

*Marko Hoikka*

PREHOSPITAL RISK  
ASSESSMENT AND PATIENT  
OUTCOME – A POPULATION  
BASED STUDY IN NORTHERN  
FINLAND

UNIVERSITY OF OULU GRADUATE SCHOOL;  
UNIVERSITY OF OULU,  
FACULTY OF MEDICINE;  
MEDICAL RESEARCH CENTER





ACTA UNIVERSITATIS OULUENSIS  
D Medica 1497

*MARKO HOIKKA*

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AND PATIENT OUTCOME – A  
POPULATION BASED STUDY IN  
NORTHERN FINLAND**

Academic dissertation to be presented with the assent of the Doctoral Training Committee of Health and Biosciences of the University of Oulu for public defence in the Kouta Auditorium of the Kaukametsä Congress and Cultural Centre (Koskikatu 2-4, Kajaani), on 14 December 2018, at 12 noon

UNIVERSITY OF OULU, OULU 2018

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Acta Univ. Oul. D 1497, 2018

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ISBN 978-952-62-2135-9 (Paperback)  
ISBN 978-952-62-2136-6 (PDF)

ISSN 0355-3221 (Printed)  
ISSN 1796-2234 (Online)

Cover Design  
Raimo Ahonen

JUVENES PRINT  
TAMPERE 2018

## **Hoikka, Marko, Prehospital risk assessment and patient outcome – a population based study in Northern Finland**

University of Oulu Graduate School; University of Oulu, Faculty of Medicine; Medical Research Center

*Acta Univ. Oul. D 1497, 2018*

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### *Abstract*

Emergency medical services (EMS) are designed to provide prompt response, on-scene treatment and transport for definitive care in patients with acute illness or injury. In recent years, the growing number of missions for non-urgent matters has challenged emergency care to design risk assessment protocols and tools to support decision-making and resource management at both dispatch and on-scene.

The present study was designed to examine the efficacy of a criteria based dispatch protocol and National Early Warning Score (NEWS) in the Finnish EMS system. In addition, the aim of the research was to obtain data on patient allocation and mortality in the Northern Finnish population.

The study data included 13,354 EMS missions from a six-month cohort (1.1.2014 - 30.6.2014) of prehospital emergency patients in two hospital districts – Kainuu and Länsi-Pohja – in Northern Finland, using a retrospective, observational design. Prehospital data including patient clinical physiological variables were combined with the national Finnish registries (Care Registry for Health Care, Intensive Care Consortium Database and Cause of Death Registry) in order to examine risk assessment in EMS and prehospital patient outcomes.

Based on the result, the risk assessment at the dispatch was correct in 67.5% of the cases and four out of ten EMS missions did not lead to transportation by an ambulance. The use of the Finnish dispatch protocol resulted in an overall rate of 23% of over-triage and a 9% rate of under-triage. The highest NEWS category showed a good sensitivity for 1-day mortality but failed to adequately discriminate patients in need of intensive care or who died within 30-days in a large, unselected, typical EMS population.

In conclusion, the criteria based dispatch protocol resulted in over-triage of a quarter of missions and in a significant rate of EMS missions without ambulance transportation. In addition, the predictive value of prehospital NEWS regarding the patient's risk of death and need for intensive care was low.

*Keywords:* Causes of Death, Diagnostic Test, Early Warning Score, Emergency Medical Dispatch, Emergency Medical Services, Hospital Admission, Triage



## **Hoikka, Marko, Hoikka, Marko, Riskinarvio ensihoidossa ja hoidontulokset – väestötutkimus Pohjois-Suomessa**

Oulun yliopiston tutkijakoulu; Oulun yliopisto, Lääketieteellinen tiedekunta; Medical Research Center

*Acta Univ. Oul. D 1497, 2018*

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### ***Tiivistelmä***

Ensihoitopalvelu on suunniteltu tarjoamaan nopeaa vastetta, paikalla tapahtuvaa hoitoa ja kuljetusta lopulliseen hoitopaikkaan potilaille, joilla on akuutti sairaus tai vamma. Viime vuosien lisääntyneet yhteydenotot ei-kiireellisissä asioissa on johtanut riskinarviotyökalujen kehittämiseen tukemaan päätöksentekoa ja resurssienhallintaa hätäpuhelun aikana ja tapahtumapaikalla.

Tässä tutkimuksessa tarkasteltiin kriteeripohjaista hätäpuhelun käsittelyä sekä varhaisen varoituspistejärjestelmän (NEWS) tehokkuutta suomalaisessa ensihoitojärjestelmässä. Lisäksi tutkimuksen tavoitteena oli saada tietoa ensihoitopotilaiden hoitotuloksista ja kuolleisuudesta Pohjois-Suomessa.

Tutkimukseen sisältyi 13 354 ensihoitotehtävää kuuden kuukauden kohortista (1.1.2014 – 30.6.2014) kahden sairaanhoitopiirin alueelta – Kainuu ja Länsi-Pohja – Pohjois-Suomessa käytämällä retrospektiivistä havainnoivaa tutkimusmenetelmää. Ensihoidon aikana kerätty tieto, mukaan lukien potilaan kliiniset fysiologiset arvot, yhdistettiin kansallisiin rekistereihin (hoitoilmoitusrekisteri, tehohoitokonsortion laatu-tietokanta sekä kuolinsyyrekisteri) jotta ensihoitopotilaiden riskinarviota ja hoitotuloksia voitiin tutkia.

Tutkimustulosten mukaan 67.5 prosentissa tapauksista riskinarvio hätäkeskuksessa oli oikea ja neljä kymmenestä ensihoitotehtävästä ei johtanut kuljetukseen ambulanssilla. Suomalaisen hälytysprotokollan käyttö johti yliarviointiin 23 prosentissa tapauksista ja aliarviointiin 9 prosentissa tapauksista. Korkeariskin NEWS-luokan herkkyys 1-päivän kuolleisuudelle oli hyvä, mutta se ei kyennyt erottelemaan riittävän hyvin potilaita, jotka tarvitsivat tehohoitoa tai kuolivat 30 päivän sisällä suuressa ei-valikoidussa tyyppillisessä ensihoitopotilasväestössä.

Yhteenvetona todettiin, että kriteeripohjaisen riskinarvion käyttö johti yliarvioon neljänneksestä tapauksista sekä huomattavaan ensihoitotehtävämäärään ilman ambulanssikuljetusta. Lisäksi ensihoidon aikana käytetyn varhaisen varoituspistejärjestelmän ennusteellinen arvo potilaan kuolemanriskin ja tehohoidon tarpeeseen oli matala.

*Asiasanat:* diagnostinen testi, ensihoitopalvelu, hätäkeskusjärjestelmä, kuolinsyyt, sairaala-admissio, triage, varhaisen varoituksen pisteet



*To my family*



## Acknowledgements

This academic journey has been rewarding but on the other hand fine abrasive. Writing these words arouses many emotions in my mind. I have been privileged to cooperate with several people during the study. You all deserve a great praise.

My warmest gratitude and respect goes to Professor Tero Ala-Kokko, my main supervisor of the thesis. In 2013, I had an idea of a single study but never even thought of a doctoral dissertation. Your genuine enthusiasm and encouragement gave a spark to start this project, for which I am particularly grateful to you. During these five years you have supported me with your infinite energy. You have a special ability to call at exactly the right moment when obstacles have seemed insuperable. It has been a great honor to get to know you.

Docent Tom Silfvast, co-supervisor. Your calmness and unique positivity are admirable qualities and made cooperation with you very easy. You have always been ready to help and share your knowledge of emergency medicine, even from the dock of the summer cottage.

Dr. Sami Länkimäki, MD, co-author. I thank you for sharing your ideas and thoughts especially during the design of study. Some colleagues may consider you a bit "crazy", but the development of prehospital emergency care requires your creativity and courage.

Docent Jaakko Långsjö and Docent Annika Takala, my official reviewers. Thank you for prompt review and valuable comments and thoughts. Your feedback enabled me to significantly improve the thesis in its final form.

Docent Jouko Laurila, Docent Juha Koskenkari and Docent Janne Liisanantti, my official follow-up group during doctoral studies. I warmly thank you for your time and guidance during my doctoral studies.

Pasi Ohtonen, MSc. Your assistance in medical statistics and interpretation of results have been immensely valuable. Dr. Michael Spalding, PhD. Thank you for editing the English.

EMS providers inside the study area. I thank you all, without the data you have collected during the emergency care, this research would never have been achieved. I appreciate above all your work to care people during their greatest distress. I am fortunate to be a part of this EMS community.

My family. You deserve my greatest gratitude. The deepest apologies for the countless hours that the dissertation has taken. My wife Heidi. Without your support and love I would not have achieved anything like this. Osku and Sulo. my boys. You are my true heroes.

I acknowledge financial support from Oulu University Hospital (EVO funding), The Finnish Society of Anaesthesiologists and The Finnish Cultural Foundation (Kainuu Regional Fund).

October 2018

Marko Hoikka

## Abbreviations

ALS	Advanced Life Support
AVPU	Alert Verbal Pain Unresponsive
BLS	Basic Life Support
CBD	Criteria Based Dispatch
EMCC	Emergency Medical Communication Centre
EMS	Emergency Medical Service
ePCR	Electronic Patient Care Record
EWS	Early Warning Score
FRU	First Responding Unit
GCS	Glasgow Coma Scale
HEMS	Helicopter Emergency Medical Services
HILMO	HoitoILMOitusjärjestelmä
ICU	Intensive Care Unit
LOS	Length of Stay
MEWS	Modified Early Warning Score
MPD	Medical Priority Dispatch
NACA	National Advisory Committee for Aeronautics
NEWS	National Early Warning Score
NLR	Negative Likelihood Ratio
NPV	Negative Predictive Value
NTR	Non Transportation Rate
PLR	Positive Likelihood Ratio
PMEWS	Physiological-social Modified Early Warning Score
PPV	Positive Predictive Value
RAPS	Rapid Acute Physiology Score
REMS	Rapid Emergency Medicine Score
IEWS	VitalPAC Early Warning Score



## List of original publications

This thesis is based on the following publications, which are referred throughout the text by their Roman numerals:

- I Hoikka, M., Länkimäki, S., Silfvast, T. & Ala-Kokko TI. (2016). Medical priority dispatch codes – comparison with National Early Warning Score. *Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine*, 24(1), 142.
- II Hoikka, M., Silfvast, T. & Ala-Kokko, TI. (2017). A high proportion of prehospital emergency patients are not transported by ambulance: a retrospective cohort study in Northern Finland. *Acta Anaesthesiologica Scandinavica*, 61(5), 549-556.
- III Hoikka, M., Silfvast, T. & Ala-Kokko TI. (2018). The ability of prehospital National Early Warning Score to discriminate patients in need of intensive care: A population-based study in two hospital districts in Northern Finland. (manuscript).
- IV Hoikka, M., Silfvast, T. & Ala-Kokko TI. (2018). Does the prehospital National Early Warning Score predict the short-term mortality of unselected emergency patients? *Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine*, 26(1), 48.

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# 1 Introduction

The emergency medical services (EMS) has developed from a system of diverse providers of transportation in the 1960's into an integrated system delivered by the healthcare professionals of today (Shah, 2006; Sasser, Varghese, Kellermann & Lormand, 2005). The primary purpose of modern EMS is to provide early response, on-scene treatment and transport to definitive care for acute illnesses and injuries to prevent early deaths (Roudsari et al., 2007). The operative emergency care consists of both an emergency medical dispatch system and tiered ambulance network. There is significant variation, however, with regards dispatch systems and organization of EMS between different countries (Lyon, Bohm, Christensen, Olasveengen, & Castren, 2013).

The key elements of a successful EMS system are prompt emergency patient identification, correct risk assessment and feasible management of available resources (Ornato, 2009). Over-triaging and merely sending ambulances leads to an inappropriate use of EMS resources and prolonged delays with patient encounters, whereas under-triage negatively impacts on patient survival (Jacobs, 2011). An efficient dispatch system guides the patient, if necessary, to other health care services than the EMS and thus reduces unnecessary non-transportation missions.

New challenges have emerged in the EMS systems around the world in recent decades as the number of missions has increased considerably (Lowthian et al., 2011; Pittet, Burnand, Yersin, & Carron, 2014). In particular, increased contacts in non-urgent matter, even in minor illnesses, minor injuries or social problems, have increased the EMS workload (Booker, Shaw, & Purdy, 2015). This has caused challenges in identifying true life-threatening situations from a large number of calls. Each year in Finland, Emergency Medical Communication Centres (EMCCs) receive about 2.7 million emergency calls and dispatch about 750,000 missions to EMS providers. In addition, the health and social services have undergone a reform in Finland, which has centralised urgent and emergency specialized healthcare (Ministry of Social Affairs and Health, 2016). In the sparsely populated area of Northern Finland this has resulted in travelling prolonged distances, up to hundreds of kilometres, for patients with acute illnesses to receive professional medical consultation.

To address this global problem, several risk assessment tools have been developed to support decision-making during both call handling in emergency medical communication centre (EMCC) and in patient evaluation on-scene. The Finnish dispatch system is based on the criteria based dispatch (CBD) protocol, which is

also used widely in other Nordic Countries. Since the Royal College of Physicians' recommendation in 2012 to use National Early Warning Score (NEWS) throughout the entire chain of care, several hospitals and EMSs have implemented it's use in Finland (Royal College of Physicians, 2012). In the near future, NEWS will be integrated into the national electronic patient care record (ePCR) for prehospital EMS.

Despite promising results, the generalizability of these risk assessment tools has been questioned (Lindström, Pappinen, Falk, & Castren, 2011; Williams, Tohira, Finn, Perkins, & Ho, 2016). A validation of risk assessment tools in the prehospital environment is also lacking. However, an effective risk assessment has the potential to reduce adverse patient outcomes – intensive care admission, cardiac arrest and death – through the rapid identification of critical illness and earlier access to definite care.

The present study was designed to examine the efficacy of a criteria based dispatch protocol and National Early Warning Score in the Finnish EMS system. In addition, the aim of the research was to obtain data on patient allocation and outcome in the Northern Finnish population.

## 2 Review of the literature

### 2.1 EMS system in Northern Finland

In Finland, the common European emergency phone number 112 is used for all emergencies, whether the need be for police, medical care, fire and rescue or social services. The emergency calls are connected to the closest of the six regional emergency medical communication centres (EMCCs) administered by the national dispatch authority. EMCC personnel undergo an authorized 18-month training without the status of a health care professional. Dispatchers seek to identify the most appropriate keyword to describe the reason for contact for all incoming calls. Medical emergencies are handled according to a national criteria based dispatch (CBD) protocol, which includes predetermined questions to guide in risk assessment. Based on the criteria of the patient's main complaint, clinical condition or the mechanism of injury, calls are prioritized into four categories from A (highest priority) to D (lowest priority) (Table 1).

**Table 1. Priority definitions and responses in Finnish EMS system (1, published by permission of BMC).**

Priority code	A	B	C	D
Definitions	Serious disturbance of vital functions	Suspicion of failure of vital functions	Minor symptoms	No disturbance of vital functions
	High-energy mechanism of injury	Mechanism of injury is suspected to lead on failure of vital functions	Low-energy mechanism of injury	
Dispatch priority	Immediately	Immediately	Patient reached within 30 minutes	Patient reached within 120 minutes
EMS unit response	FRU + ALS + (HEMS) Lights and sirens	ALS (+ FRU if quicker on scene) Lights and sirens	BLS or ALS Normal driving	BLS Normal driving

*FRU, first responding unit; ALS, advanced life support unit; BLS, basic life support unit; HEMS, Physician helicopter unit.*

The hospital districts are responsible for organizing EMS, either independently, in collaboration with rescue services or by purchasing services from a private EMS provider. The EMS is three-tiered, with the first tier consisting of basic life support (BLS) ambulances and first responding units (FRU). The second tier consists of advanced life support (ALS) ambulances operated by paramedics. The third tier of EMS are physician-manned helicopter units.

The tasks of the EMS system, response times for highest priority calls, as well as education required by the EMS providers are highly regulated legislatively (Decree by the ministry of social affairs and health on the emergency medical services (585/2017)). In addition, prehospital patient care and decision-making are largely controlled by predetermined guidelines.

## **2.2 The role of emergency medical dispatch**

The important role of the emergency medical dispatch in the patient's chain of care has been recognized since the 1970s (Zachariah & Pepe, 1995). The key components of emergency medical dispatching include emergency patient identification, correct risk assessment, management of available EMS resources, and maintaining an appropriate call processing time in life-threatening emergencies (Jacobs, 2011; Ornato, 2009). Over-triage of emergency calls leads to inappropriate use and overload of EMS units, whereas under-triage may negatively impact patient survival (Jacobs, 2011).

There is a substantial variation between countries with regard to dispatch platforms and organization of emergency medical dispatch systems (Lyon et al., 2013). The main difference between the most widely used dispatch platforms, Criteria Based Dispatch (CBD) and Medical Priority Dispatch (MPD), is the handling of emergency calls. CBD system uses a protocol with keywords based on the caller's descriptions of signs and symptoms and the EMS missions are prioritized according to predetermined criteria in every keyword (Culley, Henwood, Clark, Eisenberg, & Horton, 1994). MPD system uses a scripted caller interrogation protocol with a series of structured questions and algorithms to determine the urgency of the call (Clawson, Cady, Martin, & Sinclair, 1998; Deakin, Sherwood, Smith, & Cassidy, 2006). The MPD system is mainly used in North America and in the United Kingdom, whereas the CBD system is used in European countries (e.g. Finland, Denmark, Norway, Belgium and Switzerland).

### **2.2.1 Efficacy of criteria based dispatch**

The use of the criteria based dispatch has a beneficial impact on the efficiency of the EMS system as the ambulance resources are targeted to the correct patients (Culley et al., 1994). The CBD system has been demonstrated to adequately identify patients with critical emergency situations, such as cardiac arrest and stroke (Dami, Heymann et al., 2015; Ellensen, Naess, Wisborg, Hunskaar, & Zakariassen, 2018; Hardeland et al., 2014). In addition, the Danish CBD protocol seems to identify patients with a high risk of hospital admission and death (Andersen et al., 2013).

There is no consensus of quality indicators for medical dispatch system or optimum platform for handling emergency calls, and dispatching emergency medical resources also remains undefined (Lyon et al., 2013). One study examining the accuracy of CBD according to the National Advisory Committee for Aeronautics (NACA) score at the scene showed over- and under-triage of 78% and 4.6%, respectively (Dami, Golay et al., 2015).

In 2006, the Finnish criteria based dispatch protocol was nationally standardized in every EMCC. This implementation increased the number of high priority EMS calls but had some controversial results regarding the correct recognition of patients with life-threatening conditions, such as cardiac arrest, stroke and ST-elevation myocardial infarct (Lindström et al., 2011; Määttä et al., 2010).

### **2.3 Non-transportation EMS missions**

In recent years, EMS systems have been under pressure due to increasing demands for services, especially in non-urgent situations (Booker et al., 2015; Lowthian et al., 2011; Pittet et al., 2014). In order to avoid unnecessary patient transfers and prevent overcrowding of the emergency departments, guidelines for non-transportation situations have been implemented in EMS systems (Gray & Wardrope, 2007).

A recent systematic review of the literature showed a significant variation in non-transportation rates (3.7-93.7%) between different patient populations (Ebben et al., 2017). One study carried out in the Oulu-Koillismaa region in Northern Finland reported a 37.7% non-transportation rate (Pekanoja, Hoikka, Kyngäs, & Elo, 2018).

The factors causing non-transportation are affected by the availability of other healthcare services and by risk assessment at the dispatch (Ebben et al., 2017).

## **2.4 Early warning scores**

Interest in the development of early warning score (EWS) systems to facilitate early recognition of deteriorating in-patients began in the 1990s (Morgan, Williams, & Wright, 1997). EWSs are based on vital parameters measured and weighted by the deviation from the normal physiological variables but may also include laboratory findings and therapeutic treatments (Rhee, Fisher Jr., & Willitis, 1987; Smith, Prytherch, Schmidt, & Featherstone, 2008).

An increase in research led to a variety of different EWS tools developed for in-hospital and prehospital use (Table 2). However, a recent systematic review showed that despite promising results, clinical evidence supporting the use on EWS in prehospital is scarce (Williams et al., 2016) .

### **2.4.1 National early warning score**

The National Early Warning Score (NEWS) is based on six physiological parameters (respiratory rate, oxygen saturation, systolic blood pressure, pulse rate, level of consciousness and temperature). Each measurement is allocated a score of 0-3 determined by how much the parameter varies from normal. The score is aggregated and added by 2 points if supplemental oxygen is required to maintain recommended oxygen saturation. According to the score, medical risk can be categorized in three groups: low (NEWS 0-4), medium (NEWS 5-6, or individual parameter score of 3), and high (NEWS  $\geq$  7). Each group should be used as a trigger for appropriate urgency and quality of the clinical response.

In the hospital setting, the National Early Warning Score (NEWS) has shown better performance in discriminating adverse outcomes (ICU admission, cardiac arrest and death within 24 hours) than 33 other EWSs (Prytherch, Smith, Schmidt, & Featherstone, 2010; Smith, Prytherch, Meredith, Schmidt, & Featherstone, 2013) and the Royal College of Physicians recommends the use of NEWS in order to standardize the risk assessment of acutely ill patients throughout the entire chain of medical care, including in the prehospital phase (Royal College of Physicians, 2012). The recommendation was updated in 2017 to also consider patients with acute confusion or chronic hypercapnic respiratory failure (Royal College of Physicians, 2017)

**Table 2. Examples of different early warning score tools.**

Early Warning Score tool	Score range	Vital parameters	Other variables	Use in patient assessment
The Rapid Acute Physiology Score (RAPS)	0-16	Heart rate, mean arterial blood pressure, respiratory rate, Glasgow Coma Scale (0-4)		ED
Rapid Emergency Medicine Score (REMS)	0-26	Heart rate, mean arterial blood pressure, respiratory rate, Glasgow Coma Scale, oxygen saturation (0-4)	Age (0-6)	EMS, ED
Modified Early Warning Score (MEWS)	0-15	Respiratory rate, heart rate, systolic blood pressure, level of consciousness (AVPU), temperature (0-3)		Hospital Wards
VitalPAC Early Warning Score (VIEWS)	0-21	Heart rate, systolic blood pressure, respiratory rate, temperature, oxygen saturation, level of consciousness (AVPU) (0-3)	Supplemental oxygen used (0-3)	ED, Hospital wards
Physiological-social Early Warning Score (PMEWS)	0-21	Respiratory rate, heart rate, systolic blood pressure, oxygen saturation, level of consciousness (AVPU), temperature (0-3)	Age, social isolation, chronic diseases, performance status (0-1)	EMS, ED
National Early Warning Score (NEWS)	0-20	Heart rate, systolic blood pressure, respiratory rate, temperature, oxygen saturation, level of consciousness (AVPU) (0-3)	Supplemental oxygen used (0-2)	EMS, ED, Hospital wards
National Early Warning Score 2 (NEWS2)	0-20	Heart rate, systolic blood pressure, respiratory rate, temperature, oxygen saturation (scale for use in patients with hypercapnic respiratory failure), level of consciousness (ACVPU) (0-3)	Supplemental oxygen used (0-2)	EMS, ED, Hospital wards

The applicability of the NEWS in the prehospital setting is somewhat uncertain as the validation of this score has been performed with in-patients. The results of two studies with small cohorts (n=287 and 1684) suggest that prehospital NEWS could predict patients most likely to deteriorate (Shaw, Fothergill, Clark, & Moore, 2017; Silcock, Corfield, Gowens, & Rooney, 2015).

## **2.5 Emergency patient outcomes**

There is only scarce information on the outcomes of a heterogenous prehospital population. Several studies consist of particular patient groups and their outcomes.

The proportion of transported EMS patients discharged from Emergency Department is reported to vary between 52.8 and 71.0% (Clesham, Mason, Gray, Walters, & Cooke, 2008; Levine et al., 2006), whereas those admitted to intensive care is between 0.75 and 6.1% (Levine et al., 2006; Williams et al., 2015).

A Finnish study showed that 0.7% of EMS missions resulted in prehospital death (Kuisma et al., 2004). One study in United Kingdom showed a mortality rate of 6.2% at hospital discharge (Nicholl, West, Goodacre, & Turner, 2007). Furthermore, a large population-based Danish study with almost 150 000 EMS patients showed an overall 1-day mortality of 1.8% and a 30-day mortality of 4.7% (Christensen et al., 2016).

## **2.6 Summary of the literature**

The review of literature showed that there are gaps in our knowledge on whether the use of a National Early Warning Score in the prehospital setting is beneficial for evaluating the severity of illness and outcomes of prehospital patients.

### **3 Aims and hypothesis of the study**

The present study was designed to examine the efficacy of the criteria based dispatch protocol and the National Early Warning Score in the Finnish EMS system. Additionally, the aim of the research was to obtain data on patient allocation and mortality in the Northern Finnish population.

This study consists of four sub studies (I-IV) and addresses the following research questions

1. By how much does the use of Finnish criteria based dispatch protocol cause over- and under-triage? (I)
2. What is the proportion of non-transportation missions in the Finnish EMS system and what are the reasons for these missions? (II)
3. What is the allocation of transported emergency patients and does the prehospital National Early Warning Score differentiate patients requiring intensive care? (III)
4. Does the prehospital National Early Warning Score predict short-term mortality in unselected emergency patients? (IV)



## **4 Materials and methods**

### **4.1 Setting and design**

All studies (I-IV) were retrospective observational studies based on a six-month cohort (1.1.2014 – 30.6.2014) of prehospital emergency patients in two hospital districts – Kainuu and Länsi-Pohja – in Northern Finland (Fig. 1). All data were gathered from registries, and no clinical interventions or patient interviews were made.

#### **4.1.1 Study area**

The study areas comprised mostly scarcely habituated suburban and rural settings with long distances. These areas are home to a total of 140,000 inhabitants, representing 2.6% of the Finnish population, with a population density of 4.7 inhabitants per square kilometre. The age-standardized morbidity indexes were 118.3 in the Kainuu district and 128.5 in Länsi-Pohja during the study period (Finnish average 100) (The National Institute for Health and Welfare, 2015).

There are 6-8 municipal health care centres and one regional hospital in both districts. Health care centres are open during office hours on working days (Mon-Fri: 8am-4pm) providing most day-to-day medical services. Urgent care outside office hours is provided in the regional hospitals.

#### **4.1.2 Study permissions**

Permission to perform these studies was obtained from both hospital districts (12Mar2014 & 8Apr2014) and the Office of Data Protection Ombudsman (719/4225/2014). Additionally, to obtain access for the national in-patient and death registry data, the study protocol was approved by the Northern Ostrobothnia Hospital ethics committee (15/2015).



**Fig. 1. Map of Northern Finland and study areas (II, published by permission of Wiley).**

## **4.2 Registries and databases**

### **4.2.1 EMS database (I-IV)**

All prehospital data were gathered for the study from the study areas and named as EMS database. In the Kainuu region, the data was transferred manually from the paper EMS data sheets. In the Länsi-Pohja region, the data was transferred from the electronic EMS system (Merlot Medi®, CGI). Secondary inter-facility transports, homecare assistance missions and missions aborted by the EMCC were excluded from the data.

Collected data included the date and time of the EMS mission, response time, the patient's social security number, age, sex, dispatch code and priority, non-transportation code and first clinical variables (pulse rate, systolic blood pressure, respiration rate, oxygen saturation, Glasgow coma score and temperature) recorded at the scene, and whether supplemental oxygen for inspired air was used.

The statistical programme automatically calculated NEWS from the variables obtained in the database. In the Finnish emergency care services, a Glasgow Coma Scale (GCS) is used to evaluate the level of consciousness instead of AVPU-scale (Alert, response to Voice, response to Pain, Unresponsive) used in NEWS. In this study, a GCS of 14-15 was considered equivalent to A (Alert), and GCS < 14 as equivalent to VPU (Voice, Pain, Unresponsive).

#### **4.2.2 Finnish Care Registry for Health Care (HILMO) (III)**

The Finnish National Institute for Health and Welfare (THL) administrates the HILMO-register containing a range of data on the activities of health care centres, hospitals and other institutions providing inpatient care and, on the patients, treated in these facilities. The health care units are required to annually submit data to the register.

Data collected included the definitive care facility, length of hospital stay and primary diagnosis according to the ICD-10.

#### **4.2.3 Finnish Intensive Care Consortium Database (III)**

The Finnish Intensive Care Consortium is a benchmarked national quality database maintained by Tieto Healthcare & Welfare® including all the intensive care departments in Finnish hospitals. Core data on the severity of disease, given treatments and outcome are recorded in the database for each ICU admission. The comprehensiveness of the data in this database is good (Mussalo & Tenhunen, 2007).

The data collected included the length of ICU stay and primary diagnosis according to the ICD-10.

#### **4.2.4 Finnish Cause of Death Registry (IV)**

The Finnish Cause of Death Registry, with 100 per cent coverage, is maintained by Statistic Finland (Statistic Finland, 2015) . According the Finnish law and the Act on Determining of the Cause of Death (1973/459) an investigation of the cause of death is compulsory for deceased persons who were domiciled in Finland at the time of death.

Based on the data in death certificates, the registry contains data on deaths and mortality by cause of death, age, gender and other demographic variables. The statistics have been compiled since 1996 according to the 10th revision of the International Classification of Diseases (ICD-10).

Collected data included the time and cause of death.

### **4.3 Summary of study design and main outcome variables**

The summary of study designs and outcomes are presented in the Table 3. The flow chart describing step-by-step inclusion criteria of the 16,177 EMS missions included in the study data registry is presented in Figure 2.

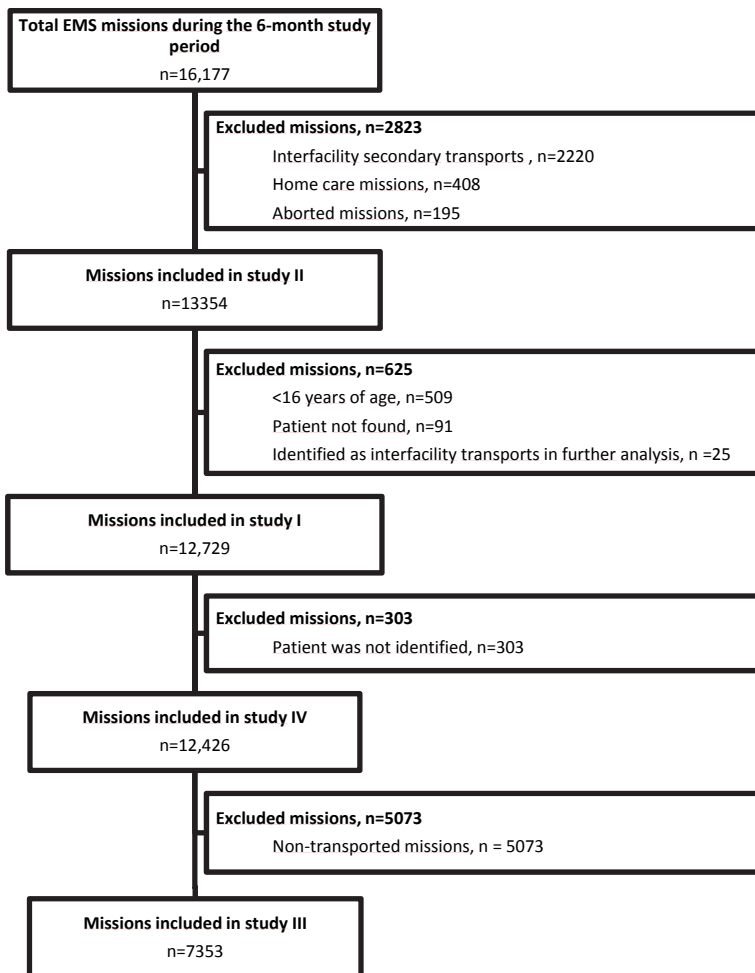
#### **4.3.1 Study I**

All EMS missions resulting in a patient encounter were included. Because NEWS has not been validated in children, missions involving patients less than 16 years of age were excluded. The EMS data gathered included demographic data, dispatch priority and NEWS-score.

To evaluate the accuracy of the dispatch protocol, the determined priority at the dispatch was compared with the NEWS at the scene. The high NEWS risk group was considered equal to highest priority A, the medium NEWS risk group as priority B and the low NEWS risk group as priority C and D (Table 4).

#### **4.3.2 Study II**

All missions from the EMS database were included in the study. Prehospital data consisted of the following: priority and dispatch code, demographic data, non-transportation code and distances to the hospital. In addition, regional information on health care use was collected from the national statistical database (The National Institute for Health and Welfare, 2015).



**Fig. 2. Flowchart of study inclusion criteria for the 16,177 EMS missions included in the study data registry.**

**Table 3. Summary of study designs and outcomes.**

Study designs and outcomes	Study I	Study II	Study III	Study IV
Registries used	EMS database	EMS database	EMS database HILMO-registry Intensive Care Consortium Database	EMS database Cause of Death Registry
Number of missions	12,739	13,354	7,353	12,426
Study question	How much does the use of Finnish criteria based dispatch protocol cause over- and under-triage	What is the proportion of non-transportation missions in Finnish EMS system and what are the reasons for these missions	Does the prehospital National Early warning score discriminate patients requiring intensive care	Does the prehospital National Early Warning Score predict the short-term mortality in unselected emergency patients
Primary analysis	Comparison of risk assessment at the dispatch (A-D) with on-scene (high-low)	Descriptive analysis of non-transportation missions	Binary diagnostic test at the cut-off risk levels	Binary diagnostic test at the cut-off risk levels
Main outcome	Dispatch accuracy: correct, over-triage, under-triage	Rate and cause of non-transportation missions	Efficacy of NEWS to predict ICU admission	Efficacy of NEWS to predict short-term mortality

**Table 4. Definition of dispatch priority accuracy (I, published by permission of BMC).**

Priority	NEWS High	NEWS Medium	NEWS Low
A	Correct	Over-triage	Over-triage
B	Under-triage	Correct	Over-triage
C	Under-triage	Under-triage	Correct
D	Under-triage	Under-triage	Correct

### **4.3.3 Study III**

All transported patients over 16 years of age by the EMS were included in the study. In order to obtain dispositions within 48 hours for patients, the prehospital data was merged with the Finnish Care Registry for Health Care (HILMO-registry) and the Finnish Intensive Consortium Database by using the patients' national social security number. Four patient outcome categories were formed: discharged from emergency department, admitted to a primary care ward, admitted to a hospital ward and admitted to the intensive care. The primary diagnosis according to ICD-10 was also retrieved from the HILMO-registry.

### **4.3.4 Study IV**

All prehospital patients over 16 years of age were included in the study. The patients' national social security number was used to couple prehospital data, including prehospital NEWS, to the mortality data retrieved from the Causes of Death Registry maintained by Statistic Finland.

## **4.4 Statistical methods**

Statistical analyses were performed using SPSS statistics-software, versions 22-24 (IBM Corp. Armonk, NY). Simple descriptive statistics (mean, standard deviation, range) were used in all studies, when analysing the data (I-IV).

In NEWS calculations, missing parameter values and symbols indicating normal values (e.g. □, N) were considered within normal range. (I, III-IV) In addition, a sensitive complete case analysis was performed to reduce bias. (I)

The Cohen's kappa coefficient was used to calculate inter-rater reliability between dispatch priority and NEWS. (I) A kappa value of >0.80 indicates almost

perfect reliability, 0.61-0.80 substantial reliability, 0.41-0.60 moderate reliability, 0.21-0.40 fair reliability, and <0.20 slight reliability.

Fisher's exact test was used to compare categorical data and a two-tailed P value of <0.05 was considered statistically significant. (II) To evaluate the association between hospital and rate of non-transportation missions, the Spearman's correlation was used. (II)

In study III, an EMS mission (as each mission representing a patient) was used as the unit in mortality calculations. Kaplan-Meier survival curves were drawn for the 30-day mortality. In addition, risk ratios with confidence intervals were calculated and Wald's test was used for statistical comparison with reference level. (III)

Statistical calculations for sensitivities, specificities, positive predictive values (PPVs), negative predictive values (NPVs), positive likelihood ratios (PLRs), and negative likelihood ratios (NLRs) for 1-day mortality, 30-day mortality and intensive care admission at the cut-off risks were performed (III, IV).

## 5 Results

The main results of the present study are presented in the Table 5. The flow chart describing the step-by-step inclusion criteria of the 16,177 missions included in the study data registry is presented in Figure 2.

**Table 5. Main results of the study.**

Study	Aim	Missions included	Main results
I	To study the accuracy of Finnish criteria based dispatch protocol	12,739	Risk assessment was correct in 67.5% of cases. Under-triage occurred in 9.2% and over-triage in 23.4% of cases.
II	To determine rate and causes of non-transportation missions	13,354	41.7% of the EMS missions did not lead to transportation. 48.2% of those did not require acute treatment and 33.9% did not require medical care at all.
III	To study the efficacy of prehospital NEWS in discriminating patients in need of intensive care	7,353	2.6% of EMS patients required intensive care and 39.8% of those were categorised as high-risk NEWS patients at the scene. The highest NEWS category showed a poor sensitivity for ICU admission (0.398)
IV	To study the accuracy of prehospital NEWS in predicting short-term mortality	12,426	A relative risk for 1-day and 30-day mortalities were 101.5 and 16, respectively, for patients with high risk NEWS. The highest NEWS category showed a good sensitivity for 1-day mortality (0.801) but 30-day sensitivity was low (0.424).

### 5.1 The accuracy of Finnish criteria based dispatch protocol (I)

Of the 12,729 patients, 4.8 % (616) were categorized as priority A by the dispatch, 25.1% (3193) as priority B, 44.3% (5637) as priority C and 25.8% (3283) as priority D. The distribution of the NEWS risk categories within each priority group is presented in Table 6.

**Table 6. Mission distribution according to dispatch priorities and National Early Warning Score (NEWS), number of cases (% of cases within priority).**

Priority	NEWS high	NEWS medium	NEWS low	Total
A	142 (23.1)	108 (17.5)	366 (59.4)	616 (100.0)
B	248 (7.8)	445 (13.9)	2500 (78.3)	3193 (100.0)
C	150 (2.7)	554 (9.8)	181 (5.5)	5637 (100.0)
D	33 (1.0)	4933 (87.5)	3069 (93.5)	3283 (100.0)
Total	573 (4.5)	1288 (10.1)	10868 (85.4)	12729 (100.0)

A comparison of dispatch assessment with the prehospital NEWS showed that the risk assessment was correct in 67.5% of cases (Table 7). Under-triage and over-triage occurred in 9.2% and 23.4% of the cases, respectively. Three-quarters of the calls classified as the highest A or B priorities were over-triaged. Under-triage occurred in 12.5% and 6.5% of cases among those classified as low-priority C and D missions, respectively. For all missions, the kappa coefficient was 0.131 (95% CI 0.109-0.152), indicating slight reliability between dispatch priority and prehospital NEWS.

**Table 7. The accuracy of risk assessment, derived from the NEWS, % of cases (number of cases) (I, published by permission of BMC).**

Priority	Correct	Under-triage	Over-triage	Total
A	23.1 (142)	-	76.9 (474)	100.0 (616)
B	13.9 (445)	7.8 (248)	78.3 (2500)	100.0 (3193)
C	87.5 (4933)	12.5 (704)	-	100.0 (5637)
D	93.5 (3069)	6.5 (214)	-	100.0 (3283)
Total	67.5 (8589)	9.2 (1166)	23.4 (2974)	100.0 (12729)

## 5.2 Patient allocation in prehospital population in Northern Finland

### 5.2.1 Non-transportation EMS missions (II)

The patient was not transported by the ambulance in 41.7% (5,570/13,354) of the EMS missions. The non-transportation rate (NTR) was 29.3% (95% CI: 27.9-30.7) during office hours (Mon-Fri 8:00 am to 4:00 pm) and 46.9% (95% CI: 45.9-48.0) outside office hours, respectively. Longer distances to the emergency department had an impact on higher NTR outside office hours (Spearman  $\rho = 0.656$ ,  $P = 0.008$ ), but not during office hours (Spearman  $\rho = 0.220$ ,  $P = 0.431$ ). There were differences in the NTRs between regions, the NTR of the Kainuu region was 46.2% (95% CI:

45.1-47.3), compared to 32.3% (95% CI: 30.9-33.6) ( $P < 0.001$ ) in the Länsi-Pohja region.

### **5.2.2 The definite care site of transported EMS patients (III)**

Among transported EMS patients, 57.4% (4,224/7,353) required in-hospital care, while 42.6% were discharged after care given at the emergency department. 19.4% of transported patients were admitted to primary care wards, 35.4% to hospital wards and 2.6% to the intensive care. The mean length of stay for all hospitalized patients was 11.8 days. For those admitted to primary care wards, hospital wards and intensive care, the length of stay was 9.4, 12.6 and 17.6 days, respectively. Mean ICU days was 3.8.

### **5.2.3 Short-term mortality of EMS patients (IV)**

In this cohort, the overall 30-day mortality was 4.5% (561/12,426). Of the patients that died, death occurred within 24 hours of the EMS mission in 191 cases, 118 during the prehospital phase, and 73 in the hospital.

## **5.3 Diagnostic pattern of hospitalized EMS patients and causes of death (III-IV)**

The most frequent diagnoses for hospitalized patients according to the ICD-10 categories were 'diseases of the circulatory system' (19.9%), 'injury, poisoning and certain other consequences of external cause' (13.8%), 'diseases of the respiratory system' (12.2%) and 'symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified' (10.7%). The proportions of 'diseases of the circulatory system' and 'injury, poisoning and certain other consequences of external cause' were higher in intensive and hospital care, whereas 'mental and behavioural disorders' and 'symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified' in the general wards.

In this population, circulatory system diseases (44.2%) were the leading causes of death, followed by neoplasms (16.6%), diseases of the nervous system (10.5%), and external causes (e.g. injuries, poisonings) (9.8%). The majority of early deaths (within 24 hours) were caused by circulatory system diseases and external causes. The proportion of neoplasms and diseases of the nervous system increased during days 2-30.

## 5.4 Efficacy of the prehospital National Early Warning score (III-IV)

Table 8 summarises the efficacy of prehospital NEWS in predicting important clinical outcomes: need for intensive care and short-term mortality.

**Table 8. Sensitivity and specificity for adverse patient outcomes at the cut-off high and medium risks categorized according to the prehospital National Early Warning Score (NEWS).**

Outcome	Statistical measure	NEWS High	NEWS Medium
	Missions, n	550	1958
ICU admission	Sensitivity (95% CI)	0.398 (0.328-0.471)	0.717 (0.648-0.780)
	Specificity (95% CI)	0.934 (0.928-0.940)	0.746 (0.736-0.756)
	PPV	0.138	0.070
	NPV	0.983	0.990
	PLR	6.01	2.82
	NLR	0.64	0.38
		Missions, n	718
1-day mortality	Sensitivity (95% CI)	0.801 (0.737-0.855)	0.890 (0.837-0.931)
	Specificity (95% CI)	0.954 (0.950-0.958)	0.806 (0.798-0.813)
	PPV	0.213	0.067
	NPV	0.997	0.998
	PLR	17.36	4.58
	NLR	0.21	0.14
		Missions, n	718
30-day mortality	Sensitivity (95% CI)	0.424 (0.383-0.466)	0.630 (0.588-0.670)
	Specificity (95% CI)	0.960 (0.956-0.963)	0.815 (0.808-0.822)
	PPV	0.332	0.138
	NPV	0.972	0.979
	PLR	10.49	3.40
	NLR	0.60	0.46

RR: relative risk; 95% CI: 95% confidence interval; PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio.

#### **5.4.1 Ability to predict intensive care admission (III)**

Patients admitted to intensive care had significantly higher mean NEWS value (6.32) than had those patients admitted to other definitive care sites (hospital ward 2.70; primary care 2.39; discharged 1.73). The proportion of the high NEWS risk category in patients admitted to intensive care was also higher (39.8%) compared to those admitted onto hospital wards (10.3%), admitted to primary care wards (7.1%) and discharged from the emergency department (3.3%).

The high NEWS risk category had a poor sensitivity (0.398; 95% CI 0.328-0.471) in predicting ICU admission, but specificity was high (0.934; 95% CI 0.928-0.940). The corresponding sensitivity and specificity values for the medium NEWS risk category were 0.717 (95% CI 0.648-0.780) and 0.746 (95% CI 0.736-0.756).

#### **5.4.2 Ability to predict short-term mortality (IV)**

Among prehospital adult patients, the mortality rate exceeded 10% in patients with NEWS values above twelve (1-day mortality) and NEWS values above six (30-day mortality). A relative risk for 1-day and 30-day mortality in the high NEWS risk category was 101.5 and 16, respectively, compared with the low NEWS risk category. Similarly, in medium NEWS risk category, the relative risk was 3.0 and 4.4, respectively.

The high NEWS risk category had a good sensitivity for 1-day mortality (0.801; 95% CI 0.737-0.855) but poor sensitivity for 30-day mortality (0.424; 95% CI 0.383-0.466). Specificity values of high NEWS category for 1-day and 30-day mortality were high 0.954 (95% CI 0.950-0.958) and 0.960 (95% CI 0.956-0.963), respectively.



## **6 Discussion**

### **6.1 Main findings**

The results of this study showed an under-triage rate of 9% and an over-triage rate of 23 % at dispatch using a criteria based dispatch protocol, and with a National Early Warning Score (NEWS) risk assessment at the scene (I). In addition, the use of a protocol resulted in a significant rate of EMS missions without ambulance transportation (II).

For the majority of the patients encountered by the EMS personnel, the medical treatment could be carried out at scene or at the emergency department (II, III). Indeed, only a small proportion of patients needed intensive care or died within 30 days of the EMS mission (III, IV).

There were some associations between the prehospital NEWS and adverse outcomes, such as the need for intensive care and short-term mortality, implying that prehospital NEWS may be a useful tool in the EMS setting. However, the predictive value of prehospital NEWS in discriminating patients at risk of death and their need for intensive care was not adequate, as the sensitivities were poor (III, IV).

These findings demonstrate the inconvenience of the risk assessment in a large, non-selected population in which only a few patients are critically ill.

### **6.2 Strengths of the study and generalizability of the results**

The principal strength of this study is a large cohort representing a typical unselected EMS population in two different hospital districts. A sufficiently large cohort is necessary to test the effectiveness of risk assessment tools in clinical work and to describe the overall features of prehospital emergency care. In addition, the data registries used for the research were of high quality with a low degree of missing information (Reinikainen et al., 2012; Sund, 2012)

The study results are generalizable on the national level, as the use of the same criteria based dispatch protocol, as well as general guidelines and procedures in the EMS do not markedly differ from region to region in Finland. There are some disparities in the availability of health care services between hospital districts, however, which may affect the population's tendency to contact the EMS.

Due to disparities in dispatch protocols in different countries, the results of studies I-II are not fully generalizable. This is particularly true in countries using

medical priority dispatch system (MPD) protocols with more structured questions and different urgency determinants.

As NEWS is a standardized tool, the results of III-IV studies can be generalized internationally to some extent, although there are differences between countries in mortality and patient characteristics. For example, the prevalence of cardiovascular or cancer diseases may vary between countries. In addition, differences in health care policies and resources may impact on the place of death (Cohen et al., 2015).

### **6.3 The accuracy of the Finnish criteria based dispatch protocol (I)**

In the present study, the distribution of dispatch priorities was comparable with other Finnish studies, including those undertaken in the Helsinki metropolitan area and in Southern-Finland (Kuisma et al., 2004; Lindström et al., 2011). The dispatch priority allocation differed from the Danish dispatch system (Andersen et al., 2013).

This study showed that a quarter of EMS missions were over-triaged and 9% of missions were under-triaged. Only 23% of the highest priority missions were still assessed as high priority at the scene. Similar findings have been found in the Swedish system, which accounted for a 27% discrepancy of the risk assessments between the dispatch and at the scene (Khorram-Manesh, Lennquist Montán, Hedelin, Kihlgren, & Örténwall, 2011). In addition, more than 70% of the highest priority missions were evaluated as non-life-threatening situations (Zakariassen, Burman, & Hunskaar, 2010)

These findings indicate that the current Finnish dispatch protocol is not optimal. The high rate of over-triage has been shown to lead to an inappropriate use of EMS resources and may thus increase the risk of ambulance traffic accidents due to unnecessary light-and-siren calls (Ornato, 2009). Longer delays in reaching patients and an underestimation of the severity of the condition at dispatch may together result as a negative impact on the patients' morbidity and survival.

It is challenging to find critically ill patients in a large, heterogenic population, resulting in a problematic definition of an acceptable level of over- and under-triage. Among trauma patients, over-triage rates of 25-50% and under-triage rates of 1-5% has been considered as being acceptable (*Guidelines for field triage of injured patients. Recommendations of the national expert panel on field triage, 2009*).

## **6.4 Non-transportation EMS missions (II)**

In the present study, four out of 10 EMS patients were not deemed necessary for ambulance transport. This finding agrees with another more recent study performed in Northern Finland (Pekanoja et al., 2018). Paramedics instructed approximately half of these patients to contact their primary health care with a non-urgent matter. No need for ambulance transportation to the emergency department was applicable for 3.8% of patients, while one-third of patients did not need any medical care at all. The rate of non-transportation increased outside office hours and in relation to increasing distance.

The worldwide problem of inappropriate utilization of EMS resources has been recognized since the 1970s (Lowthian et al., 2011; Morris & Cross, 1980). The reasons for people requesting ambulance with minor illnesses or non-medical problems may be multi-factorial, including their perceptions of urgency, sociodemographic factors, social circumstances and access to other health care services. A recent review summarized factors in five broad categories: factors associated with individual patients; actions of care-givers and bystanders; population-level factors; health infrastructure factors and challenges faced by health professionals (Booker et al., 2015).

These results emphasize the difficulty of assessing a patient's condition over the phone, especially by non-healthcare professionals. A Swedish study found that it is difficult to obtain adequate information from the caller, which subsequently results in the need for assessment at the scene (Hjälte, Suserud, Herlitz, & Karlberg, 2007).

## **6.5 The definite care site of transported EMS patients (III)**

In this study, 42% of transported EMS patients were discharged after the care given at the emergency department while only a few patients needing intensive care. A similarly low rate of ICU-admission (4,5 %) following hospitals admission was reported in a recent US study with an EMS patient cohort of non-trauma, non-cardiac arrest adults (Kievlan et al., 2016). The present findings indicate that despite the high rate of non-transportation decisions during the prehospital phase, a prominent proportion of the transported patients had minor illnesses or traumas.

## **6.6 Short-term mortality of EMS patients (IV)**

This study showed that the overall 1-day and 30-day mortality of EMS patients is low, 1.5% and 4.3%, respectively. The results in the present study resemble those in a population-based Danish study (Christensen et al., 2016), but differ considerably from the 48-hour mortality rate of 11% reported in a Swiss study (Pittet et al., 2014).

## **6.7 Diagnostic pattern of hospitalized EMS patients and causes of death (III-IV)**

The diagnostic pattern of hospitalized EMS patients varied widely and included all chapters of the ICD-10. This result indicates the wide variety of prehospital patient characteristics and therefore the prehospital research should not focus only on specific groups as has been elsewhere suggested (Fevang, Lockey, Thompson, Lossius, & Torpo, 2011). In the present study, circulatory diseases, traumas and respiratory diseases consisted of more than half of the diagnoses. The proportion of non-specific Z- and R-diagnoses would be higher if patients treated at the emergency department were to be included (Christensen et al., 2016).

In general, cardiovascular diseases dominate the cause of death in prehospital patients, but traumatic deaths were more prevalent in the cases with a 1-day mortality. A prominent number of traumatic deaths are still estimated to be preventable and the EMS system needs to be further developed (Bakke & Wisborg, 2017) A high proportion of deaths due to neoplasms and diseases of the nervous system indicate that a large number of chronically ill patients need EMS during their last days of life.

## **6.8 Efficacy of prehospital the National Early Warning Score (III, IV)**

In the present study, there were some associations between prehospital NEWS and adverse outcomes, as patients with a high NEWS risk category were more likely to be admitted to intensive care or had a higher risk for death. The use of prehospital NEWS had a good sensitivity for predicting 1-day mortality, however, but failed to acceptably predict ICU admission or 30-day mortality due to the large number of false negatives.

A British study showed higher NEWS values in patients admitted to the ICU (mean 7.46) or who died (mean 7.20), than that observed in those who were discharged from ED (mean 1.72) or admitted to the ward (mean 3.13) (Shaw et al., 2017). The study by Silcock et al. showed a high risk NEWS category sensitivity for ICU admission, 48h mortality and 30-day mortality 0.411, 0.714 and 0.404, respectively (Silcock et al., 2015). These results resemble the findings of this study. In addition, a recent British study demonstrated a 4.45 fold increase in the odds of death or ICU admission in patients with high risk NEWS compared to low risk patients (Abbott et al., 2018).

The results of the present study suggest that the predictive value of a single prehospital NEWS measurements in the brief time interval is low. The trend data from repeated NEWS calculations or a multivariable model may offer a better tool for discriminating patients developing a critical illness (Cameron, Rodgers, Ireland, Jamdar, & McKay, 2015).

## **6.9 Limitations of the thesis**

This study has some evident limitations. First, the study design was retrospective, and the registries used were not originally designed for the study. Nevertheless, this was the only possible method for collecting, for example, mortality data.

Secondly, in the NEWS calculations, the missing values and symbols indicating normal (e.g. N, ) were considered as normal range (I, III, IV). This may have contributed to the fact that some patients were incorrectly assigned with a lower risk value. In daily practice, however, patients who are assessed as being sicker by EMS personnel are more comprehensively evaluated. Excluding a significant proportion of patients with incomplete data would have resulted in a greater bias in the results.

Third, the Finnish personal identification number was missing from 1.9% (303) of patients, so hospital care and mortality data could not be collected (III, IV).

Fourthly, data on emergency department care was not available due to the lack of such a registry (III). In addition, collecting such a large number of patients through individual patient records would have been overwhelming.

Finally, dispatchers' compliance with the dispatch protocol was not retrieved, and, therefore, the results could be biased by subjective decisions by the EMCC personnel (II).

## 6.10 Clinical and practical implications

It is evident in the light of the results of this study that the current risk assessment practices in Finnish EMS are suboptimal and may negatively affect the management of the already limited emergency care resources. In the context of legislative reforms, it is also necessary to evaluate its impact on the availability of health care services in order to avoid unnecessarily increasing the burden and costs of different units.

When creating triage and non-transportation guidelines, it should be careful when defining the word “unnecessary” as the patient’s need for some care does, however, exist. The overall health care system should respond to the patients’ primary care -level and social problems in order to avoid patients overburdening the emergency care services with chronic conditions. One way would be to develop electronic triage applications for patient self-determination of urgency. The implementation of a community paramedical program in the EMS is also recommended to supplement the health care system. The decision to not transport a patient by the EMS staff at the scene requires a robust protocol and an accurate prehospital scoring system to ensure patient safety.

It is necessary to create a national EMS database which includes EMCC data combined with automated patient data records, to enable high quality research on emergency care in the future. The Finnish dispatch protocol needs to be re-evaluated by analysing individual dispatch criteria, especially for non-urgent keywords to improve triage accuracy. Validation of the criteria based dispatch protocol is needed, preferably through international cooperation. In non-urgent cases in which the emergency has been ruled out by the dispatcher, directing calls to health care professionals for secondary assessment could be beneficial. There are models that use secondary nurse triage protocol to identify risk patients among the low-acuity calls (Scott et al., 2015)

Implementation of a National Early Warning Score throughout the chain of patient care may be suggested. The positive impact would be a similar risk assessment at each treatment stage, enabling trend data from repeated measurements. NEWS calculations should be performed automatically based on the vital parameters entered in the electronic patient care records. As the results of this study demonstrated, however, the decision-making should not be based solely on the NEWS. In addition to evaluating the NEWS, healthcare providers must also access co-existing factors that increase the risk of a life-threatening condition in individual patients.

## **6.11 Suggestions for future studies**

Dispatch protocols today vary markedly between countries. More data on the efficacies and accuracies of the different national protocols is needed in order to find the optimum protocol in the future. In addition, factors affecting triage over the phone should be identified and more closely studied. Prehospital risk scores should also be developed to more accurately estimate illness severity during the prehospital phase to help patient triage, as should the risk adjustment necessary for quality registry of prehospital care. Prospective studies are needed to identify the risk assessment scores best suited to the prehospital setting.

Risk assessment tools in hospitalised patients using other variables should also be tested in prehospital setting such as the recently studied prehospital lactate measurements (Tobias et al., 2014). Furthermore, there is a need for a specific scoring system for the out-of-hospital identification of patients with life threatening sepsis (Barbara et al., 2018; Tugul, Carron, Yersin, Calandra, & Dami, 2017).

This study also indicated that the overall provision of emergency care in health care systems should be evaluated in more detail.



## 7 Conclusion

The present study aimed to examine the efficacy of a criteria based dispatch protocol and the National Early Warning Score in the Finnish EMS system. Overall, the answers to the study questions were successfully achieved using a large unselected, typical EMS population from two different hospital districts. An additional aim of the study was to obtain data on patient allocation and outcome in a Northern Finnish population. The results support existing evidence and specifically highlight that the extended use of NEWS in the prehospital environment is not fully reliable as a single measurement.

Based on the results, the following conclusions were drawn:

1. The use of the Finnish dispatch protocol resulted overall in a 23% rate of over-triage and a 9% rate of under-triage (I).
2. 42% of EMS patients were not transported by ambulance, of which half were directed to contact their primary care facility in a non-urgent matter, while another third required no medical care at all (II).
3. 2.6% of EMS patients transported were admitted to intensive care units. A pre-hospital National Early Warning Score showed a poor sensitivity for discriminating patients in need of intensive care (III).
4. A prehospital National Early Warning Score predicted the 1-day mortality acceptably, but the predictive value for 30-day mortality was poor (IV).



## References

- Abbott, T. E. F., Cron, N., Vaid, N., Ip, D., Torrance, H. D. T., & Emmanuel, J. (2018). Pre-hospital national early warning score (NEWS) is associated with in-hospital mortality and critical care unit admission: A cohort study. *Annals of Medicine and Surgery*, 27, 17-21. doi:10.1016/j.amsu.2018.01.006.
- Andersen, M. S., Johnsen, S. P., Sørensen, J. N., Jepsen, S. B., Hansen, J. B., & Christensen, E. F. (2013). Implementing a nationwide criteria-based emergency medical dispatch system: A register-based follow-up study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 21(1) doi:10.1186/1757-7241-21-53.
- Bakke, H. K., & Wisborg, T. (2017). The trauma chain of survival — each link is equally important (but some links are more equal than others). *Injury*, 48(5), 975-977. doi://doi.org/10.1016/j.injury.2017.04.001.
- Barbara, P., Graziano, C., Caputo, W., Litvak, I., Battinelli, D., & Hahn, B. (2018). The quick sequential organ failure assessment (qSOFA) identifies septic patients in the out-of-hospital setting. *American Journal of Emergency Medicine*, 36(6), 1022-1026. doi:10.1016/j.ajem.2018.01.073.
- Booker, M. J., Shaw, A. R. G., & Purdy, S. (2015). Why do patients with ‘primary care sensitive’ problems access ambulance services? A systematic mapping review of the literature. *BMJ Open*, 5(5) doi:10.1136/bmjopen-2015-007726.
- Cameron, A., Rodgers, K., Ireland, A., Jamdar, R., & McKay, G. A. (2015). A simple tool to predict admission at the time of triage. *Emergency Medicine Journal*, 32(3), 174-179. doi:10.1136/emermed-2013-203200.
- Christensen, E. F., Larsen, T. M., Jensen, F. B., Bendtsen, M. D., Hansen, P. A., Johnsen, S. P., & Christiansen, C. F. (2016). Diagnosis and mortality in prehospital emergency patients transported to hospital: A population-based and registry-based cohort study. *BMJ Open*, 6(7) doi:10.1136/bmjopen-2016-011558.
- Clawson, J. J., Cady, G. A., Martin, R. L., & Sinclair, R. (1998). Effect of a comprehensive quality management process on compliance with protocol in an emergency medical dispatch center. *Annals of Emergency Medicine*, 32(5), 578-584. doi:10.1016/S0196-0644(98)70036-8.
- Clesham, K., Mason, S., Gray, J., Walters, S., & Cooke, V. (2008). Can emergency medical service staff predict the disposition of patients they are transporting? *Emergency Medicine Journal*, 25(10), 691-694. doi:10.1136/emj.2007.054924.
- Cohen, J., Pivodic, L., Miccinesi, G., Onwuteaka-Philipsen, B. D., Naylor, W. A., Wilson, D. M., Deliens, L. (2015). International study of the place of death of people with cancer: A population-level comparison of 14 countries across 4 continents using death certificate data. *British Journal of Cancer*, 113(9), 1397-1404. doi:10.1038/bjc.2015.312.
- Culley, L. L., Henwood, D. K., Clark, J. J., Eisenberg, M. S., & Horton, C. (1994). Increasing the efficiency of emergency medical services by using criteria based dispatch. *Annals of Emergency Medicine*, 24(5), 867-872. doi:10.1016/S0196-0644(54)00223-5.

- Dami, F., Golay, C., Pasquier, M., Fuchs, V., Carron, P. -, & Hugli, O. (2015). Prehospital triage accuracy in a criteria based dispatch centre. *BMC Emergency Medicine*, 15(1) doi:10.1186/s12873-015-0058-x.
- Dami, F., Heymann, E., Pasquier, M., Fuchs, V., Carron, P. -, & Hugli, O. (2015). Time to identify cardiac arrest and provide dispatch-assisted cardio-pulmonary resuscitation in a criteria-based dispatch system. *Resuscitation*, 97, 27-33. doi:10.1016/j.resuscitation.2015.09.390.
- Deakin, C. D., Sherwood, D. M., Smith, A., & Cassidy, M. (2006). Does telephone triage of emergency (999) calls using advanced medical priority dispatch (AMPDS) with department of health (DH) call prioritisation effectively identify patients with an acute coronary syndrome? an audit of 42 657 emergency calls to hampshire ambulance service NHS trust. *Emergency Medicine Journal*, 23(3), 232-235. doi:10.1136/emj.2004.022962.
- Decree by the ministry of social affairs and health on the emergency medical services (585/2017), Retrieved from <https://www.finlex.fi/fi/laki/alkup/2017/20170585>.
- Ebben, R. H. A., Vloet, L. C. M., Speijers, R. F., Tönjes, N. W., Loef, J., Pelgrim, T., Berben, S. A. A. (2017). A patient-safety and professional perspective on non-conveyance in ambulance care: A systematic review. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 25(1) doi:10.1186/s13049-017-0409-6.
- Ellensen, E. N., Naess, H., Wisborg, T., Hunskaar, S., & Zakariassen, E. (2018). Stroke identification by criteria based dispatch – a register based study. *Acta Anaesthesiologica Scandinavica*, 62(1), 105-115. doi:10.1111/aas.13032.
- Fevang, E., Lockey, D., Thompson, J., Lossius, H. M., & Torpo, R. C. (2011). The top five research priorities in physician-provided pre-hospital critical care: A consensus report from a european research collaboration. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 19, 57.
- Gray, J. T., & Wardrope, J. (2007). Introduction of non-transport guidelines into an ambulance service: A retrospective review. *Emergency Medicine Journal*, 24(10), 727-729. doi:10.1136/emj.2007.048850.
- Guidelines for field triage of injured patients. Recommendations of the national expert panel on field triage. *Morbidity and mortality weekly report*. (2009). (No. 1).
- Hardeland, C., Olasveengen, T. M., Lawrence, R., Garrison, D., Lorem, T., Farstad, G., & Wik, L. (2014). Comparison of medical priority dispatch (MPD) and criteria based dispatch (CBD) relating to cardiac arrest calls. *Resuscitation*, 85(5), 612-616. doi:10.1016/j.resuscitation.2014.01.029.
- Hjälte, L., Suserud, B., Herlitz, J., & Karlberg, I. (2007). Why are people without medical needs transported by ambulance? A study of indications for pre-hospital care. *European Journal of Emergency Medicine*, 14(3), 151-156. doi:10.1097/MEJ.0b013e3280146508
- Jacobs, I. G. (2011). Emergency medical dispatch – more than merely sending the ambulance! *Resuscitation*, 82(12), 1473-1474. doi://doi.org/10.1016/j.resuscitation.2011.10.004.

- Khorram-Manesh, A., Lennquist Montán, K., Hedelin, A., Kihlgren, M., & Örtenwall, P. (2011). Prehospital triage, discrepancy in priority-setting between emergency medical dispatch centre and ambulance crews. *European Journal of Trauma and Emergency Surgery*, *37*(1), 73-78. doi:10.1007/s00068-010-0022-0.
- Kievlan, D. R., Martin-Gill, C., Kahn, J. M., Callaway, C. W., Yealy, D. M., Angus, D. C., & Seymour, C. W. (2016). External validation of a prehospital risk score for critical illness. *Critical Care*, *20*(1) doi:10.1186/s13054-016-1408-0.
- Kuisma, M., Holmström, P., Repo, J., Määttä, T., Nousila-Wiik, M., & Boyd, J. (2004). Prehospital mortality in an EMS system using medical priority dispatching: A community based cohort study. *Resuscitation*, *61*(3), 297-302.
- Levine, S. D., Colwell, C. B., Pons, P. T., Gravitz, C., Haukoos, J. S., & McVane, K. E. (2006). How well do paramedics predict admission to the hospital? A prospective study. *Journal of Emergency Medicine*, *31*(1), 1-5. doi:10.1016/j.jemermed.2005.08.007.
- Lindstrom, V., Pappinen, J., Falk, A. C., & Castren, M. (2011). Implementation of a new emergency medical communication centre organization in finland--an evaluation, with performance indicators. *Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine*, *19*, 19. doi://dx.doi.org/10.1186/1757-7241-19-19.
- Lowthian, J. A., Cameron, P. A., Stoelwinder, J. U., Curtis, A., Currell, A., Cooke, M. W., & McNeil, J. J. (2011). Increasing utilisation of emergency ambulances. *Australian Health Review*, *35*(1), 63-69. doi:10.1071/AH09866.
- Lyon, R. M., Bohm, K., Christensen, E. F., Olasveengen, T. M., & Castren, M. (2013). The inaugural european emergency medical dispatch conference--a synopsis of proceedings. *Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine*, *21*, 73. doi://dx.doi.org/10.1186/1757-7241-21-73.
- Määttä, T., Kuisma, M., Väyrynen, T., Nousila-Wiik, M., Porthan, K., Boyd, J., Räsänen, P. (2010). Fusion of dispatching centres into one entity: Effects on performance. *Acta Anaesthesiologica Scandinavica*, *54*(6), 689-695. doi://dx.doi.org/10.1111/j.1399-6576.2010.02243.x.
- Ministry of Social Affairs and Health. (2016). *International expert panel pre-review of health and social care reform in Finland*. Retrieved from <http://urn.fi/URN:ISBN:978-952-00-3848-9>.
- Morgan, R., Williams, F., & Wright, M. (1997). An early warning scoring system for detecting developing critical illness. *Clinical Intensive Care*, *8*, 100.
- Morris, D. L., & Cross, A. B. (1980). Is the emergency ambulance service abused? *British Medical Journal*, *281*(6233), 121-123.
- Mussalo, P., & Tenhunen, J. (2007). Data completeness in the finnish intensive care quality consortium database. *Critical Care*, *11*, P501. doi:10.1186/cc5661.
- Nicholl, J., West, J., Goodacre, S., & Turner, J. (2007). The relationship between distance to hospital and patient mortality in emergencies: An observational study. *Emergency Medicine Journal*, *24*(9), 665-668. doi:10.1136/emj.2007.047654.
- Ornato, J. P. (2009). Science of emergency medical dispatch. *Circulation*, *119*(15), 2023-2025. doi:10.1161/CIRCULATIONAHA.109.855130.

- Pekanoja, S., Hoikka, M., Kyngäs, H., & Elo, S. (2018). Non-transport emergency medical service missions – a retrospective study based on medical charts. *Acta Anaesthesiologica Scandinavica*, *62*(5), 701-708. doi:10.1111/aas.13071.
- Pittet, V., Burnand, B., Yersin, B., & Carron, P. (2014). Trends of pre-hospital emergency medical services activity over 10 years: A population-based registry analysis. *BMC Health Services Research*, *14*(380) doi:10.1186/1472-6963-14-380.
- Prytherch, D. R., Smith, G. B., Schmidt, P. E., & Featherstone, P. I. (2010). ViEWS--towards a national early warning score for detecting adult inpatient deterioration. *Resuscitation*, *81*(8), 932-937. doi://dx.doi.org/10.1016/j.resuscitation.2010.04.014.
- Reinikainen, M., Mussalo, P., Hovilehto, S., Uusaro, A., Varpula, T., Kari, A., & Pettilä, V. (2012). Association of automated data collection and data completeness with outcomes of intensive care. A new customised model for outcome prediction. *Acta Anaesthesiologica Scandinavica*, *56*(9), 1114-1122. doi:10.1111/j.1399-6576.2012.02669.x.
- Rhee, K. J., Fisher Jr., C. J., & Willitis, N. H. (1987). The rapid acute physiology score. *American Journal of Emergency Medicine*, *5*(4), 278-282. doi:10.1016/0735-6757(87)90350-0.
- Roudsari, B. S., Nathens, A. B., Arreola-Risa, C., Cameron, P., Civil, I., Grigoriou, G., Rivara, F. P. (2007). Emergency medical service (EMS) systems in developed and developing countries. *Injury*, *38*(9), 1001-1013. doi:10.1016/j.injury.2007.04.008.
- Royal College of Physicians. (2012). *National early warning score (NEWS): Standardizing the assessment of acute-illness severity in the NHS. Report of a working party*. London.
- Royal College of Physicians. (2017). *National early warning score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS. Updated report of a working party*. London.
- Sasser, S., Varghese, M., Kellermann, A., Lormand, J. D. (2005). Prehospital trauma care systems. Geneva, World Health Organization.
- Scott, G., Clawson, J., Fivaz, M. C., McQueen, J., Gardett, M. I., Schultz, B., Olola, C. H. O. (2015). Using on-scene EMS responders' assessment and electronic patient care records to evaluate the suitability of EMD-triaged, low-acuity calls for secondary nurse triage in 911 centers. *Prehospital and Disaster Medicine*, *31*(1), 46-57. doi:10.1017/S1049023X15005567.
- Shah, M. N. (2006). The formation of the emergency medical services system. *American Journal of Public Health*, *96*(3), 414-423. doi:10.2105/AJPH.2004.048793
- Shaw, J., Fothergill, R. T., Clark, S., & Moore, F. (2017). Can the prehospital national early warning score identify patients most at risk from subsequent deterioration? *Emergency Medicine Journal*, *34*(8), 533-537. doi:10.1136/emmermed-2016-206115.
- Silcock, D. J., Corfield, A. R., Gowens, P. A., & Rooney, K. D. (2015). Validation of the national early warning score in the prehospital setting. *Resuscitation*, *89*(C), 31-35. doi:10.1016/j.resuscitation.2014.12.029.
- Smith, G. B., Prytherch, D. R., Meredith, P., Schmidt, P. E., & Featherstone, P. I. (2013). The ability of the national early warning score (NEWS) to discriminate patients at risk of early cardiac arrest, unanticipated intensive care unit admission, and death. *Resuscitation*, *84*(4), 465-470. doi:10.1016/j.resuscitation.2012.12.016.

- Smith, G. B., Prytherch, D. R., Schmidt, P. E., & Featherstone, P. I. (2008). Review and performance evaluation of aggregate weighted 'track and trigger' systems. *Resuscitation*, 77(2), 170-179. doi:10.1016/j.resuscitation.2007.12.004.
- Statistic Finland. (2015). *Statistical database*. Statistic Finland.
- Sund, R. (2012). Quality of the finnish hospital discharge register: A systematic review. *Scandinavian Journal of Public Health*, 40(6), 505-515. doi:10.1177/1403494812456637.
- The National Institute for Health and Welfare. (2015). Statistical database. Retrieved from <https://www.thl.fi/en/web/thlfi-en/statistics>.
- Tobias, A. Z., Guyette, F. X., Seymour, C. W., Suffoletto, B. P., Martin-Gill, C., Quintero, J., Yealy, D. M. (2014). Pre-resuscitation lactate and hospital mortality in prehospital patients. *Prehospital Emergency Care*, 18(3), 321-327. doi:10.3109/10903127.2013.869645.
- Tusgul, S., Carron, P., Yersin, B., Calandra, T., & Dami, F. (2017). Low sensitivity of qSOFA, SIRS criteria and sepsis definition to identify infected patients at risk of complication in the prehospital setting and at the emergency department triage. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 25(1) doi:10.1186/s13049-017-0449-y.
- Williams, T. A., Tohira, H., Finn, J., Perkins, G. D., & Ho, K. M. (2016). The ability of early warning scores (EWS) to detect critical illness in the prehospital setting: A systematic review. *Resuscitation*, 102, 35-43. doi:10.1016/j.resuscitation.2016.02.011.
- Williams, T. A., Finn, J., Fatovich, D., Brink, D., Ho, K. M., & Tohira, H. (2015). Prehospital factors associated with an ICU admission from the emergency department. *Critical Care*, 19, P405. doi:10.1186/cc14485
- Zachariah, B. S., & Pepe, P. E. (1995). The development of emergency medical dispatch in the USA: A historical perspective. *European Journal of Emergency Medicine*, 2(3), 109-112.
- Zakariassen, E., Burman, R.A., & Hunskaar, S. (2010). The epidemiology of medical emergency contacts outside hospitals in Norway – a prospective population based study. *Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine*, 18, 9. doi://dx.doi.org/10.1186/1757-7241-18-9.



## Original publications

- I Hoikka, M., Länkimäki, S., Silfvast, T. & Ala-Kokko TI. (2016). Medical priority dispatch codes – comparison with National Early Warning Score. *Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine*, 24(1), 142.
- II Hoikka, M., Silfvast, T. & Ala-Kokko, TI. (2017). A high proportion of prehospital emergency patients are not transported by ambulance: a retrospective cohort study in Northern Finland. *Acta Anaesthesiologica Scandinavica*, 61(5), 549-556.
- III Hoikka, M., Silfvast, T. & Ala-Kokko TI. (2018). The ability of prehospital National Early Warning Score to discriminate patients in need of intensive care: A population-based study in two hospital districts in Northern Finland. (manuscript).
- IV Hoikka, M., Silfvast, T. & Ala-Kokko TI. Does the prehospital National Early Warning Score predict the short-term mortality of unselected emergency patients? *Scandinavian Journal of Trauma, Resuscitation & Emergency Medicine*, 26(1), 48.

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