in the patient's medical records. The most common AD/LCO is DNAR. Other limitations usually concern intensive care, intubation, mechanical ventilation, invasive procedures, and intravenous antibiotics, transferring the patient to a hospital, and feeding or hydrating the patient intravenously or enterally. Palliative care and terminal care are often accompanied by DNAR and the limitation of intensive care, but these preferences need to be stated separately.

In the prehospital setting, paramedics can independently withhold a cardiopulmonary resuscitation attempt if there are secondary signs of death, obviously lethal trauma, or an existing DNAR order [8]. Paramedics can withdraw a resuscitation attempt after consulting the

HEMS physician in cases of unwitnessed cardiac arrest, prolonged downtime, or end-stage chronic medical conditions [8, 20]. The HEMS physician can make a LCO via phone if needed and may cancel the HEMS unit's participation in certain missions if he/she assesses that adequate medical resources are already at the site of the patient or after making a LCO.

Measures and statistics

We collected demographic data on the physicians' HEMS unit, age, gender, specialty and all previous work experience within the medical field. Our survey with 38 questions explored their opinions, attitudes, and experiences with prehospital LCOs in general, HEMS missions designated to HCF and NHs, and the LCOs set in those places. The closed questions or claims were answered with five-point Likert-scale choices with the sixth response choice being 'I wish not to answer this question'. The open questions addressed the features and challenges of prehospital LCOs. The questionnaire was given in Finnish, and the English translation is provided in Additional file 1.

Statistical analyses were performed using SPSS applications (IBM SPSS Statistics for Macintosh, Version 24.0, Armonk, NY: IBM Corp). We described the material with descriptive statistics (measures of central tendency and spread, and graphs) and differences based on the demographics of the physicians. We compared the answers in the following demographic groups: men and women, the age of the physician, and work experience in years. We analysed the Likert-scale answers with contingency tables, the Chi-Square or Fisher's exact test, and a Spearman correlation [28]. A p-value < 0.05 was considered statistically significant, and all tests were two-sided. For the qualitative data, we used content analysis to evaluate the information from the material and quantified the most commonly occurring reduced expressions [29].

Results

The total number of HEMS physicians during the study period was 67, and they were equally distributed to the five helicopter bases. Fifty-nine (88%) HEMS physicians participated in the study and the response rates by bases varied between 69 and 100%. The respondents were mainly experienced anaesthesiologists (Table 1).

HEMS physicians' attitudes, opinions, and experiences with LCOs

There was some variation in the physicians' opinions and experiences concerning LCOs. General LCO practices are presented in Fig. 1, the opinions and experiences on prehospital LCOs in Fig. 2 and the results concerning patients in HCFs and NHs in Fig. 3. The physicians perceived that their LCO was valid until the next physician's evaluation, n = 31 (53%), during the adjacent hospitalization period, n = 13 (22%), only in the current situation, n = 9 (15%), and permanently, n = 2 (3%), while n = 1 (2%) selected 'other' and n = 3 (5%) did not reply.

Every other physician (n = 28, 49%) had sometimes decided not to do a medically justifiable LCO because they wanted to avoid a conflict with the patient, the next of kin, or HCF/NH staff. Two physicians (4%) answered that in this kind of situation they never make LCOs, but in contrast, 17 (30%) stated that they always make the necessary LCOs regardless of the possible conflict. Twelve (21%) physicians stated that they had never encountered that kind of situation and two (3%) did not respond to the question.

Similarities between HEMS physicians' attitudes, opinions, and experiences

We recognized only a few patterns in attitudes, opinions, and experiences between the physicians when we analysed the groups based on gender, age, and work experience. The bases did not differ in terms of the age or experience of the respondents. Although the portion of women varied between 14 and 56% within the bases, the gender distribution was generally similar (p = 0.363). The answers of female and male physicians differed to only one question. The women found that making LCOs is a task among others and not an especially burdensome part of work, as 60% of the women fully agreed with this claim and 30% agreed with the claim versus 26 and 51% of men (p = 0.024, Fisher). The total correlations between the physicians' answers and age or work experience as physicians are shown in Table 2. The physicians with 20 years or more of work experience had fewer neutral answers compared to other physicians (see Additional file 2).

Qualitative data

The majority of the HEMS physicians (n = 50, 85%) reported challenging patient groups or situations for LCOs that are shown in Table 3. An example of such a case is an acutely ill child with an intellectual disability and severe chronic comorbidities but no emergency care plan or LCO. The prominent aspect of prehospital LCO situations was that there is only a limited amount of information available when making LCOs in the field, and yet the features of LCO situations are variable (Table 3). Many physicians (n = 32, 54%) found it more difficult to make LCOs via telephone and not meeting the patient, a few (n = 2, 3%) found those situations easier, and for some (n = 6, 10%) there was no difference.

Although the questionnaire did not demand that the respondents define LCO, many physicians did describe LCO decision-making. Twenty-two (37%) physicians expressed their personal principles or practices regarding how they make LCOs, seven (12%) wrote some definition for the

Table 1 Sociodemographic data of Helicopter Emergency Medical Service (HEMS) physicians in Finland in 2017

Sociodemographic background of the respondents $n = 59$	*n*	%
Gender		
Men	39	66
Women	20	34
Age		
Mean, years (SD)	43	(6.02)
Min – max, years	31–59	
First specialty		
Anaesthesiology and Intensive Care	53	90
Internal Medicine	3	5
Emergency Medicine	2	3
General Medicine	1	2
Specialization status		
Specialized	52	91
Specializing	5	9
Not responded	2	3
Second specialty; Emergency Medicine	9	15
Specialized	5	8
Specializing	4	7
Special competence (SC)[a]	37	63
1 SC, Emergency medical services (EMS)	26	44
1 SC, other than EMS	4	7
2 SC, EMS and some other	5	8
2 SC, both other than EMS	1	2
3 SC, EMS and two other SCs	1	2
Work experience in EMS		
Median, years (Q1–Q3)	10	(6–16)
Min – max, years	1–27	
Work experience as physician		
Median, years (Q1–Q3)	15	(10–20)
Min – max, years	1[b] – 33	
Work experience as EMS physician ($n = 55$)		
Median, years (Q1–Q3)	8.5	(5–13)
Min – max, years	0.5[b] – 24	

[a] The Finnish Medical Association can bestow special competences as additional to the official specialisation system. Special competences relate to certain specialty areas that particular skills are demanded (https://www.laakariliitto.fi/koulutus/erityispatevyydet/ohjeet/)
[b] One experienced HEMS paramedic had recently graduated from medical school

term LCO, and 14 (24%) expressed an opinion on LCOs or how they should be made. The most controversial topic was whether or not a HEMS physician's decision to cancel the HEMS mission could be considered as an LCO when reviewing the definitions of LCO. The physicians said they usually make LCOs concerning only life-sustaining therapies and some feel uncomfortable issuing other LCOs, such as 'no transportation'. The physicians wished to have further education on the general guidelines and clear criteria for LCOs ($n = 20$, 34%) and training on legal issues ($n = 12$, 20%). Forty-three (73%) physicians suggested more education for HCF and/or NH staff on LCOs and end-of-life care issues. Only 16 (27%) suggested that paramedics should receive more education on LCOs.

Discussion

This is the first multicentre study on HEMS physicians' opinions, attitudes, and experiences regarding LCOs

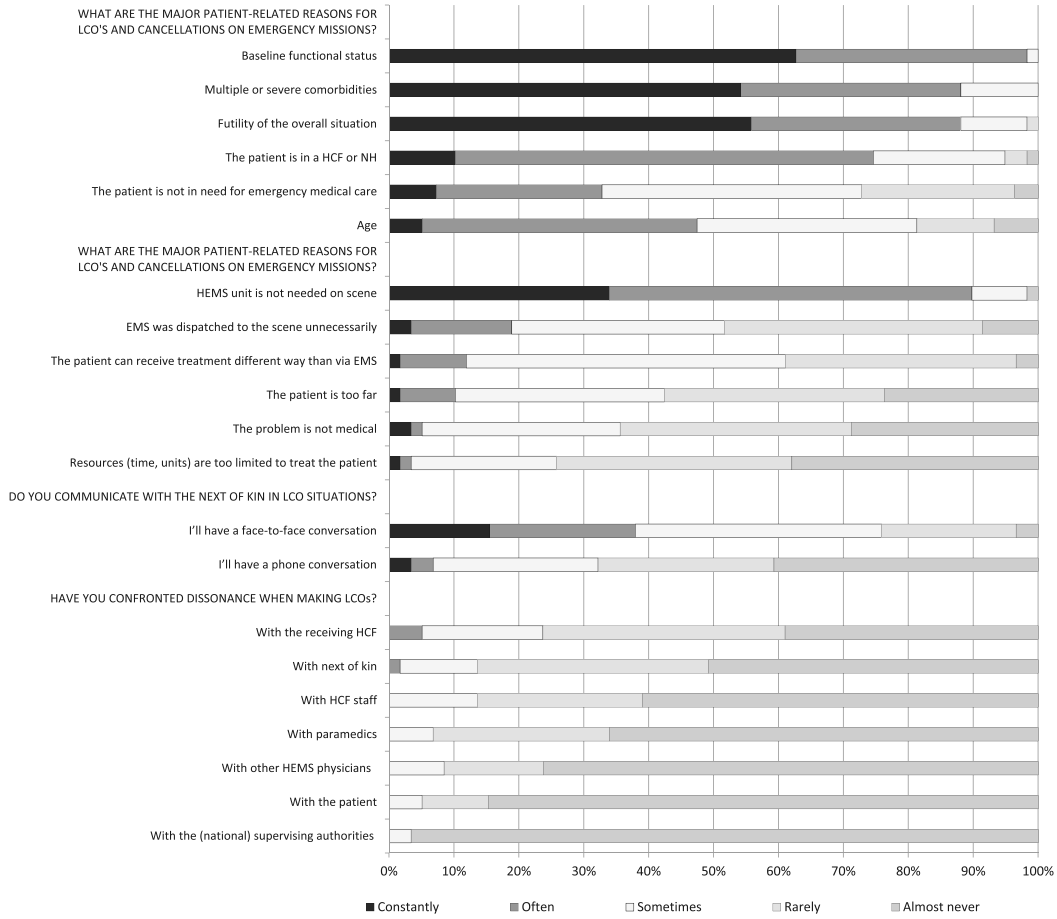

Fig. 1 The practices of Finnish HEMS physicians ($n = 59$) to make limitation of care orders (LCO). HCF is a healthcare facility and NH is a nursing home

[11]. We had a special interest in situations where a HEMS physician encountered LCO decision-making concerning patients in HCFs and NHs. The main finding of the study was that though all the respondents make LCOs, the principles for LCOs in the prehospital setting are not clear, and opinions and practices differ between physicians. Every other physician had sometimes decided not to do a medically justifiable LCO because they wanted to avoid a possible conflict with the patient, next of kin or HCF/NH staff. The HEMS physicians perceived their LCOs to concern usually only life-sustaining atherapies, such as intensive care and cardiopulmonary resuscitation. Almost all (93%) physicians working in HEMS units often encounter patients in HCFs and NHs who do not have appropriate LCOs, at least from the perspective of the HEMS physicians.

The experiences of HEMS physicians

Altering LCO definitions, various personal practices, as well as different opinions and experiences could not be fully explained by the respondents' professional or sociodemographic backgrounds. The less experienced physicians more often found the existing guidance on LCO situations to be insufficient, called the next of kin when making LCOs, and had encountered emergency care plans made for patients in 24-h care. Younger physicians felt they answered phone consultations concerning patients from HCFs or NHs more often than older physicians. The experienced physicians had greater confidence to make LCOs and stronger opinions on topics related to LCOs that probably stem from their repeated exposure to LCO decision-making situations during their career. Yet it seems that the variation in attitudes mainly reflected the differences between individual

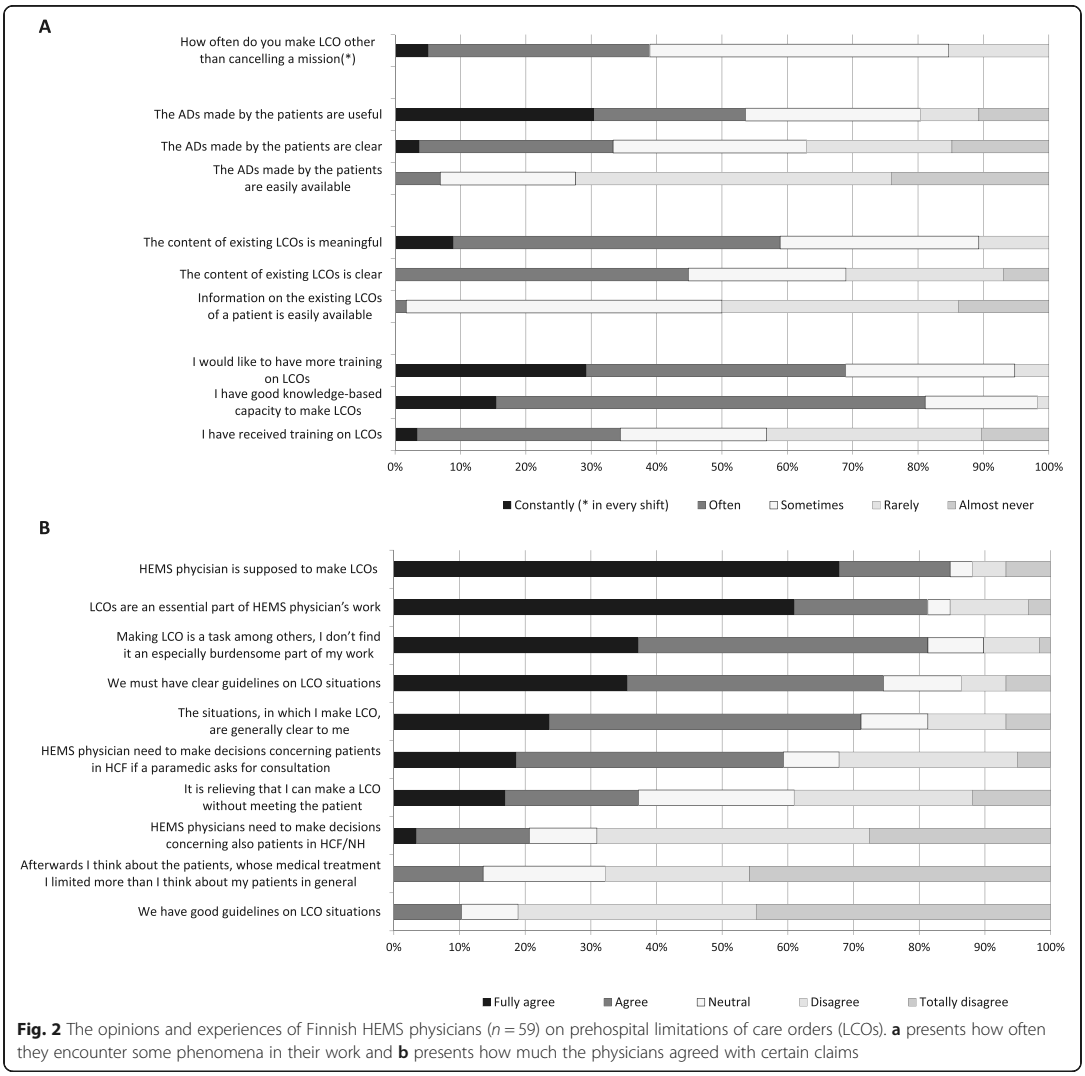

Fig. 2 The opinions and experiences of Finnish HEMS physicians ($n = 59$) on prehospital limitations of care orders (LCOs). **a** presents how often they encounter some phenomena in their work and **b** presents how much the physicians agreed with certain claims

physicians, which was also seen in another recent study [13]. The different working cultures between the bases may also regulate the individual's decisions, especially in ethically or cognitively challenging situations involving prehospital LCO decisions [7, 30].

Interestingly, the baseline functional status was the most frequent patient-related reason for the provision of a LCO in this study. Defining a patient's functional status and then adjusting the goals of care and estimating the prognosis of chronic illnesses may be challenging in a prehospital setting. Patients tend to evaluate their quality of life better than their physicians, and if the physician estimates the quality of life as poor, they are more inclined to withhold life-sustaining therapies [5]. Many physicians wished for more guidance on LCOs, which is understandable based on these results.

The challenges of prehospital LCOs

Every other HEMS physician had at occasion decided not to limit the patients' treatment in order to avoid a possible conflict. This phenomenon isn't unique [31], but the solution to withhold LCO might not reflect the patient's best interest. In addition to avoiding conflict, refraining from making an LCO might be due to preferentially avoiding prolonged scene times, but in this study the physicians very seldom described the lack of time

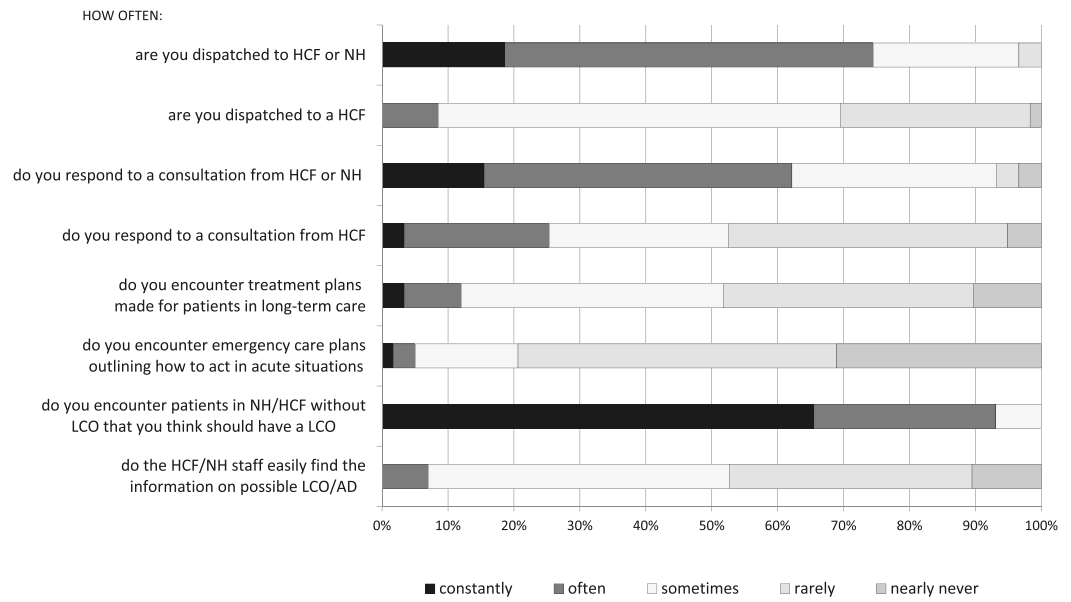

Fig. 3 The opinions and experiences of Finnish HEMS physicians ($n = 59$) on missions designated to treat a patient in a healthcare facility (HCF) and nursing home (NH) and phone consultations from those locations made by a paramedic or HCF/NH staff. LCO is a limitation of care order made by the physician and AD is an advance directive made by the patient

affecting their decision-making. Instead, the physicians reported that information regarding the medical history of the patient in the prehospital setting is minute and scattered, which usually leads to full treatment and transportation to a hospital rather than to hasty LCOs as the early withdrawal of life-sustaining therapies may lead to excessive mortality [32]. The physicians have access to the patient records while working on the helicopter bases, but their access to any patient records in the field is limited due to the absence of mobile patient records.

HEMS missions to HCFs and NHs

The challenging nature of LCOs in HCFs and NHs may be the reason why HEMS physicians are sometimes asked to make the end-of-life decisions, though it should be the responsibility of the patient's treating physician.

Table 2 The significant Spearman correlations between the Likert-scale questions or claims and the work experience or the age of HEMS physicians

	Correlation coefficient	*p*
The experience as physician in years in total		
Have a phone conversation with the next of kin in LCO situation	0.29	0.026
We have good guidance on LCO situations	−0.311	0.017
The situations, in which I make a LCO, are generally clear to me	−0.276	0.034
I have encountered emergency care plans made for patients in long-term care	0.269	0.041
I would like to have more education on LCOs	0.281	0.032
Age of physician in years		
Respond to a (phone)consultation from HCF or NH	0.349	0.010
The advance directives made by the patients are useful	−0.336	0.016

In the Likert-scale, "1" was fully agree/constantly, "3" is neutral/sometimes and "5" is totally disagree/almost never. If the correlation coefficient is positive, the more experienced physicians more often disagreed with the claim (more often chose the option number "5") than less experienced physicians. If the correlation coefficient is negative, the more experienced physicians more often agreed with the claim (chose the option number "1"). LCO is a limitation of care order, HCF is a health care facility and NH is a nursing home

Table 3 Features of prehospital limitation of care order decisions

Features of prehospital limitation of care order decisions	Physicians who mentioned	
	n	(%)
Patient characteristics		
Challenging situations to make a LCO by patients' characteristics	41	69
Children and adolescent	26	44
Severe comorbidities	16	27
-Malignancy	5	8
Disabled patients (incl. intellectual and developmental disabilities)	11	19
In nursing home or in health care facility	11	19
Aged	10	17
Decreased cognitive status	4	7
Existing DNAR without other LCO	2	3
Event characteristics		
Limited data in use in the situation	31	53
Importance of solving the baseline functional status	17	29
Acute situations (cardiac arrest, injury, drowning etc.)	17	29
Interaction/communication with the next-of-kin	15	25
Lacking treatment plans on patients in HCF/NH	5	8
The limited resources of EMS system and health care	4	7
Limited time in use in the situation	3	5

The first part shows patients for whom making a prehospital limitation of care orders (LCO) are the most challenging. Other features of prehospital LCO situations in general are presented in the lower part of the table. Repeating reduced expressions (=codes) were identified in the HEMS physicians' qualitative answers and quantified. The numbers are physicians who mentioned a certain code, regardless of how many times that physician mentioned the code. DNAR is a 'do not attempt cardiopulmonary resuscitation' order, EMS is Emergency Medical Services, HCF is health care facility and NH is nursing home

Discussion on end-of-life topics is difficult and LCOs may have a negative impact on the patient [5, 7, 33]. In addition, physicians at HCFs and NHs may overestimate the prognoses of their patients [34] and yet may not be as familiar with treating acutely ill patients as HEMS physicians are. In addition to either offering or limiting life-sustaining therapies while on the scene, HEMS physicians also provide their competence in clinical decision-making when evaluating and treating severely ill patients [7, 35].

The clinical relevance of HEMS physicians treating patients in HCFs and NHs is significant as 75% of physicians answered that they are often dispatched to treat patients in HCFs and NHs. This patient population is remarkable, and as the Finnish population ages, the number of people in HCFs and NHs will remain high. Among people over 75 years old, 50,373 (9%) lived in 24-h care in Finland as of 31st Dec 2016 [36]. The biggest client group in 24-h care consists of aged patients with modern to severe dementia who often have simultaneous comorbidities [24]. Their survival from critical illness is low, but they often don't have appropriate emergency care plans for acute situations, LCOs, or sufficient palliation [3, 5, 34]. Finnish people aged 70 years or older usually die in a HCF, typically in a municipal health center in-patient ward, and 70 to 80% of aged people are transferred to a HCF during the last 3 months of their life [21, 24]. Nevertheless, in NHs, EMS providers are often needed to provide palliation and to ease the distress of the HN staff or to execute those transfers at the end of life [15]. Therefore, the HEMS physicians' perception of deficient treatments plans, end-of-life care plans, and emergency care plans is understandable [26]. Unfortunately, the low prevalence of these plans seems to reflect the status of end-of-life care quality, equality, and availability [3, 24]. This may lead to excess suffering and healthcare costs, and increases the risk of concurrent EMS missions [10, 37].

Strengths and limitations

The major strength of this study was that almost all Finnish HEMS physicians participated in the study. As the exact definition of LCO and the content of different LCOs are unclear, giving any definitions for this study would have constituted an intervention, and we wanted to find all possible heterogeneity in the answers. This study was conducted among Finnish HEMS physicians. Although the professional background of the respondents was fairly similar to that of other European HEMS physicians, this sets the frames for the overall generalizability of these studies; results may not apply in countries with different clinical practices or arrangements of healthcare, EMS systems, and care of the aged [1, 2, 13]. Based on our results, more data on other countries are urgently warranted.

Conclusions

Making LCOs is an important but often invisible part of HEMS physicians' work in Finland. These physicians often treat patients in NHs and HCFs, and they stated that among those patients, emergency care plans and LCOs should have been made in advance more often than occur at the moment. The physicians want to avoid conflicts and are reluctant to limit treatments in indistinct circumstances. There is variation in LCO practices and attitudes based partly on the experience of the physicians, but the differences are mostly caused by the varying individual working procedures and deficient guidelines. Further research is needed to determine the true frequency and content of prehospital LCOs.

Additional files

Additional file 1: The study survey with English translations. (DOCX 50 kb)

Additional file 2: The differences in opinions and practices between the most experienced quartile of Finnish HEMS physicians (with 20 years or more of work experience as physician in total, $n = 12$) and other physicians ($n = 47$) analysed with Fisher's exact test. (DOCX 16 kb)

Abbreviations

AD: Advance directive; ALS: Advanced life support; CPR: Cardiopulmonary resuscitation; DNAR: Do-not-attempt-resuscitation; EMS: Emergency medical services; HCF: Health care facility; HEMS: Helicopter emergency medical services; IQR: Interquartile range; LCO: Limitation of care order; NH: Nursing home

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Authors' contributions

All authors designed the study, assessed the questionnaire, drafted and critically revised the manuscript. HK and SH collected the data. HH recorded the data from paper questionnaires to Microsoft Word and SPSS files and analysed the responses after which the anonymous data and results were sent to the HK for further analysis and interpretation of results. All authors revised the analyses. All authors have read and approved the final manuscript.

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Availability of data and materials

Please contact the author for data requests.

Ethics approval and consent to participate

This was an observational study among Finnish HEMS physicians, and no clinical interventions were performed. The Ethics Committee of the Tampere University Hospital approved the study protocol (Approval no: R15048). The study was accepted by all five Finnish university hospitals, the National Institute for Health and Welfare, and FinnHEMS Ltd. Due to the design of the study, the need for written informed consent was waived. Participation was voluntary, and returning a filled questionnaire was considered as consent to participate the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Out-of-hospital cardiac arrests in nursing homes and primary care facilities in Pirkanmaa, Finland.

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ORIGINAL ARTICLE

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Out-of-hospital cardiac arrests in nursing homes and primary care facilities in Pirkanmaa, Finland

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Background: Dispatching Emergency Medical Services to treat patients with deteriorating health in nursing homes and primary care facilities is common in Finland. We examined the cardiac arrest patients to describe this phenomenon. We had a special interest in patients for whom cardiopulmonary resuscitation was considered futile.

Methods: We conducted an observational study between 1 June 2013 and 31 May 2014 in the Pirkanmaa area. We included cases in which Emergency Medical Services participated in the treatment of cardiac arrest patients in nursing homes and primary care facilities.

Results: Emergency Medical Services attended to a total of 355 cardiac arrest patients, and 65 patients (18%) met the inclusion criteria. The included patients were generally older than 65 years, but otherwise heterogeneous. Nineteen patients (29%) had a valid do-not-attempt-resuscitation order, but paramedics were not informed about it in 10 (53%) of those cases. Eight (12%) of the 65 patients survived to hospital admission and 3 (5%) survived to hospital discharge with a neurologically favourable outcome. Two patients were alive 90 days after the cardiac arrest; both were younger than 70 years of age and had ventricular fibrillation as primary rhythm. There were no survivors in nursing homes.

Conclusions: The do-not-attempt-resuscitation orders were often unavailable during a cardiopulmonary resuscitation attempt. Although resuscitation attempts were futile for patients in nursing homes, some patients in primary care facilities demonstrated a favourable outcome after cardiac arrest. Emergency Medical Services seem to be able to recognise potential survivors and focus resources on their treatment.

KEYWORDS
aged, cardiac arrest, cardiopulmonary resuscitation, do-not-attempt-resuscitation, emergency medical services, end-of-life, ethics, nursing home, utstein

1 | INTRODUCTION

Sudden cardiac arrest (CA) generally results in poor outcomes, as the survival to hospital discharge has been reported as only 7%-8%.[1] Recently, some encouraging studies on out-of-hospital cardiac arrest (OHCA) have been published, that report increasing survival over time due to improvements in CA management.[2-5] Yet the survival rate among patients older than 80 years of age has not improved as much over time when compared to the rate among younger CA patients.[6] Better survival after CA is associated with cardiopulmonary resuscitation (CPR) factors, such as a shockable initial

Kangasniemi and Setälä are contributed equally.
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rhythm, witnessed arrest, bystander CPR, a shorter Emergency Medical Services (EMS) response and a public location of CA.[1,7,8] Survival from CA decreases among aged persons after the age of 65-70. Nevertheless, age is a poor independent prognostic factor of survival with good neurological outcome.[2,5,8-14] Many studies show the increasing burden of pre-arrest comorbidities to be associated with decreasing survival after CA,[8,15-19] while in many recent studies this association has not been found.[5,11,13,14] Studies concerning the impact of nursing home (NH) residence and functional status of the patients are even more scarce and controversial.[2,4,9,12,14,20-22]

Emergency Medical Services respond equally to all medical emergencies in Finland, including those of patients in health care facilities and aged NH residents with comorbidities. In cases of acute critical illness or emergency, patients in smaller health care facilities and NHs need to be transferred to a hospital. Occasionally, EMS is inappropriately dispatched to treat patients in health care facilities and NHs due to deficient treatment plans or lack of advance directives concerning end-of-life care.[23] The purpose of our study was to describe the CA patients treated by EMS in health care facilities and NHs, a subgroup that is usually excluded from either Utstein-style OHCA or in-hospital cardiac arrest (IHCA) reports. We focused specifically on patients with pre-existing do-not-attempt-resuscitation (DNAR) orders and on those patients with whom cardiopulmonary resuscitation was attempted but with efforts being promptly ceased due to evidence of medical futility.[24]

Editorial comment

Patients in nursing homes are by definition out-of-hospital according to the Utstein resuscitation registry template for cardiac arrest. Owing to the nature of their health status, many of the patients have do-not-attempt-resuscitation orders. This prospective cardiac arrest cohort documents extensive lack of advance care directives and ignorance of existing do-not-attempt-resuscitation orders in a Finnish region.

2 | MATERIALS AND METHODS

2.1 | Ethics

We conducted an observational study with prospective data collection and post hoc analysis. The Ethics Committee of Tampere University Hospital reviewed the study protocol (Approval no: R15048). The study was approved by Tampere University Hospital, the National Institute for Health and Welfare and the Finnish Population Register Centre. The need for patient consent was waived due to the observational nature of the study.

2.2 | Setting

In the Finnish health care system, there are 5 university hospitals, 14 central hospitals and in addition, every municipality has a public general practitioner-level primary health care facility (PCF). The PCFs have policlinics and wards that admit patients with low-risk acute conditions, such as infections requiring intravenous antibiotics, rehabilitation after surgery, patients with terminal conditions, and patients who are waiting for residency at NHs. PCFs often have an on-call physician only for phone consultations outside office hours. Finnish patients have the right to long-term care on the basis of chronic medical conditions or decreased functional status caused by comorbidities or advanced age (over 65 years of age). Long-term care denotes both social and medical aid as needed and mainly takes place at patients' homes, but nursing homes provide long-term care for the oldest, most morbidly ill, and functionally impaired patients. NHs usually do not have any on-call physician on duty.

All acute EMS units are alarmed via a centralised emergency dispatch centre. The dispatcher makes a risk assessment based on the symptoms of the patient and defines the appropriate response. All patients with similar symptoms and similar risk analyses receive the same EMS response, regardless of whether the patient is located in a health care facility or NH. In the case of a CA patient without a DNAR order, advanced life support units are dispatched simultaneously with an anaesthetist physician-staffed Helicopter Emergency Medical Services (HEMS) unit. The purpose of this arrangement is to begin the intensive care unit-level treatment as soon as possible. Although details on the EMS, anaesthetist physician-staffed HEMS, and acute hospitals in the Pirkanmaa area were described in our previous study,[24] we provide a summary here. The EMS serves approximately 525 000 inhabitants. Alongside the EMS unit, the HEMS is always dispatched to a suspected CA patient. One HEMS unit operates in the area 24 hours a day. Patients with return of spontaneous circulation (ROSC) are transported to Tampere University Hospital.

2.3 | Data and definitions

We collected all data concerning OHCAs and cardiopulmonary resuscitation attempts in the Pirkanmaa area from 1 June 2013 to 31 May 2014, according to the Utstein template.[25,26] This study analyses a subgroup of CPR attempts in various nursing homes and the emergency departments and wards of primary care facilities. Exclusion criteria were locations in a private residence, work place, recreational place, public place or EMS transport.

The Utstein data were prospectively collected by paramedics. We collected the additional data on patients' backgrounds and outcomes from EMS datasheets and primary care and university hospital patient records retrospectively. To evaluate the patients' prior health, we used the weighted Charlson Comorbidity Index (CCI),[27] which is a validated index used to predict short-term mortality. In addition, we collected data on the presence of an existing DNAR order or limitations of medical treatment from all available patient records compiled by paramedics during CPR attempts. Limitations of medical treatment were defined as limitations in providing intensive care,

intubation and/or ventilator treatment, invasive procedures such as dialysis or percutaneous coronary intervention, transportation to specialised medical care facilities or allowing natural death. One author (HK) completed the data retrospectively if additional information was found during a re-check of the medical records. The dates of deaths were collected from the Finnish Population Register Centre. To describe the survival of these patients, we reported survival to hospital admission, survival to hospital discharge and 90-day survival. We also reviewed the relevant patient records to determine the neurological status of the survivors before CA and at hospital discharge. The neurological status was characterised by Cerebral Performance Category (CPC) as either favourable (CPC 1-2, ie, independent) or unfavourable (CPC 3-5, ie, dependent, comatose, brain-dead).[25] Futile resuscitation attempts were defined as those performed on patients with dismal chances of survival, including those with prolonged downtime, end-stage terminal illness, multiple traumas and unwitnessed asystole as the primary rhythm.[24]

2.4 | Statistics

Data are presented as frequencies and percentages or as median and interquartile ranges (Q_1-Q_3). When comparing survivors and non-survivors, we used the Chi-Square test and Fisher's exact test for categorical variables and the Mann-Whitney *U* test for numerical variables. *P* values <.05 were considered statistically significant, and all tests were 2-sided. Statistical analyses were performed using SPSS applications (IBM SPSS Statistics for Macintosh, Version 24.0 Armonk, NY: IBM Corp).

3 | RESULTS

In total, n = 355 CA patients were identified, and n = 65 (18%) patients met the inclusion criteria (Figure 1). The patients included in our study were heterogeneous by their background characteristics, and mainly older than 65 with multiple comorbidities. We present the patient characteristics in Table 1. Twenty-one (32%) CAs occurred in NHs and n = 44 (68%) in PCFs. Fifteen of n = 23 (65%) NH residents had a DNAR order. Resuscitation was attempted on n = 38 (86%) of PCF patients and n = 14 (67%) of NH patients (*P* = .10, Pearson Chi-Square; Table 2).

3.1 | Considered futility

An EMS unit was dispatched to treat a CA victim with a DNAR order in n = 19 (29%) cases. The EMS received information about the existing DNAR order in 9 of these cases (47%), but in 10 cases (53%), the EMS did not receive this information and started CPR. Eight of the 10 patients were in long-term care.

In addition to the 9 patients with known DNARs, CPR attempts were discontinued due to considered futility in n = 20 cases. The reasons for futility designation were prolonged downtime (n = 9), DNAR-order revealed during the resuscitation attempt (n = 5) or an end-stage terminal disease (n = 6). The 6 (9%) patients with diagnosed terminal illness did not have any limitations of medical treatment. HEMS physicians recognised the futility in these cases within a median of 16 minutes from dispatch (Q_1-Q_3 10-23) and ordered the EMS unit to terminate the resuscitation attempt. All these patients were over 87 years old except 1 patient, who had an old brain injury. Two of these patients did not receive bystander CPR (Table 1).

3.2 | Return of spontaneous circulation (ROSC) and survival after CA

Ten patients (n = 10; 15%) achieved permanent ROSC. The treatment of 2 patients was limited after ROSC due to a dismal prognosis, and they were transferred to palliative care. Eight patients (12%) survived to the hospital and none of them was a NH patient. The survivors were younger, were more often resuscitated at a PCF emergency department, and had had a shorter admission period in the unit where CA occurred and a shorter EMS response time (Table 1). The HEMS unit was more often present on the resuscitation attempt (ie, not cancelled) in cases where the patient survived to hospital admission (75% for survivors vs 12% for non-survivors, *P* < .001), hospital discharge (100% vs 15%, *P* = .001) and 90 days after CA (100% vs 17%, *P* = .038).

Four patients admitted to the university hospital survived to hospital discharge (6% of all 65 patients). Three patients were discharged with the same neurological status as prior to CA, and 1 patient remained comatose. Only 2 patients (3%) were alive 90 days after CA, both with CPC 1-2. They were males under 70 years old, had ventricular fibrillation as the first monitored rhythm, and were in PCF due to an acute illness at the time of CA.

4 | DISCUSSION

In this Utstein-style study, we report the results of cases in which Emergency Medical Services were dispatched to nursing homes or primary care facilities to address patients with cardiac arrest. These heterogeneous cases are normally excluded from OHCA or IHCA reports but—in this material—represent 18% of EMS-treated cardiac arrests. In this study, the rate of survival after CA with a neurologically favourable outcome was 5%. In addition, we found deficiencies in the nursing homes' and primary care facilities' resuscitation protocols,[28] the most striking of which was the high proportion of patients with DNARs who received cardiopulmonary resuscitation. However, the EMS system and Helicopter Emergency Medical Services physicians seemed to recognise patients with an assumed favourable prognosis.

None of the NH residents survived in this study. Interestingly, the survival rate in our study was generally worse than survival rates reported in other recent studies investigating elderly CA patients or those living in NHs.[9,10,12-14,22] This could be explained by our wide inclusion criteria, as some previous studies have excluded patients

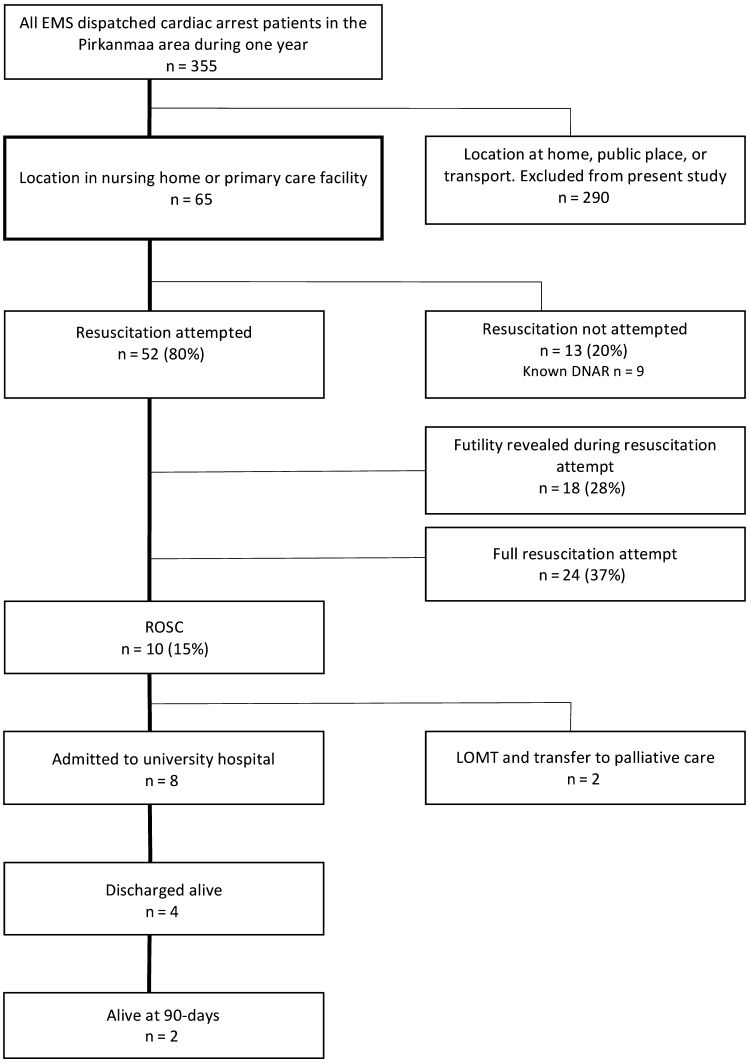

FIGURE 1 The inclusion and survival of patients in our study. EMS, Emergency Medical Services; ROSC, return of spontaneous circulation; DNAR, do-not-attempt-resuscitation order; LOMT, limitations of medical treatment

with DNAR decisions or cases with unattempted resuscitation from their survival analysis.[6,11-14,21,22] Also, the patients in this study were older compared to the patients studied in previous reports,[1] which reflects the characteristics of Finnish NH residents.[29] As EMS responded promptly to CAs in this study, the poor survival rate can be explained mainly by the demographics of the studied patient group, although the deficiencies in the resuscitation protocol may also have had an impact on survival rates.

The most important deficiency in resuscitation protocols found in our study was that information on DNAR orders was not readily available during the resuscitation attempt. It is alarming that EMS received the DNAR information in fewer than half of the cases. Interestingly, while many of the patients with a pre-existing DNAR order underwent an inappropriate resuscitation attempt, some of the patients without a DNAR order did not receive bystander CPR, even if the CA was witnessed by a NH/PCF nurse. The proportion of DNAR patients receiving CPR was higher compared to a recent French study (53% vs 24%).[30] We also included those cases where data on DNAR orders were accessed from medical records retrospectively, while the French study only reported the number of advance directives that EMS accessed during the CPR attempts.

Another deficiency in resuscitation protocols seen in this study was a delay in emergency dispatch calls and in the initiation of resuscitation. The longest emergency dispatch call delays (>10 minutes) occurred in PCFs with a physician working around the clock, and the primary call to the on-call physician most likely delayed the emergency call. The longer EMS response time for non-survivors may partly explain their more dismal survival rates in our study. In contrast, the EMS system and HEMS physicians seem to recognise

TABLE 1 EMS units encountered cardiac arrest patients in nursing homes and primary care facilities during 1 y in the Pirkanmaa area. The table shows detailed information on demographics of patients and resuscitation attempts

Patient demographics, detailed information on CA situation and CPR	All n = 65	Survived to hospital n = 8	Deceased on scene n = 57	*P*
Age, years				
Median (Q1-Q3)	82 (68-90)	70 (62-82)	84 (70-90)	.03**
Male median (Q1-Q3)	77 (67-87)	64 (52-76)	80 (70-88)	.03**
Female median (Q1-Q3)	88 (75-91)	83 (-)	88 (72-91)	.49**
Male gender n (%)	36 (55)	6 (75)	30 (53)	.28*
Physical performance[a] n (%)				.33
Outdoor independence	16 (29)	1 (13)	15 (32)	
In-house independence	26 (47)	6 (75)	20 (43)	
Dependent on assistance	13 (24)	1 (13)	12 (26)	
Impaired Cognition n (%) (missing n = 10)	28 (51)	4 (57)	24 (50)	1.00
CCI score, median, (Q1-Q3)	4 (3-6)	3 (2-4.8)	4 (3-6)	.25**
CCI ≥ 3 n (%)	46 (78)	5 (63)	41 (80)	.36*
Independent living n (%) (missing n = 3)	21 (34)	2 (25)	19 (35)	.71
In institutional LTC n (%)	23 (37)	0 (0)	23 (43)	.02
Days spent at current location prior CA[b]				.04
0-1	15 (28)	5 (63)	10 (22)	
2-7	16 (30)	3 (38)	13 (28)	
8-90	10 (19)	0 (0)	10 (22)	
over 90	13 (24)	0 (0)	13 (28)	
Arrest location n (%)				.002
Primary care emergency department	7 (11)	4 (50)	3 (5)	
Primary care hospital ward	37 (57)	4 (50)	33 (58)	
Nursing home	21 (32)	0 (0)	21 (37)	
Existing DNAR n (%)	19 (29)	0 (0)	19 (33)	.09
DNAR, resuscitation attempted	10 (53)	0 (0)	10 (53)	
Witnessed arrest n (%)	53 (82)	8 (100)	45 (79)	.33*
Arrest after arrival of EMS n (%)	12 (18)	3 (38)	9 (16)	.16
Bystander CPR[c], n (%)	43 (81)	5 (100)	38 (79)	.57*
No existing DNAR, no bystander CPR	2 (4)	0 (0)	2 (5)	
Presumed cardiac aetiology n (%)	53 (82)	5 (63)	48 (84)	.16*
First monitored rhythm n (%)				.16
VF/pulseless VT/AED-shockable	13 (20)	3 (38)	10 (18)	
PEA/AED non-shockable	22 (34)	3 (38)	19 (33)	
Asystole	26 (40)	1 (13)	25 (44)	
Other	4 (6)	1 (13)	3 (5)	
Time intervals, median, minutes (Q1-Q3)				
Collapse-to-call[d]	2 (0-8)	2 (0.5-15.5)	2 (0-8)	.46**
Call-to-EMS arrival	7 (5-10.5)	4 (1.75-7)	7 (5-11.5)	.006**
Collapse-to-ROSC[e]	15 (7-33.5)	17 (7-39.8)	13 (13-13)	.89**
Beginning-of -to-end-of EMS CPR	9 (1-19)	9 (3.3-22.8)	9 (0-19)	.82**
Any ROSC n (%)	23 (35)	8 (100)	15 (26)	<.001*
HEMS on scene n (%)	13 (20)	6 (75)	7 (12)	<.001*
Treatment withdrawn n (%)				<.001
On field	31 (48)	1 (13)	30 (53)	

(Continues)

TABLE 1 (Continued)

Patient demographics, detailed information on CA situation and CPR	All n = 65	Survived to hospital n = 8	Deceased on scene n = 57	P
In hospital emergency department	3 (5)	3 (38)	0 (0)	
No limitation of medical treatment	31 (48)	4 (50)	27 (47)	

CA, Cardiac arrest; CPR, cardiopulmonary resuscitation; CCI score, Charlson Comorbidity Index score (missing n = 6); LTC, Long-term care (missing n = 3); DNAR, Do-not-attempt-resuscitation order, HEMS, Helicopter Emergency Medical Service; ROSC, Return of spontaneous circulation.
Q1-Q3 is the 25th-75th percentile.
Impaired cognition: Patient with diagnosed dementia of any cause, Mini-Mental State Examination score <24, moderate or severe intellectual disability or severe skitsofrenia with residence in NH.
[a]Last week before CA, observed from patient records, missing n = 10.
[b]Missing n = 11.
[c]Among not EMS witnessed CA cases.
[d]Witnessed cases, without EMS witnessed cases, n = 32.
[e]n = 10.
P values marked with * are calculated with Pearson Chi-square test and with ** are calculated with the Mann-Whitney *U* test, and the others are calculated with the Fisher exact test.

TABLE 2 The survival rates of cardiac arrest patients with attempted cardiopulmonary resuscitation grouped by the location of the patient in primary health care facility (PCF) or in nursing home (NH). All patients were resuscitated by an EMS unit in the Pirkanmaa area during 1 y. LOMT is limitations of medical treatment.

Survival rates of patients with cardiopulmonary resuscitation attempted	All patients n = 52		PCF n = 38		NH n = 14	
	n	%	n	%	n	%
Any return of spontaneous circulation	22	42	21	55	1	7
Survival to hospital	8	15	8	22	0	0
LOMT in hospital Emergency Department	3	6	3	8	0	0
Survival to hospital discharge	4	8	4	11	0	0
90-d survival	2	4	2	5	0	0

those patients with a favourable prognosis, as the HEMS unit was present in those CPR attempts that led to the patients' survival. Primarily, the HEMS unit is dispatched to all cardiac arrest cases, but if the physician recognises the case as futile, the physician submits a cancellation for the HEMS unit. In this study, the EMS response in the resuscitation protocol was good in general.

In addition, we found that advance directives concerning end-of-life care[31,32] were often not documented. This was most obvious for patients with terminal illness. It is evident that the end-of-life care of these patients should have been planned earlier. Finnish health care regulation states that treatment plans must be easily available and must contain patient's wishes and his/her physician's statement on intensity of treatments in case of acute illness or acceding death.[23] If the end-of-life care planning fails, this leads not only to futile resuscitation attempts, but also to the absence of good palliative care when death is inevitable.

This is the first study on CA patients in NHs and PCFs treated by EMS in Finland. The study sample was small, but due to prospective recording, this study contains detailed data on all patients and the situations that occurred during the study period. Because of the small cohort, the statistical power to demonstrate differences was restricted and the results cannot be generalised without further research. Yet, the total number of beds in all locations meeting the inclusion criteria remains unknown, and we were unable to estimate the incidence of CA in this population. Our study is also limited in explaining whether the low survival rate was due to the patients' overall poor prognosis or to deficiencies in treatment. The HEMS unit was cancelled in most of the cases, which may cause selection bias, as the same reasons that lead to the poor survival of the patients often lead to the HEMS cancellation.

We conclude that CA patients in nursing homes and primary care facilities are a heterogeneous patient group. In this study, there were no CA survivors in nursing homes. Most patients with a futile prognosis could be recognised in advance. However, there were patients in primary care facilities with a good prognosis who were also well recognised by EMS. Although the prevalence of DNAR orders was reasonable, more attention should be paid to operational procedures in cases of acute deterioration of old patients with comorbidities.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest regarding this study.

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PUBLICATION III

Limiting treatment in pre-hospital care: a prospective, observational multicentre study.

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ORIGINAL ARTICLE

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Limiting treatment in pre-hospital care: A prospective, observational multicentre study

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Background: Data are scarce on the withdrawal of life-sustaining therapies and limitation of care orders (LCOs) during physician-staffed Helicopter Emergency Medical Service (HEMS) missions. We investigated LCOs and the quality of information available when physicians made treatment decisions in pre-hospital care.

Methods: A prospective, nationwide, multicentre study including all Finnish physician-staffed HEMS bases during a 6-month study period. All HEMS missions where a patient had pre-existing LCOs and/or a new LCO were included.

Results: There were 335 missions with LCOs, which represented 5.7% of all HEMS missions (n = 5895). There were 181 missions with pre-existing LCOs, and a total of 170 new LCOs were issued. Usually, the pre-existing LCO was a do not attempt cardiopulmonary resuscitation order only (n = 133, 74%). The most frequent new LCO was 'termination of cardiopulmonary resuscitation' only (n = 61, 36%), while 'no intensive care' combined with some other LCO was almost as common (n = 54, 32%). When issuing a new LCO for patients who did not have any preceding LCOs (n = 153), in every other (49%) case the physicians thought that the patient should have already had an LCO. When the physician made treatment decisions, patients' background information from on-scene paramedics was available in 260 (78%) of the LCO missions, while patients' medical records were available in 67 (20%) of the missions.

Conclusion: Making LCOs or treating patients with pre-existing LCOs is an integral part of HEMS physicians' work, with every twentieth mission involving LCO patients. The new LCOs mostly concerned withholding or withdrawal of cardiopulmonary resuscitation and intensive care.

1 | BACKGROUND

In Finland, helicopter emergency medical service (HEMS) physicians are dispatched to treat all patients with life-threatening conditions, including patients in health care facilities (HCF) and nursing homes (NHs), on the basis of patient risk assessments made by centralized emergency dispatchers.[1] Occasionally, medical treatment is considered futile and ceased on-scene due to lethal trauma or sudden cardiac arrest with a perceived negligible chance of survival.[2] Sometimes, the acute deterioration of the patient results from the end stage of a terminal illness rather than an unexpected event.[3] In these situations, the HEMS physician may decide to limit life-sustaining therapies (LST) and proceed with palliative care procedures, respecting the ethical principles of medicine: patient autonomy, beneficence, non-maleficence, justice, dignity and honesty.[4]

Data on limitation of care decisions in a pre-hospital setting are scarce.[5-8] Studies on limitation of care orders (LCOs) other than termination of cardiopulmonary resuscitation (TOR) are rare and face a range of ethical and practical challenges.[5,9,10] We therefore aimed to determine how often LCOs occurred during HEMS missions and the frequency, content and reasons for new LCOs made by HEMS physicians. We conducted a prospective observational trial and further studied the prevalence and contents of pre-existing LCOs and the overall situation on the scene when HEMS physicians made decisions regarding treatment and LCOs during missions.

2 | METHODS

2.1 | Study design

This was a prospective, observational multicentre study involving all five physician-staffed HEMS bases in Finland. The data were collected from all HEMS missions during a six-month study period between 6 Sept 2017 and 6 Mar 2018. We included missions in which HEMS physicians identified the patient as having a pre-existing LCO, made a new LCO at the scene or identified the patient as already having a pre-existing LCO and also made a new LCO at the scene. We also included missions in which the HEMS unit's participation was cancelled after it was dispatched. We excluded phone consultations. The study followed the STROBE statement checklist.[11]

2.2 | Ethics

This was an observational study, and no clinical interventions were performed. The Ethics Committee of the Tampere University Hospital approved the study protocol on 17 March 2015 (Approval no: R15048). The study was approved by all five Finnish university hospitals (TAUH R15048 on 9 Apr 2015, KUH Medical Superintendent's Decision 9/2016 on 17 Jan 2016, TUH T14/2016 on 18 Jan 2016, OYS on 15 Dec 2016 and HUS HUS231/2016 on 14 Nov 2016), the National Institute for Health and Welfare (THL/861/5.05.00/2015 on 11 Nov 2015) and FinnHEMS Ltd (20 Nov 2015). Due to the design of the study, the need for informed consent was waived, as this study was not a medical trial according to Finnish legislation and the patients were not contacted by researchers. The HEMS physicians collected the data after being informed verbally and by an information letter about the study, and their participation was voluntary. Completion of the normal mission reports and medical records was obligatory according to the standard operating procedure.

Editorial Comment

One in every twenty Helicopter Emergency Medical Service (HEMS) mission results in a treatment limitation according to this prospective study from Finland. The most common treatment limitation was do not resuscitate in case of cardiac arrest and do not initiate intensive care type interventions. These decisions were more common in HEMS mission involving nursing homes and health care facilities.

2.3 | Setting

The structure of the Finnish emergency medical service (EMS) system has been explained previously.[6] In addition to EMS units, HEMS units are dispatched by the national emergency dispatch centre to treat patients with severe trauma or critical medical emergencies. There are five physician-staffed HEMS bases located in cities with university hospitals in addition to one HEMS unit operating in Lapland with an advanced nurse paramedic. HEMS units aim to reach the majority of the Finnish population (5.51 million inhabitants) within approximately 30 minutes. The physician-staffed HEMS units are staffed with a HEMS crewmember, a pilot and a HEMS physician, and the physicians are mainly experienced anaesthesiologists. Medical records are not readily available electronically for physicians during missions.

HCFs and NHs have been described in detail previously.[1,12] In this study, HCFs refer mainly to municipal primary health care centres. NHs consist of various public or private homes and institutions staffed with health care professionals that provide care and assistance for old, morbid and disabled people, most of whom have dementia. Unlike in many other countries, long-term care patients in Finland reside in NHs permanently.[13,14]

2.4 | Definitions

In pre-hospital settings in Finland, nurse paramedics can independently terminate a cardiopulmonary resuscitation (CPR) attempt in case of an unwitnessed cardiac arrest with asystole, secondary signs of death, obviously lethal trauma or if a 'do not attempt cardiopulmonary resuscitation' (DNAR) order is identified.[15] Other pre-hospital LCOs, such as the decision to terminate a CPR attempt, are made by physicians on-scene or over the phone. HEMS physicians are allowed to make all the same LCOs as in-hospital physicians if indicated, and TOR protocols adhere to the European Resuscitation Council Guidelines.[15] In this study, a 'DNAR' decision also included situations where return of spontaneous circulation had been achieved after a cardiac arrest, but the HEMS physician withheld further CPR attempts in case a re-arrest would occur. 'Termination of a CPR attempt' meant discontinuing on-going CPR following the HEMS physician's order. 'No intensive care' was loosely defined to cover all treatments that HEMS physicians perceive as intensive care treatments, such as invasive monitoring, endotracheal intubation, mechanical ventilation or drugs that are comparable to those administered in ICUs. 'No intubation' was defined as no endotracheal intubation. 'No tertiary hospital transfer' meant that the patient could be moved from a private home or NH to a municipal primary HCF, but 'No transfer' meant that the patient would be treated in the current location: a private home or an NH. 'Other LCOs' concerned providing conservative treatment instead of invasive procedures (eg drug therapy instead of coronary artery bypass or meningioma resection) or the use of intravenous drugs, fluids or nasogastric feeding. For the sake of clarity, we use the abbreviation 'NH' to refer to both HCFs and NHs, while 'other locations' refer to private homes, public places and transport.

2.5 | Data

The FinnHEMS database is an electronic database including data on HEMS missions, phone consultations and medical records of HEMS missions. A study sheet designed specifically for the purposes of this study was generated in the database when a HEMS physician identified an LCO during a HEMS mission. The primary object of the study was to examine the content and reasoning of new LCOs and what kind of information the physicians had available when making decisions about treatment.

2.6 | Statistics

Statistical analyses were performed using IBM SPSS version 25, Statistics for Macintosh (Armonk, NY; IBM Corp). The data were described with frequencies, percentages and graphs. Differences between the patients located in NHs and those in other locations were analysed with Chi-Square or Fisher's Exact tests when appropriate. A *P*-value <.05 was considered statistically significant, and all tests were two-sided.

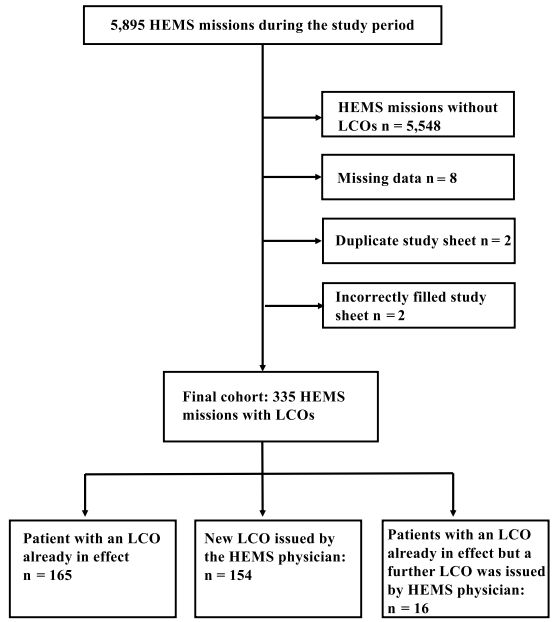

FIGURE 1 The data collection, inclusion and exclusion criteria of our study. LCO is a 'limitation of care order'

3 | RESULTS

There were 5895 HEMS missions during the study, of which 11% (n = 644) directly involved NHs. A total of 335 missions were associated with an LCO, representing 5.7% of all missions (Figure 1). The LCO patients were older than the HEMS patients on average (mean age 78 vs 53 years). In NHs, 25% (n = 158/644) of the missions were associated with LCOs compared to 3.4% (n = 177/5251) in other locations, ($P < .001$). HEMS units encountered the patient on 140 (22%) missions to NHs and on 1734 (33%) missions to other locations; in the rest of the cases, the missions were cancelled.

3.1 | Pre-existing LCOs

There were 181 missions with pre-existing LCOs (54% of all missions with LCOs; 3.1% of all HEMS missions). The pre-existing limitations are shown in Table 1A. Thirty-four patients with pre-existing LCOs (19%) had multiple LCOs. The majority (n = 117/181, 65%) of the patients with pre-existing LCOs were in NHs. Typically, the pre-existing limitation was DNAR only (n = 133/181, 74%). We observed six spontaneous comments from physicians indicating that the pre-existing LCO was revealed only during or after a CPR attempt and two comments saying that, regardless of reasonable LCOs, the HEMS physician was dispatched to give end-of-life care in an NH. One HEMS physician was also dispatched to treat a terminal care patient in a private home.

TABLE 1 The frequency and content of limitation of care orders in HEMS missions

The frequencies and contents of limitation of care orders (LCOs)	All N = 335		NH/HCF N = 158		Other locations N = 177	
	N	%	N	%	N	%
(A) Pre-existing LCOs (N = 181)	181	54	117	74	64	36
The frequency of different pre-existing LCOs[a]						
DNAR	167	92	110	94	57	89
No intensive care	37	20	20	17	17	26
No tertiary hospital admission	2	1.1	1	0.9	1	1.6
No transfers	1	0.6	1	0.9	—	—
Other[b]	11	6.1	4	3.4	7	11
The number of patients with pre-existing LCOs						
DNAR	133	73	92	79	41	64
DNAR + no intensive care	31	17	18	15	13	20
Other single limitation of medical care	10	5.5	4	3.4	6	9
No intensive care	3	1.7	2	1.7	1	1.6
DNAR + no intensive care + some other LCO	3	1.7	—	—	3	4.7
No tertiary hospital transfer	1	0.6	1	0.9	—	—
(B) New LCOs (N = 170)	170	51	50	32	120	68
The frequency of different new LCOs[c]						
DNAR	69	41	17	34	52	43
Termination of a resuscitation attempt	66	39	16	32	50	42
No intensive care	63	37	27	54	36	30
No intubation	46	27	18	36	28	23
No tertiary hospital admission	2	1.2	2	4.0	—	—
No transfer	4	2.4	4	8.0	—	—
Other	12	7.1	1	2.0	11	9.2
The number of patients with new LCOs						
End of a resuscitation attempt	61	36	14	28	47	39
No intensive care + some other LCO	54	32	22	44	32	27
DNAR	24	14	3	6	21	18
Other new LCO or other combination of LCOs	22	13	6	12	16	13
No intensive care	9	5.3	5	10	4	3

Note: DNAR is do not attempt cardiopulmonary resuscitation.

[a]Thirty-four patients had multiple pre-existing LCOs.

[b]The category "other" included three patients with a living will, two patients with diagnosed terminal care and one patient with diagnosed palliative care.

[c]Sixty-four patients had multiple new LCOs.

3.2 | New LCOs

We observed 170 missions with new LCOs (51% of all missions with LCOs; 2.9% of all HEMS missions), of which 16 were made on patients who already had a pre-existing LCO. The frequency and content of new LCOs are shown in Table 1B. Almost every third (n = 50/170, 29%) new LCO was made on a patient in an NH. In half (n = 75/153, 49%; data on one patient missing) of the cases with a new LCO, the physician thought that the patient should have already had some limitation of treatment, while the other half of cases concerned trauma or an unexpected onset of critical illness (n = 34/40, 85% in NHs vs n = 41/113, 36% in other locations, $P < .001$).

3.3 | Reasons for new LCOs

The reasons for new LCOs are shown in Table 2. The most common reason was the futility of the overall situation (n = 49/170, 29%). For 65% of patients, the physician selected multiple reasons for the LCO decision. If the new LCO was made for a patient in an NH, the physician usually (n = 31/50, 62%) selected three to five reasons for the limitation.

3.4 | Information available when making decisions regarding treatment and new LCOs

For 85% of the patients with pre-existing LCOs, the physicians reported having information on the pre-existing LCO on-scene when making treatment decisions. When making new LCOs, background information from nurse paramedics on-scene was available in 89% of the cases. The HEMS physicians made a full clinical examination in one third (34%) of the cases and the medical records were only available in 22% of cases (Table 3). Among the NH patients, the physicians did not report on any pre-existing emergency treatment plans, and the NH staff was sometimes unfamiliar with the resident's history. HEMS physicians mostly made decisions regarding new LCOs without receiving a second opinion (n = 147/170, 87%). In 18 cases (11%), the HEMS physician consulted another physician, usually a specialist in a central or university hospital who also had access to medical records. Discussions with NH physicians (n = 4, 2%) or another HEMS physician (n = 2, 1%) were rare.

TABLE 2 The reasons that HEMS physicians made new limitation of care orders (LCOs) in HEMS missions

Reasons for new LCOs (n = 170)	n	%
Reasons for new LCOs		
Futility of the overall situation	125	74
Multiple/severe comorbidities	84	49
Old age	73	43
Poor baseline functional status	72	42
Pre-existing LCOs or advance directive	11	6.5
Other	10	5.9
Patients with different reasons for new LCOs		
One reason for a new LCO	60	35
Futility of the overall situation	49	29
Old age	6	3.5
Comorbidities	2	1.2
Poor baseline functional status	2	1.2
Pre-existing LCOs or advance directive	0	0
Other	1	0.6
Two reasons for a new LCO	44	26
Comorbidities + functional status	14	8.2
Overall situation + old age	14	8.2
Other combination	16	9.4
Three reasons for a new LCO	38	22
Comorbidities + functional status + old age	10	5.9
Comorbidities + functional status + overall situation	10	5.9
Comorbidities + old age + overall situation	9	5.3
Other combination	9	5.3
Four reasons for a new LCO	27	16
Comorbidities + functional status + age +overall situation	18	11
Other combination	9	5.3
Five reasons for a new LCO	1	0.6
Comorbidities + functional status + age +overall situation + pre-existing LCOs	1	0.6

4 | DISCUSSION

This is the first prospective nationwide study of pre-hospital limitations on medical treatment. We explored the prevalence and contents of pre-existing LCOs, the available information and the overall situation when the HEMS physicians made LCOs. We found that 5.7% of HEMS missions were associated with LCOs. In most cases (74%), the observed pre-existing LCO was DNAR only, and withdrawing or withholding a CPR attempt comprised half of the new LCOs on-scene. Other pre-existing and new LCOs were rare on all HEMS missions. Missions with pre-existing or new LCOs were considerably more frequent in NH and HCF settings than elsewhere. Furthermore, new LCOs were often made for patients who the HEMS physicians thought should have already had an LCO. These findings strengthen the concern that the EMS system handles problems that arise from deficient end-of-life care planning and capability in society.[13,16]

The prevalence of identified pre-existing LCOs in NHs on HEMS missions was 18%, but HEMS physicians did not encounter any pre-existing emergency care plans during NHs missions. The prevalence of advance directives and LCOs seems surprisingly low, although it was higher than in an earlier study in 2002 (13%).[17] In another Finnish study, the prevalence of DNAR orders among NH residents was 67% and the prevalence of treatment plans in electric medical records was 71% in 2011.[18] The reason for these differences could be geographic variability, or, if the NH residents have sufficient end-of-life care plans, the HEMS physicians may not need to be dispatched at all; moreover, information on pre-existing LCOs is rarely available in EMS situations.[1,19] Thus, numerous cases may have been left outside of this study cohort, as HEMS units may have treated NH patients without knowing about the pre-existing LCOs. We were therefore unable to identify the true prevalence of pre-existing LCOs among HEMS missions. In recent studies of out-of-hospital cardiac arrest patients, the prevalence of advance directives was found to

TABLE 3 The information available when HEMS physicians made decisions on treatment and new limitation of care orders

Type of information available	All n = 335	%	New LCO n = 170	%
Information from EMS situation	260	78	154	91
Full clinical examination by HEMS physician	83	25	57	34
Anamnesis from a nurse paramedic	256	76	152	89
Measured vital parameters	159	47	90	53
ECG	46	14	28	16
Information from a person on scene[a]	156	47	90	53
Information on any pre-existing LCOs	154	46	13	7.6
Medication list without medical records	68	20	39	23
Medical records	67	20	38	22
Information only from emergency dispatch centre[b]	41	12	7	4.1

Abbreviations: HEMS, helicopter emergency medical service; LCO, limitation of care order.

[a]Not EMS personnel; for example, a proxy, NH staff, some other physician, police or neighbor.

[b]Information from the dispatch centre is received via text message or spoken information retrieved from the emergency dispatch centre on the radio while traveling to the scene. This may contain information on pre-existing LCOs or NH residence. In cases shown in the inferior row of the table, the text message was the only available information.

be 7.5% in France,[19] and the prevalence of DNAR orders was 6.2% in UK.[20] In Germany, 89% of pre-hospital physicians have encountered patients with advance directives in emergency settings.[21]

As the numbers of old and very old citizens increases, so does the number of people with multiple comorbidities and those who need assistance in daily activities.[22] Generally, all of these individuals have the need for advance care planning.[23] The national guidelines require that residents in 24-hour NH care have treatment plans easily available, which must include a medical emergency care plan for acute situations and end-of-life care—DNAR alone is not a sufficient treatment plan.[16,23-25] Communication between the patient and/or proxies and attending physician about treatment goals may ease the conversations on LCOs, the harms and benefits of different treatments and increase both the patient's and proxies' understanding about the inevitably approaching end of life.[4,26] The situation is always suboptimal if the HEMS physician on-scene has to make LCOs for patients who—and whose proxies—have not previously understood the severity of the overall situation.[27]

Other new LCOs besides TOR or DNAR were rare (1% of all HEMS missions). Almost all new LCOs concerned only LST, whereas primary care was never limited. In a French study, 76% of pre-hospital physicians reported that they had made at least one pre-hospital LCO concerning LST, and the reasons for the LCOs were similar to our results.[5] Interestingly, in our study poor functional status was a reason for 42% of new LCOs. This is the most ethically controversial topic related to LCOs, but poor functional status seems to decrease patients' survival from critical illness.[28,29] In the Finnish system, in practice, poor functional status means dependence in basic activities of daily living as a result of chronic conditions. In other areas as well, living in an NH has been found to negatively affect survival from an acute critical illness,[30,31] although CPR in NHs is not always futile.[30] Nonetheless, NH residence has been considered a reason for ICU admission refusal,[32] and it has been suggested to be a good starting point for end-of-life care planning.[24,28]

The rate of new LCOs made by HEMS physicians seems reasonable and suggests that making LCOs is an integral part of pre-hospital physicians' clinical work in Finland. Because in some cultures the practice of withholding LST in pre-hospital settings may seem brutal,[33] we would like to highlight that the new LCOs were made in clearly futile situations. In other situations and with a lack of sufficient information, HEMS physicians usually proceed with full LST.[34] If HEMS is dispatched to a futile situation with insufficient pre-planned end-of-life care, experienced pre-hospital physicians can provide palliative care in addition to the LCOs. This practice would likely be more humane than burdensome transitions to emergency departments.[12,35] However, the use of HEMS to solve organization-level problems in end-of-life care arrangements probably does not represent the optimal use of health care resources.[36]

The availability of medical records in only one-fifth of the cases of new LCOs is alarming. In addition, there were cases in which the physician making treatment decisions was not informed about pre-existing LCOs, and the dispatch algorithm does not include compulsory questions about such orders. According to Finnish legislation, the patient should always be treated with respect to his or her wishes or assumed best interest. The law allows any single licensed physician to make any LCO without discussion (if impossible to discuss etc) with the patient or proxy, but all LCOs must be clearly documented and reasoned. In addition, it is not considered acceptable to offer treatments that are expected to be ineffective, maleficent or extremely expensive with minor expected health benefits. Hence, guidelines recommend making LCOs only through shared decision-making by a physician representing an appropriate specialty after discussion with the patient and/or the patient's family to come to a mutual understanding—and documenting this discussion.[25] However, in a HEMS setting, adhering to these guidelines is often cumbersome if not impossible. Mobile access to electronic medical records would clearly improve this situation. In Finland, the National Archive of Health Information already contains reliable up-to-date records from both the private and public sectors, so creating such access should be pursued.[37] However, more emphasis should be placed on making advance care plans earlier—and by physicians

familiar with the patient's situation rather than HEMS physicians—in order to ensure patients' access to appropriate and qualified palliative care.[16]

When interpreting these results, one must remember that we only included missions where HEMS units were dispatched to the scene. The national emergency dispatch centre dispatches the HEMS unit only if there is suspicion of severe trauma, acute cardiac arrest, unconsciousness or severe vital dysfunction. When the HEMS unit is dispatched, the physician can call to the EMS unit on-scene to clarify the situation and cancel the HEMS unit's participation in that mission if needed. NHs and private homes have many kinds of patients with varying comorbidities and functional status, and they all have equal rights for similar health care. LCOs can be made after individual assessment of the patient's ability to recover from severe trauma or critical illness, but HEMS dispatch cannot be excluded only by the location of the patient in an NH or HCF.[1,30] When looking at the cancellation rates, it is noticeable that HEMS physicians can often make decisions before arriving on-scene. Yet, the dispatch criteria should give the HEMS physician an opportunity to make a confirmation call before accepting the mission.

4.1 | Strengths and limitations of the study

The major strengths of this study are its nationwide prospective multicentre design and collection of data using the same electronic database used for HEMS missions. However, the results represent only the situations in which the HEMS physicians perceived that they made a new LCO or identified a pre-existing LCO. The difference between the decision to forego treatment after all reasonable efforts have been made to save the patient and the decision to limit medical treatment because of futility is minute; there might be variation between the physicians' perceptions of what is considered as treatment withdrawal. In addition, there may be some cancelled missions not included in the data, as cancellation of a HEMS unit is not an LCO, although it means withholding their clinical competence and intensive care-level treatments on-scene. This study is also unable to identify patients for whom the HEMS physician did not dare to make a new LCO even if they considered it. Potential reasons for not making a new LCO include insufficient available background information or the fact that making and documenting LCOs can be time consuming. The opportunity to 'load and go' may be faster, and leaving the possible LCO decision-making to hospital emergency departments can be juridically safer and generally acceptable, although some transfers at the end of life may be burdensome.[13,33] The low prevalence of pre-existing LCOs suggests that LCOs could be more common than they appear in our results. There were at least eight cases in which data were missing due to HEMS physicians' decision not to volunteer to collect data. In these cases, the HEMS physicians had stated that the mission was associated with an LCO in the compulsory database, but they did not complete the study sheet.

5 | CONCLUSIONS

Making limitations of medical treatment is an integral part of HEMS physicians' clinical work in Finland. LCOs are common when the HEMS unit is dispatched to nursing homes and health care facilities. Usually, new pre-hospital LCOs involve withholding or withdrawing CPR and intensive care. When issuing a new LCO, the physicians that were studied often thought that the patient should have already had an LCO. The findings of this study suggest that there is still room for improvement in advance care planning in Finland and that HEMS physicians handle these end-of-life care challenges in their daily work.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest regarding this study.

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PUBLICATION IV

Advising and limiting medical treatment during phone consultation: a prospective multicentre study in HEMS settings.

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ORIGINAL RESEARCH Open Access

Advising and limiting medical treatment during phone consultation: a prospective multicentre study in HEMS settings

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Abstract

Background: We investigated paramedic-initiated consultation calls and advice given via telephone by Helicopter Emergency Medical Service (HEMS) physicians focusing on limitations of medical treatment (LOMT).

Methods: A prospective multicentre study was conducted on four physician-staffed HEMS bases in Finland during a 6-month period.

Results: Of all 6115 (mean 8.4/base/day) paramedic-initiated consultation calls, 478 (7.8%) consultation calls involving LOMTs were included: 268 (4.4%) cases with a pre-existing LOMT, 165 (2.7%) cases where the HEMS physician issued a new LOMT and 45 (0.7%) cases where the patient already had an LOMT and the physician further issued another LOMT. The most common new limitation was a do-not-attempt cardiopulmonary resuscitation (DNACPR) order (n = 122/210, 58%) and/or 'not eligible for intensive care' (n = 96/210, 46%). In 49 (23%) calls involving a new LOMT, termination of an initiated resuscitation attempt was the only newly issued LOMT. The most frequent reasons for issuing an LOMT during consultations were futility of the overall situation (71%), poor baseline functional status (56%), multiple/severe comorbidities (56%) and old age (49%). In the majority of cases (65%) in which the HEMS physician issued a new LOMT for a patient without any pre-existing LOMT, the physician felt that the patient should have already had an LOMT. The patient was in a health care facility or a nursing home in half (49%) of the calls that involved issuing a new LOMT. Access to medical records was reported in 29% of the calls in which a new LOMT was issued by an HEMS physician.

Conclusion: Consultation calls with HEMS physicians involving patients with LOMT decisions were common. HEMS physicians considered end-of-life questions on the phone and issued a new LOMT in 3.4% of consultations calls. These decisions mainly concerned termination of resuscitation, DNACPR, intubation and initiation of intensive care.

Keywords: Emergency medical services, Treatment limitations, Ethics, Nursing home, DNACPR, Decision-making, Limitation of medical treatment, Prehospital physicians, Anaesthesiology, HEMS

Introduction

Emergency medical service (EMS) personnel treat patients in varying circumstances with the primary aim to save lives. EMS personnel need to identify and treat seriously ill or injured patients and convey them rapidly to the hospital. Life-sustaining therapies (LST) often need to be initiated promptly in a prehospital setting to

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ensure a chance for meaningful recovery [1]. It is equally important to identify patients who would not benefit from aggressive treatments because of their overall health state or the characteristics of the acute situation [2]. In such cases, aggressive treatment may cause more suffering for these patients, and hence a palliative approach would be preferable.

The number of EMS missions has increased in Europe and in Australia in recent decades [3, 4] and EMS personnel encounter more aged citizens, multimorbid patients [5] and patients in nursing homes (NHs) [6]. A notable proportion (8–15%) of out-of-hospital cardiac arrests (OHCAs) requiring cardiopulmonary resuscitation (CPR) occur in NHs, and the trend is increasing [7–10]. In Finland, Helicopter Emergency Medical Services (HEMS) physicians provide assistance and treatment recommendations to paramedics both on-scene and through phone consultations in various prehospital situations. One of those situations is determining the limitation of medical treatment (LOMT). Following European Resuscitation Council Guidelines, EMS personnel can withhold LST in situations where there are secondary signs of death, obviously lethal trauma or a valid do-not-attempt-cardiopulmonary-resuscitation (DNACPR) order; other LOMTs in prehospital setting are issued by HEMS physicians [1]. Treatment practices vary geographically, and decisions on treatment and LOMT may be ethically challenging[11].

For example, across Scandinavia EMS personnel have the ability to consult with EMS physicians when they need advice [12–15], and according to a recent study HEMS physicians were consulted in 24% of all EMS missions in Finland [15]. Yet, little is known about the content of those consultation calls. The aim of this study was to investigate LOMTs during EMS paramedic-initiated consultation calls to HEMS physicians. We specifically examined the frequency and content of the LOMTs, the reasons why new LOMTs were issued, the amount and quality of the information available when making decisions on treatment and the mortality of patients with LOMTs.

Methods

Design and setting

This prospective, observational multicentre study on consultation calls was performed on four physician-staffed HEMS bases in Finland (Turku, Tampere, Oulu and Kuopio). The study follows the Strengthening the reporting of observational studies in epidemiology ('STROBE') guidelines [16].

The Finnish EMS system is three-tiered, and all EMS units are dispatched by the national emergency dispatch centre. The first tier includes the first-responding units, mainly staffed by lay rescuers equipped with automated external defibrillators. The second tier consists of both basic life support units staffed with emergency medical technicians or firefighters and advanced life support units staffed with paramedics. The third tier is physician-staffed (H)EMS units, which are dispatched to aid the most high-risk patients. There are five physician-staffed HEMS units in Finland that operate with a ground unit or a helicopter in the vicinity of university hospitals 24 h a day and reach 75% of the Finnish population in 30 min. In this study, we included four HEMS units that used a common database for medical records; the catchment areas for highly specialised medical care of the four included bases serve approximately 3.78 million inhabitants (70% of the population), and the physicians are generally experienced anaesthesiologists [6].

Most EMS missions are handled by EMS personnel, but they can call (H)EMS physicians when supervision or advice are needed. Local standard operation protocols define consultation practices. EMS personnel need to consult a physician if a medical treatment by standard protocol has been given on the scene and the patient's condition does not improve. Typically, the (H)EMS physician is consulted on critically ill or injured patients with a vital dysfunction in situations when a physician-staffed (H)EMS unit is not dispatched to the scene, but the unit may also decide to join the mission by paramedic consultation. Medical records are electronically available for HEMS physicians only at the HEMS base; if information from medical records is needed while on-scene, the HEMS physicians can contact the on-call physicians in the hospitals. Only HEMS units use the common FinnHEMS database; other physician-staffed EMS units report their consultation calls to local medical records. This study focused on consultation calls to HEMS physicians, and did not include all EMS personnel-initiated consultation calls.

In Finland, health care facilities (HCFs) of which HEMS physicians may receive consultation calls consist mainly of municipal primary health care centres but also small hospitals. In primary health care centres there are outpatient clinics and wards with general practitioners and facilities for laboratory testing and basic X-ray imaging during office-hours. The inpatient wards serve patients in postacute care, rehabilitation and palliative care. There are various types of NHs: both public and private homes and institutions staffed with health care professionals assisting residents dependent on help in activities of daily living due to dementia, old age or multimorbidity [17]. According to the Finnish law, patients should be treated according to their will. Patients can document an advance directive in which they express their preferences regarding treatment decisions anticipating

situations they are unable to communicate. Advance directive is documented in medical records and to be fulfilled, it should meet the criteria of existence, validity and applicability [2]. Indeed, if EMS personnel find a valid advance directive containing 'DNACPR', CPR should not be performed or continued. However, if the patient insists treatment that is not medically justified or acceptable, the physician's judgement overrules the patient's will. If advance directive is unclear or not known in the case of acute critical illness, the patients are offered the treatments that are medically justified. Physician assisted death is not permitted in Finland.

Data collection

Consultation calls to HEMS physicians occurring between September 6, 2017 and March 6, 2018 were obtained from the FinnHEMS database. These calls represent 51% of all recorded events during the observation period. The remaining 5895 events represent missions where HEMS physician was on scene, and they have been analysed in another study [18]. In the present study, we focused to LOMT made by phone when the HEMS physician didn't encounter the patient personally. The electronic database includes data on HEMS missions, consultations calls and medical records from HEMS missions [19]. For the purposes of this study, a questionnaire (study sheet) was created in the FinnHEMS database. The study sheet contained questions about the content and reasoning of the new LOMT and the quality of information available when making treatment decisions. HEMS physicians completed the study sheet when documenting a consultation call in the database. Consultation calls were defined to be associated with an LOMT if the physician (1) identified that the patient had a pre-existing LOMT, (2) issued a new LOMT or (3) identified the patient as having a pre-existing LOMT and issued a new one on the phone. In this study setting, consultation calls in which a new LOMT was pondered but not issued were excluded. Consultation calls without a (or with an incorrectly completed) study sheet were excluded from the analysis. When multiple consultation calls were observed regarding a unique patient, we included the first call in the survival analysis. The mortality rate up to November 6, 2018 was retrieved from The Finnish Population Register Centre. The study sheet is presented in Additional file 1.

Definitions of LOMTs

In this study, 'DNACPR' included the decision to withhold further CPR attempts after the return of spontaneous circulation. A decision to discontinue an on-going resuscitation attempt was coded as 'termination of resuscitation' (ToR). 'No intubation' was defined as no endotracheal intubation. 'Not eligible for intensive care' (NEIC) meant withholding all treatments that the HEMS physician perceived as intensive care, such as invasive monitoring, endotracheal intubation, mechanical ventilation or drugs that demand intensive care unit (ICU)-level surveillance. If the patient should be transported to a municipal primary HCF for the primary care, the issued LOMT was 'no tertiary hospital transfer'. Limiting the treatment with 'no transfers' meant that the patient would stay in a private home or in an NH with basic care.

Data analysis

The main outcome variable was an identified pre-existing and/or new LOMT, and secondary outcome variables were the reasons for new LOMT, information available when making treatment decisions and survival measured as days from the consultation call. In addition, we analysed characteristics of the patients and the situations. Groups presented with frequencies and percentages were compared with a chi-square test and Fisher's exact test when appropriate. Groups presented with medians (Q1–Q3) were compared with a Mann–Whitney *U*-test and Kruskal–Wallis test. The survival between independent and mutually exclusive groups was described with a Kaplan–Meier curve and tested with Log-Rank test. A p-value < 0.05 was considered statistically significant, and all tests were two-sided. IBM SPSS version 27 was used for the analyses (Armonk, NY; IBM Corp).

Ethics

The study protocol was approved by the Ethics Committee of the Tampere University Hospital (Approval no: R15048 on March 17, 2015) and by the National Institute for Health and Welfare (THL/861/5.05.00/2015 on November 11, 2015) that also granted a permission to collect data on all consultation calls from medical records i.e. the FinnHEMS database. Due to the retrospective and register-based design of the study, the need for informed consent was waived. The 57 HEMS physicians received verbal instructions and an information letter about the study and their participation in the study was voluntary.

Results

Consultation calls associated with LOMT

In total, there were 6115 consultation calls (approximately 8.4 calls/day/base) during the study period. There were 483 (7.9%) consultation calls associated with an LOMT, of which 478 (99%) were included in the final analysis (Fig. 1). Study sheets were filled by 52 different HEMS physicians (corresponding to 91% of all HEMS physicians at included bases). The demographic data of the consultation calls are shown in Table 1 and the content of LOMTs in Table 2. There were 313 (5.1%)

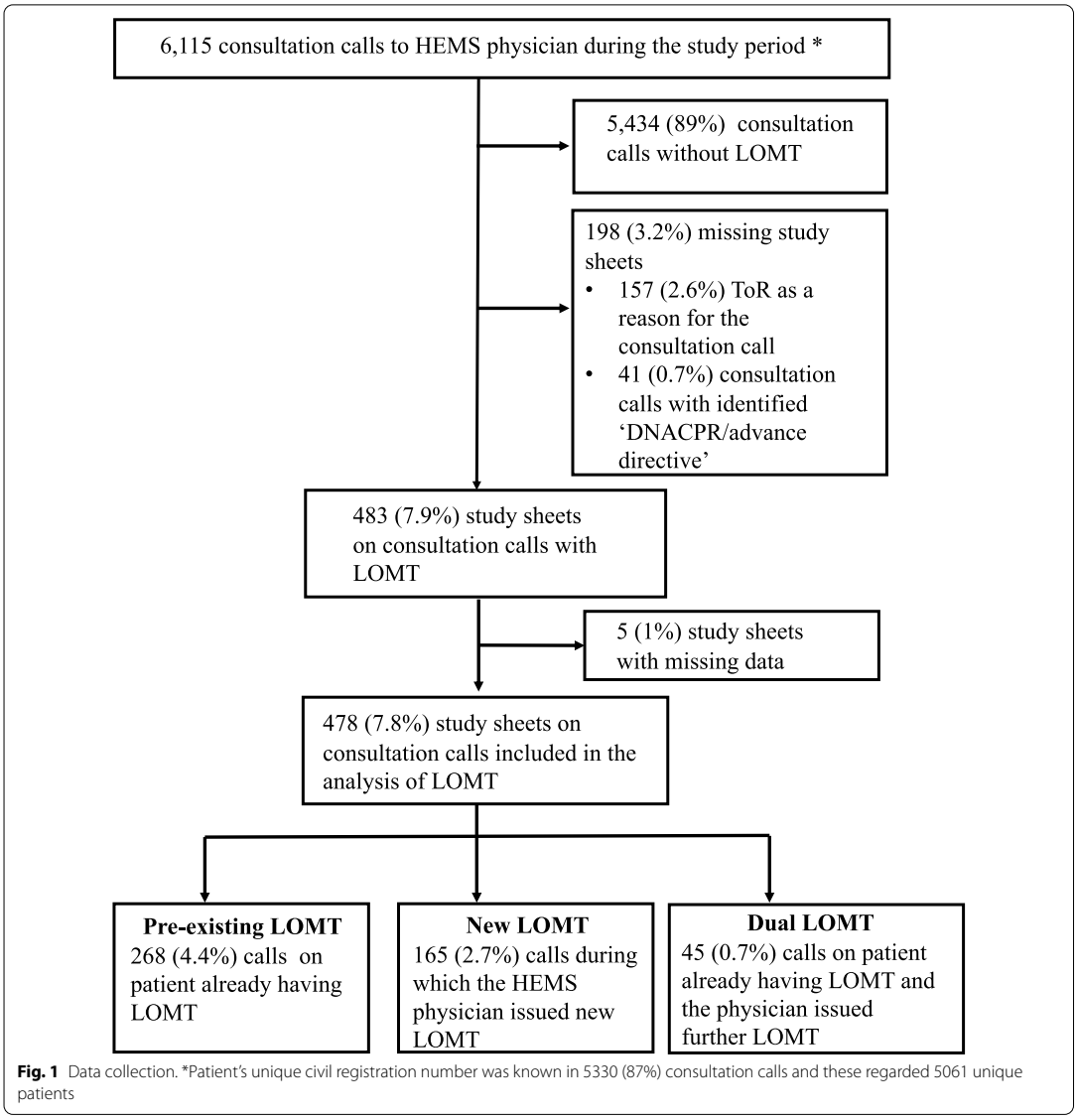

Fig. 1 Data collection. *Patient's unique civil registration number was known in 5330 (87%) consultation calls and these regarded 5061 unique patients

consultation calls involving a pre-existing LOMT, of which 93% were 'DNACPR' and/or 'NEIC'. HEMS physicians issued a new LOMT in 210 (3.4%) consultation calls, of which 45 were made for patients who already had an LOMT. In 49 (23%) calls involving a new LOMT, ToR was the only newly issued LOMT.

In consultation calls associated with an LOMT, the patients were older, more often in an HCF or NH and had more comorbidities, especially dementia and cardiovascular diseases (Table 1). When the HEMS physician issued a new LOMT during the consultation call, 32% of the patients died on the same day, and 66% died within a week from the consultation call ($p < 0.001$) (Fig. 2). In most consultation calls (n = 108/165, 66%) in which an HEMS physician issued a new LOMT during the call, the HEMS physician believed that the patient should have already had an LOMT. In the remaining one-third (n = 57/165, 35%) of cases, the patient had

Table 1 Baseline characteristics of consultation calls to HEMS physicians

Consultation calls for EMS patients, data from medical records[a]	No LOMT		Pre-existing LOMT		New LOMT		Dual LOMT		
	N = 5632	%	N = 268	%	N = 165	%	N = 45	%	*P*
Time of the call									0.001
Day (8 a.m.–4 p.m.)	2214	39	116	43	87	53	21	47	
Evening (4 p.m.–12 p.m.)	2172	39	104	39	44	27	10	22	
Night (12 p.m.–8 a.m.)	1246	22	48	18	34	21	14	31	
Reason for consultation									< 0.001
Treatment instructions	3353	60	178	66	106	64	34	76	
Destination of further admission	802	14	43	16	8	4.8	4	8.9	
Pain medicine	481	8.5	10	3.7	0		0		
ECG interpretation	416	7.4	10	3.7	0		0		
Non-conveyance	356	3.6	12	4.5	1	0.6	1	2.2	
End of resuscitation attempt	157	2.8	12	4.5	47	29	3	6.7	
Other	67	1.2	3	1.1	3	1.8	3	6.7	
Dispatch code[b]									< 0.001
Arrythmia	1169	21	51	19	12	7.3	9	20	
Chest pain	1080	19	29	11	2	1.2	2	4.4	
Dyspnea	546	9.7	76	28	33	20	11	24	
Falling (not dropping)	306	5.4	6	2.2	3	1.8	1	2.2	
Stomach pain	274	4.9	6	2.2	2	1.2	1	2.2	
Cardiac arrest	262	4.7	11	4.1	66	40	5	11	
Convulsions	250	4.4	14	5.2	2	1.2	4	8.9	
Stroke	228	4	18	6.7	5	3	1	2.2	
Unconsciousness	184	3.3	23	8.6	27	16	9	20	
Other illness	178	3.2	21	7.8	1	0.6	0		
Gender									< 0.001
Male	2870	51	106	40	83	50	20	44	
Female	2497	44	155	58	67	41	25	56	
Missing data	265	4.7	7	2.6	15	9.1	0		
Age Median (Q1–Q3)	67	(48–79)	84	(75–90)	80	(70–89)	85	(78–92)	< 0.001
Children under 18 years	412	7.3	2	0.7	0		0		< 0.001
Location of the patient									< 0.001
Home/public/work	5078	90	95	35	96	58	11	24	
Nursing home	282	5	150	56	50	30	23	51	
Primary health care facility	188	3.3	18	6.7	13	7.9	8	18	
Hospital	66	1.2	4	1.5	6	3.6	3	6.7	
Other	18	0.3	1	0.4	0		0		
Anamnesis[c]									
Previously healthy	651	12	0		3	1.8			< 0.001
DNACPR/Advance directive	41	0.7	150	56	0		29	64	< 0.001
Hypertension	1125	20	71	27	41	25	16	36	0.002
Coronary artery disease	730	13	57	21	22	13	5	11	0.002
Diabetes	617	11	38	14	16	9.7	3	6.7	0.271
Atrial fibrillation (chronic)	501	8.9	57	21	22	13	8	18	< 0.001
Asthma/COPD	445	7.9	37	14	15	9.1	5	11	0.006
Cardiac insufficiency	302	5.4	56	21	20	12	11	24	< 0.001
Dementia	211	3.7	65	24	32	19	11	24	< 0.001
Substance abuse	175	3.1	0		6	3.6	0		0.002
TIA/stroke	155	2.8	24	9	11	6.7	7	16	< 0.001
Mental health disorder	133	2.4	4	1.5	5	3	3	6.7	0.168

Table 1 (continued)

Consultation calls for EMS patients, data from medical records[a]	No LOMT		Pre-existing LOMT		New LOMT		Dual LOMT		
	N = 5632	%	N = 268	%	N = 165	%	N = 45	%	*P*
Epilepsy	124	2.2	11	4.1	4	2.4	0		0.200
Another diagnosed illness	987	18	86	32	32	19	10	22	< 0.001

HEMS, Helicopter Emergency Medical Service, DNACPR, Do not attempt cardiopulmonary resuscitation, COPD, Chronic Obstructive Pulmonary Disease, TIA, Transient Ischaemic Attack

[a] 5 consultation calls with LOMT excluded from analysis (Fig. 1)

[b] Only the 10 most common codes out of the 50 codes observed during the study period are shown

[c] The sums on patients with comorbidities exceed n = 6110 because many patients may have had several comorbidities

Table 2 The frequency and content of LOMT in consultation calls to HEMS physicians

The frequencies and contents of LOMT	N	%
A *Pre-existing LOMT (N = 313)*		
The frequency of different pre-existing LOMT[a]		
DNACPR	300	96
NEIC	59	19
No tertiary hospital admission	2	0.6
No transfers	4	1.3
Other[b]	16	5.1
B *New LOMT (N = 210)*		
The frequency of different new LOMT[c]		
DNACPR	122	58
NEIC	96	46
No intubation	67	32
ToR	54	26
No tertiary hospital admission	12	5.7
No transfer	12	5.7
Other[d]	24	11.4

LOMT, Limitation of medical treatment, HEMS, Helicopter Emergency Medical Service, DNACPR, Do-not-attempt-cardiopulmonary resuscitation, NEIC, Not eligible for intensive care, ToR, Termination of resuscitation

[a] In 64 consultations the patient had multiple pre-existing LOMT

[b] The category 'other' included three consultation calls in which the patient had an advance directive, five consultation calls on patients with palliative care decision and one call on patient with 'allow natural death' decision issued by a general practitioner

[c] In 108 consultation calls multiple new LOMT were issued

[d] The category 'other' included nine consultation calls in which the LOMT was the decision to admit the patient to the secondary hospital instead of tertiary hospital for further treatment

experienced trauma or an unexpected acute deterioration: The reason for consultation was most commonly ToR (n = 30/57, 53% vs. n = 17/108 16%, $p < 0.001$), and the patients were younger (median 74 vs. 84 years, $p < 0.001$) and often located in a private home or in a public location (n = 49/57, 86% vs. n = 47/108, 44%, $p < 0.001$). Of 478 consultation calls involving an LOMT, 60 (13%) were related to an HEMS mission. In almost all of these missions (n = 58), the HEMS unit was cancelled due to futility or LOMT (cardiac arrest n = 26, unconsciousness n = 22, other n = 10).

Reasons for new LOMT

The most common single reason for a new LOMT was the futility of the overall situation (18%) (Table 3). In cases where age was selected as a reason for the LOMT, the median age of the patient was 89 (min–max 74–104) years. In cases in which poor baseline functional status was selected as a reason for the LOMT, the patient was either located in an HCF or NH (71%) or otherwise needed help in activities of daily living.

Information available when making decisions regarding treatment via *phone*

In 39% of the consultation calls, the decisions were based entirely on the information given by the EMS personnel on-scene (Table 4). All consultations concerning NH patients lacked any pre-existing advance care plan with emergency care plans. Every other (n = 102/210, 49%) new LOMT was issued during a consultation call for patients in an HCF or NH. During these calls, the NH staff was unfamiliar with the resident's comorbidities in 21% (n = 21/102) of cases, baseline functional capacity in 15% (n = 15) of cases and pre-existing LOMT in 22% (n = 22) of the cases.

HEMS physicians mostly made decisions about new LOMTs without seeking a second opinion (n = 186/210, 89%). In 20 (10%) cases, the HEMS physicians discussed the decision via phone with another physician from a tertiary hospital or with another HEMS physician. Discussions with HCF/NH physicians were rare (n = 3, 1%). When making treatment decisions for patients with a pre-existing LOMT, the HEMS physicians received information about the previously issued LOMT in 93% (n = 291/313) of cases. In the remaining 7% of cases, the HEMS physician reported having received this information after decisions were already made, usually by reading it from the medical records when documenting the consultation call.

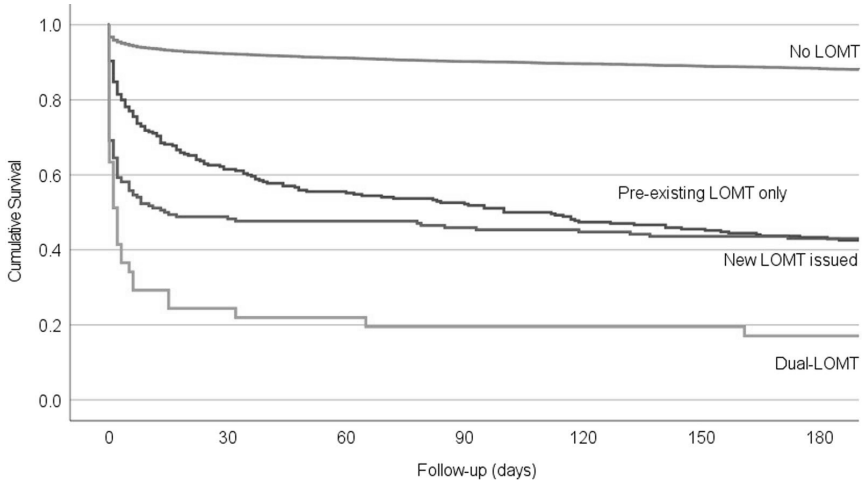

Fig. 2 The 180-day survival of the study cohort including 5061 unique patients. Among the patients concerned in the consultation calls, 4671 (92%) had no limitation in medical treatment (LOMT), 233 (4.6%) had a pre-existing LOMT, 119 (2.4%) had a new LOMT and 38 (0.8%) belonged to an independent group of patients having pre-existing LOMT but to whom HEMS physicians issued further LOMTs ('Dual LOMT')

Table 3 The reasons that HEMS physicians issued a new LOMT during a consultation call

Reasons for new limitation of medical treatment	All n = 210	%
The frequency of different reasons for a new LOMT[a]		
Futility of the overall situation	150	71
Multiple/severe comorbidities	118	56
Poor baseline functional status	117	56
Old age	103	49
Pre-existing LOMT or advance directive	33	16
Other	14	6.7

HEMS, Helicopter emergency medical service; LOMT, Limitation of medical treatment

[a] In 159/210 (76%) consultation calls with a new LOMT, the HEMS physician selected multiple reasons for the LOMT decision

Discussion

This prospective, observational multicentre study investigated 6115 EMS personnel-initiated consultation calls to HEMS physicians, with a special interest in LOMTs. Answering consultation calls is an important part of HEMS physicians' daily tasks, and 8% of these calls were associated with an LOMT. The incidence of LOMTs is increasing in Europe [20, 21]. In a French study, advance directives were available for 7.5% of OHCA patients [13], and in a recent study from USA, 9.9% of EMS-attended OHCA patients had a DNACPR order [10]. In our study, patients' pre-existing LOMTs were mainly 'DNACPR only' (75%), and no advance care plans with emergency care plans were reported [2, 22]. New LOMTs were issued in 3.4% of consultation calls, and half of them were made for patients in an HCF or NH. The most frequent new LOMT was a 'ToR' (23%), but 'DNACPR', 'NEIC' and 'no intubation' were also common.

We found that HEMS physicians issued LOMTs in extremely futile situations. According to ERC guidelines [1], withdrawal from CPR should be considered when there is no return of spontaneous circulation, no shocks are administered and EMS personnel did not witness the arrest. Resuscitation attempts can be terminated if there has been asystole continuously despite 20 min of advanced life support with an absence of a reversible cause of cardiac arrest [1]. The large proportion of ToR decisions explains the poor survival in the study population: one-third of patients with a new LOMT died on the same day of the consultation call. Notably, in two-thirds of the consultation calls involving new LOMTs the HEMS physician felt that the patient's fragile condition should have ethically mandated that the treatment limitation be issued earlier. One possible explanation for this is that the LOMT did exist, but information on these advance care plans was not available on-scene during the call, which has been reported in other studies [9, 13]. It is possible that the patient records were not available or that the family or nursing staff were unable to share this information. The criteria to initiate LST in prehospital settings are the same as admission criteria for intensive

Table 4 The information available when HEMS physicians made decisions on treatment and issued a new LOMT

Type of information available	All n = 478	%	New LOMT n = 210	%
Information from EMS situation	471	99	206	98
Anamnesis via EMS personnel	471	99	206	98
Measured vital parameters	399	83	160	76
ECG	151	32	45	21
Information from a person other than the EMS personnel[a]	117	24	79	38
Nurse familiar with the patient	59	12	39	19
Nurse unfamiliar with the patient	9	1.9	8	3.8
Attending physician in nursing home	6	1.3	4	1.9
Another physician	15	3.1	10	4.8
A relative/proxy	31	6.5	22	10
Information on any pre-existing LOMTs	291	61	35	17
Medical records	187	39	60	29
Tertiary hospital medical records	182	38	57	27
Primary care hospital/health care facility medical records	3	0.6	0	0
Nursing home client's medical records	7	1.5	3	1.4
Emergency care plan	0	0	0	0
Kanta-service[b]/National electronic medical records	1	0.2	1	0.5
Medication list	124	26	45	21
Medication list without medical records	29	6.1	17	8.1
Information available only from paramedics on scene[c]	85	18	82	39

HEMS, Helicopter Emergency Medical Service; LOMT, Limitation of medical treatment

[a] Not EMS personnel; for example, a relative/proxy, nursing home staff, physician in tertiary hospital

[b] National archive of health and social welfare information contains up to date records from both the private and public sectors. The users of the Kanta services include citizens, healthcare services, social welfare services and pharmacies

[c] Information on medical records, medication lists, pre-existing LOMTs or from any person other than EMS personnel on scene was not available

care in hospitals, but the diagnostic possibilities on-scene and access to medical records are limited. We found only one study analysing the reasons for ICU refusal rather than ICU admission [23]. The reasons to limit LST and refuse ICU admission were higher age, underlying disease, NH residency, pre-existing cognitive impairment, admission for medical reasons, sepsis, acute cardiac failure or acute central neurologic illness. In that study, 59% of the decisions to forego LST for ICU-refused patients were made via phone[23].

During the study period, we observed 5895 HEMS missions and 6115 consultation calls, although parts of the calls were related to the missions [18]. Compared to an earlier Scandinavian study, only 23% of HEMS units' events were phone calls [12]. In Finland, HEMS physicians were consulted in 39% of non-conveyance situations [15]. An interesting feature of our study was that the HEMS physicians seldom discussed LOMT decisions with another physician, which needs further consideration. This is probably due to Finnish HEMS physicians' extensive work experience in anaesthesiology and intensive care and the high proportion of ToR decisions. This is very different from a French study [24], which reported that the issuance of a new LOMT in the field was common, but the physicians consulted another physician in 59% of the cases. In this study, 14% of calls concerned patients in an HCF or NH, and half of the new LOMTs were issued for those patients, often during daytime. There should be an attending physician who has access to the patient's medical records and/or customer information and is reachable by phone at least during office hours in HCFs and NHs. When an HEMS physician issues a new LOMT during a consultation call, the information should be transmitted to the attending physician to plan the follow-up care and make an advance care plan.

There is a general consensus regarding the need for emergency care plans over limitations in treatment only [25]. However, it has been found that the EMS system helps to overcome deficiencies in end-of-life care: The report of the National Supervisory Authority for Welfare and Health states that EMS units are increasingly dispatched to treat patients in NHs due to inadequate advance care plans [26]. In addition, the Ministry of Social Affairs and Health's report on the status of the palliative care in Finland acknowledges that EMS often responds to the sudden care needs of patients in end-of-life care [27]. EMS is the only nationwide societal health care system that provides all levels of health care

24/7. Waldrop et al. identified care-related, psychological and organisational reasons that prehospital providers are called to NHs at the end of life [28]. If advanced care planning is concentrated mainly on treatment restrictions without an emergency care plan [22], when the patient suddenly deteriorates, EMS participation is usually needed to take the responsibility for clinical decision-making about when to proceed to palliative care. The patient's family members or NH staff usually need diagnostic measures and support [10, 13]. Sometimes, prehospital providers do not understand the pre-existing LOMT or need treatment instructions on how to treat critically ill patients with LOMTs [29]. The dying process should not be medically lengthened; instead, in situations where the end of life is approaching the goals of care should be palliation and dignity.

End-of-life care decisions are often difficult to make before the acute severe illness or injury. Societal service systems have difficulties handling these acute problems during on-call hours due to challenges in information transmission, work culture and work organisation. Thus, the current system places responsibility for acute decision-making upon HEMS physicians [30]. In situations where the new LOMT is issued on the phone by an HEMS physician and the patient does not die immediately, it may be challenging to ensure good continuity of care without contact with the physician responsible for the follow-up care. In view of the increased workload of the EMS system, decision makers in health care systems should actively consider the organisation and accessibility of end-of-life care services in acute situations.

Strengths and limitations of the study

To the best of our knowledge, this is the first study on pre-hospital consultation calls concerning LOMTs. The strengths of this study are the prospective multicentre design and feasible data collection; the study sheet was available in the same electronic database that was used for documentation of the consultation calls. The material is comprehensive, and the study has a nationwide coverage. Patient's unique civil registration number was missing in 13% of consultation calls and in addition three patients in the 'no LOMT' group were lost from follow-up since registered abroad. However, the practices of HEMS physicians might vary in terms of why or how actively they issue LOMTs [31–33]. This study did not record cases where a new LOMT was considered but not issued. In addition, it is possible that some HEMS physicians do not perceive the termination of a futile resuscitation attempt as an LOMT, and in such a situation they may have been unlikely to complete the study sheet. Thus, the true incidence of end-of-life questions in prehospital settings may be even higher. The results of this study cannot be generalised to other countries because the EMS and health care systems, end-of-life arrangements and NHs may be remarkably different from the Finnish systems.

Conclusion

Consultation calls to HEMS physicians concerning LOMTs are common. HEMS physicians advise EMS personnel on the phone regarding end-of-life questions as well, and in 3.4% of consultation calls they issue a new LOMT. These decisions mainly concern ToR, DNACPR, intubation and initiation of intensive care. Further research is recommended on the continuity of care of patients with a prehospital LOMT: for example a prospective study on how the information of LOMT and/or admission to palliative care should be communicated to the NH physician or a follow-up study on what happens to patients with LOMT in hospital after they are admitted to emergency department.

Abbreviations

CPR: Cardiopulmonary resuscitation; DNACPR: Do not attempt cardiopulmonary resuscitation; EMS: Emergency medical services; HCF: Health care facility; HEMS: Helicopter emergency medical services; ICU: Intensive care unit; LOMT: Limitation of medical treatment; LST: Life-sustaining therapies; NEIC: Not eligible for intensive care, NH: nursing home, OHCA: out-of-hospital cardiac arrest, ToR: termination of resuscitation.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13049-022-01002-8.

Additional file 1. The study sheet with English translations.

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Authors' contributions

All authors designed the study, assessed the study sheet, drafted, and critically revised the manuscript. HK accepted the filled study sheets. HK and HH ran the statistical analyses. All authors have read and approved the final manuscript.

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Availability of data and materials

Please contact the author for data requests.

Declarations

Ethics approval and consent to participate

This was an observational study, and no clinical interventions were performed. The Ethics Committee of the Tampere University Hospital approved the study

protocol on March 17, 2015 (Approval no: R15048). The study was accepted by all five Finnish university hospitals, the National Institute for Health and Welfare and FinnHEMS Ltd. Due to the design of the study, the need for informed consent was waived. The HEMS physicians collected the data, and their participation was voluntary.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interest regarding this study.

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