Patient Assessment and Triage in Emergency Medical Services

The Swedish EMS nurse in a new role

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The fishermen know that the sea is dangerous and the storm terrible, but they have never found these dangers sufficient reason for remaining ashore
Vincent Willem van Gogh

To all EMS nurses caring for the public every day

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ABSTRACT

Background: Pre-hospital care is highly complex care where the emergency medical services (EMS) nurse assesses patients in an unselected patient population. The increased demand for EMS resources, which also involves a large number of patients with less urgent needs, has led to the introduction of new methods of practice. The EMS nurse has been given responsibility, at the scene, to assess the patient and determine the level of care. To aid the EMS nurse in patient assessment, a triage system, the rapid emergency triage and treatment system (RETTS), is utilised.

Aims: 1. To describe the characteristics of the pre-hospital population assessed by the Emergency Medical Services (EMS), 2. To evaluate patient assessment by the EMS nurse and 3. To evaluate the performance of pre-hospital triage with the RETTS.

Methods: This was a prospective, observational study with a retrospective analysis comprising 651 children < 16 years of age and 6,712 adults that were in contact with the Swedish emergency number and assessed at the scene by an EMS nurse. Data from EMS and hospital records were reviewed manually. To evaluate triage performance, the RETTS was compared to a pre-defined reference patient including both time-sensitive conditions and vital signs. An instrument for classification was used to compare the EMS nurse field assessment with the final hospital diagnosis. The EMS RETTS triage in adults was also compared with the National early warning score (NEWS) on several outcomes.

Results: Among all the children, 30% were assessed to remain at the scene. Non-transported patients were younger, often assessed with fever or respiratory distress, whereas transported patients were more frequently associated with trauma or convulsions. Of the transported children, 32% were discharged from the emergency department (ED) without any intervention and

a total of three per cent were diagnosed with a time-sensitive condition. EMS triage showed under-triage of 33% and over-triage of 33%. The all-cause 30-day mortality rate among children was less than one per cent. The EMS nurse's field assessment was in agreement with the final hospital diagnosis in 80% of cases.

In the adult population, the median patient age was 66 years. Twenty per cent remained at the scene. It was more common not to be transported if female, with a history of psychiatric disorders or no history of a previous disease. Ten per cent of the non-transported patients visited the hospital within 72 hours and, of them, ten per cent were diagnosed with a time-sensitive condition. Among all adult patients 11% had a time-sensitive condition. The EMS triage in adults revealed under-triage of 19% and over-triage of 36%. Under-triaged patients were older and more commonly triaged to "uncertain condition". Patients triaged to the lowest levels (green or yellow) had a 79-100% lower risk of death in the first 48 hours. The RETTS for adults had a greater probability of detecting a time-sensitive condition compared with the NEWS but with lower specificity. Among adult patients with a final hospital diagnosis, the EMS nurse's field assessment was considered appropriate in 82% of cases.

Conclusions: Among children were one third assessed to remain at the scene and among those who were transported to hospital were one third over- and one third under-triaged. In the adult population did one out of five remain at the scene and only one per cent of these patients were later diagnosed with a time-sensitive condition. Among transported adults did eleven per cent have a time-sensitive condition. Over-triage was found in one third and under-triage in one in five patients. Patients with a higher risk of under-triage were older. As compared with NEWS did RETTS have a higher sensitivity for detection of a time-sensitive condition at the cost of a lower specificity. Among patients with a final diagnosis was the EMS nurse field assessment considered appropriate in about eighty per cent of the cases both among children and adults.

Keywords: Emergency medical services, Triage, Patient assessment, Nurse

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SAMMANFATTNING PÅ SVENSKA

Ambulanssjukvården har genomgått stora förändringar under en kort tid. Fler interventioner har förts ut från sjukhuset i syfte att öka överlevnad vid till exempel hjärtstoppsbehandling eller traumavård. Prehospital bedömning av patienters behov av vård har också medfört ökade krav på kompetens. Sverige har valt att öka kompetensen i ambulanssjukvården genom att införa krav på legitimerade sjuksköterskor. Ett ökande antal och ett vidgande spektrum av uppdrag innebär att ambulanssjuksköterskan idag möter patienter där behoven varierar från icke akuta kontaktorsaker till livshotande tillstånd. Alla patienter har inte behov av specialistsjukvård på sjukhus och ambulanssjuksköterskan har kommit att få uppgiften att göra bedömningar på plats om på vilken vårdnivå som patientens behov bäst kan tillgodoses. Till sin hjälp i bedömningen har ambulanssjuksköterskan ofta ett triage verktyg som anger tillståndets allvarlighetsgrad med en färg som baseras på avvikande vitalparametrar och kliniska tecken/symtom för sjukdom.

Kunskapen såväl kring patientkaraktäristika bland barn och vuxna, som utvärdering av ambulanssjuksköterskans patientbedömningar avseende vårdnivå och utfall är begränsad inom svensk ambulanssjukvård. Vi har också granskat triage systemet rapid emergency triage and treatment system (RETTS) som är ett ofta tillämpat triage system i svensk ambulanssjukvård. För att få klarhet i hur väl detta system förhåller sig har RETTS definition av allvarlighetsgrad jämförts med en fördefinierad sjuk patient samt även utfall på sjukhus. Vi gjorde också jämförelser mellan RETTS för vuxna och det i Sverige relativt nyetablerade bedömningsinstrumentet National early warning score (NEWS) som är ett system baserat på vitalparametrar för att identifiera patienter med risk för klinisk försämring av sitt tillstånd. Data har samlats in genom manuell genomgång av både ambulansjournaler och uppföljning i sjukhusjournaler.

I de två första studierna som inkluderade barn under 16 år fann vi att ambulanssjuksköterskan möter ungefär fem barn per hundra patientbedömningar. Medianålder för barn där man kallade på ambulans var tre år. En tredjedel av patienterna kvarstannande på plats med behandling, egenvårdsråd eller hänvisning till primärvård. Barn som kvarstannade var yngre, och mer ofta bedömda med symtom på feber eller andningssvårigheter medan barn som transporterades till akutmottagningen mer ofta bedömdes som drabbade av trauma eller kramper. Av de barn som transporterades till akutmottagningen skrevs över en tredjedel hem därifrån utan några mer omfattande åtgärder utöver läkarbesöket. Tre procent av barnen

diagnostiserades med ett tidskänsligt tillstånd där tid till bedömning och behandling på sjukhus var av betydelse. När triagesystemet användes före ankomst till sjukhus så var triage nivån för hög för en tredjedel av de barn som erhöll en triagefärg och triage nivån var för låg i en tredjedel av fallen. Barn som var runt ett år gamla med feber eller hög puls och som senare diagnostiserades med infektionssjukdom var mest förekommande bland de som triagerades för lågt. Av de triagerade barnen var gul färg vanligast vid inläggning på vårdavdelning. Av alla barn som erhöll de högsta färgerna dvs röd/orange före ankomst till sjukhus så identifierades senare nästan tre av fyra som icke akuta. Dödligheten under de första 30 dagarna, oavsett orsak, var mindre än en procent och samtliga av dessa barn hade initialt transporterats till akutmottagningen. Ambulanssjuksköterskans bedömning var samstämmig med slutdiagnos på sjukhus i fyra av fem fall.

I den vuxna populationen var medianåldern 66 år. I en femtedel av fallen gjordes bedömningen att patienten kunde kvarstanna på plats. Det var vanligare att kvarstanna om personen var kvinna, där det fanns en sjukhistoria med psykiatrisk ohälsa eller att personen som tagit kontakt var tidigare frisk. Tio procent av de, som ambulanssjuksköterskan initialt bedömde till en lägre vårdnivå såsom egenvård, behandling på plats eller hänvisning till primärvård, besökte akutmottagningen inom 72 timmar från första besök med ambulans, och av dem hade tio procent ett tidskänsligt tillstånd där tiden till bedömning och behandling på sjukhus har betydelse. Mest förekommande diagnoser bland dessa fall var stroke och sepsis. Bland samtliga patienter som hänvisades till en lägre vårdnivå var andelen med tidskänsliga tillstånd en procent. Utav alla patienter som transporterades till sjukhus hade elva procent ett tidskänsligt tillstånd.

Vid triagering före ankomst till sjukhus förelåg en för hög nivå i mer än en tredjedel av fallen och en för låg nivå i en femtedel av fallen, sist nämnda ökade om man var äldre. En vanlig bedömd orsak om patienter triagerades för lågt var ’ospecifika symptom’, vilket var mer vanligt bland äldre patienter. Bland samtliga patienter som triagerades till den lägsta nivån dvs grön så förelåg ingen risk för död inom 48 timmar och en låg risk för ett tillstånd där tid till kausal behandling var av betydelse. Dessa patienter kan således i de flesta fall handläggas på en lägre vårdnivå, företrädesvis i samarbete med primärvård.

När jämförelser gjordes mellan RETTS och ett annat system, NEWS, som används på sjukhus och pre-hospitalt internationellt, så hade RETTS en högre känslighet för att upptäcka patienter med tidskänsliga tillstånd men var inte lika träffsäkert på att utesluta icke akuta tillstånd.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Magnusson C, Herlitz J, Karlsson T, Axelsson C. **Initial assessment, level of care and outcome among children who were seen by emergency medical services: a prospective observational study.** *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2018;26(1):88.*

II. Magnusson C, Herlitz J, Karlsson T, Jiménez-Herrera M, Axelsson C. **The performance of the EMS triage (RETTS-p) and the agreement between the field assessment and final hospital diagnosis: a prospective observational study among children <16 years.** *BMC Pediatrics. 2019;19(1):500.*

III. Magnusson C, Herlitz J, Axelsson C. **Patient characteristics, triage utilisation, level of care, and outcomes in an unselected adult patient population seen by the emergency medical services: a prospective observational study.** *BMC Emergency Medicine. 2020;20(1):7.*

IV. Magnusson C, Herlitz J, Axelsson C. **Pre-hospital triage performance and emergency medical services nurse's field assessment in an unselected patient population attended to by the emergency medical services: a prospective observational study.** *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2020;28(1):81.*

CONTENTS

ABBREVIATIONS

ACS	Acute coronary syndrome
ALS	Advanced life support
AR	Absolute risk
ATLS	Advanced trauma life support
AVPU	Alert verbal pain unresponsive
AUROC	Area under the receiver operating characteristic curve
BLS	Basic life support
CBD	Criteria based dispatch
CCU	Cardiac care unit
CDSS	Computerised clinical decision support system
CI	Confidence interval
CPR	Cardiopulmonary resuscitation
CMM	Cribari matrix method
CTAS	Canadian triage and acuity scale
DEPT	Danish emergency process triage
DMI	Dispatch medical index
ED	Emergency department
EMDC	Emergency medical dispatch centre
EMS	Emergency medical services

EMT	Emergency medical technician
ESI	Emergency severity index
GCS	Glasgow coma scale
GP	General practitioner
ICD	International classification of diseases tenth revision Swedish edition
ICU	Intensive care unit
LBBB	Left bundle branch block
LR	Likelihood ratio
MAR	Missing at random
MI	Myocardial infarction
MICE	Multiple imputation by chained equations
MICU	Mobile intensive care unit
ML	Machine learning
MTS	Manchester triage system
NEWS	National early warning score
NHS	National health service
NPV	Negative predictive value
NSTEMI	Non-ST-elevation myocardial infarction
PAD	Peripheral artery disease
PAT	Patient assessment triangle
pED	Paediatric emergency department

PPV	Positive predictive value
qSOFA	Quick sequential (sepsis-related) organ failure assessment
RBBB	Right bundle branch block
RETTS-p	Rapid emergency triage and treatment system for paediatrics
RETTS-A	Rapid emergency triage and treatment system for adults
RLS 85	Reaction level scale
RN	Registered nurse
RR	Relative risk
SATS	South African triage scale
SBI	Serious bacterial infection
STEMI	ST-elevation myocardial infarction
UK	United Kingdom
US	United States
VS	Vital signs
WHO	World health organisation

BRIEF DEFINITIONS

Advanced life support ambulance	An ambulance with equipment and clinical competence to provide emergency medical care beyond the scope of basic life support.
Basic life support ambulance	An ambulance equipped and staffed with basic competence and equipment providing the aid to ensure the patient's immediate survival, i.e. control bleeding, CPR, basic first aid.
Emergency department	Comprises emergency departments at both regional trauma hospital and trauma receiving hospitals. Dedicated paediatric ED in the children's hospital and a dedicated receiving hospital for orthopaedic complaints.
Emergency medical dispatch centre	A system which assesses patients over the telephone who are in contact with the Swedish emergency number 112. Categorises and prioritises patients at three different levels with the support of a CBD system.
Emergency medical services	A system providing emergency medical care, including several components co-ordinating the response. In this thesis, the main point of focus is the part of the emergency medical services that responds to an incident at the scene.
EMS nurse	A registered nurse, with or without additional specialist training, staffing the EMS, responding to incidents at the scene and conducting patient assessments.

False positive	The triage level indicates the presence of a high acuity condition, but the condition is not present.
Home care	Health care provided by registered nurses at the place where the individual person is living. The primary care physician has the medical responsibility.
Negative predictive value	The proportion of true negatives among all patients with a negative prediction.
Non-transport	Patients who, after assessment, are referred to a lower level of care. This term is common in the USA and other parts of the world.
Positive predictive value	The proportion of true positives among all patients with a positive prediction.
Pre-hospital emergency care	In Sweden, this is defined as health care undertaken during transport in an ambulance or in conjunction with an ambulance and is carried out by professionally trained and employed personnel (SOSFS 2009:10). This term is used in this thesis because of the lack of better wording and implies the phase before arrival in hospital.
Primary mission	A patient that telephones the emergency number and is assessed by the EMDC in need of emergency medical care and assessed by the EMS nurse at the scene.
Sensitivity	The proportion of patients with a condition that is correctly identified as having the condition.

Specificity	The proportion of patients without a condition that is correctly identified as not having the condition.
Transport	A decision to transport a patient to hospital, regardless of type. This can be by ambulance, seated patient transport or patient transport.

INTRODUCTION

Pre-hospital care is regarded as highly complex care where the emergency medical services (EMS) nurse assesses patients in an unselected patient population, including medical, surgical, orthopaedic and psychiatric conditions in both adults and children. The increased demand for EMS resources, which also involves a large number of patients with less urgent needs, has led to the introduction of new methods of practice. The EMS nurse has been given the responsibility, at the scene, to assess the patient and determine the level of care, which includes treatment and release, advice on self-care, referral to primary care, referral to home care or a decision on transport by means other than an ambulance.

A patient assessment requires clinical knowledge and logical reasoning in order to determine a possible field diagnosis [1]. There are challenges in the assessment because the EMS nurse is often the first person to meet and assess the patient at the scene. Symptoms differ substantially and could arise from normal worries, psychiatric diseases, but they may also be indicative of a time-sensitive condition. The assessment takes place in environments which may affect the direction of the assessment; for example, the septic patient assessed in a residential home for drug rehab. On many occasions, significant others speak for the patient with their view of what the problem is and language barriers may be present.

To aid the EMS nurse in the assessment of the patient, a triage system is used: the rapid emergency triage and treatment system (RETTS). This system is used in the majority of emergency departments (ED) in Sweden and was initially developed for in-hospital use and then implemented in the ambulance organisations with the aim of initiating the triage process in the pre-hospital setting and thereby at an early stage identifying critically ill patients or patients at risk of deterioration. Within the framework of limited healthcare resources and directives on the transition of care from in-patient hospital care to primary care, the EMS nurse's new role has developed to navigate this uncharted territory and meet patients' needs at the most appropriate level of care.

BACKGROUND

THE RISE OF THE MODERN EMS

Modern pre-hospital care is relatively young and the EMS has developed over the last five decades to become an organisation with competence and resources performing assessments and advanced care in the field. From the 1980s, the development of pre-hospital emergency care has evolved rapidly, with the addition of procedures and interventions and pharmaceutical drugs to reach today's advanced care of critically ill patients at the scene [2,3]. In the 1960s, the EMS was unorganised, unregulated and uninteresting to stakeholders [4]. The development of pre-hospital care was on the battlefield, with the main emphasis on trauma care [5].

In the 1960s, several key factors that had a large impact on the future development of the civilian EMS in the United States (US) and other countries converged. The burden of disease (heart disease, stroke and cancer) and trauma due to the large volume of traffic accidents was addressed and the report on "Accidental death and disability: The neglected diseases of modern society" was published [6]. This report was pivotal and highlighted the importance of competence, organisational improvement and recommendations on legislation in order to prevent death [6]. At that time, the chance of survival was higher on the battlefield than in the streets after sustaining a trauma [6].

Research was prioritised in the US and funded at governmental level, more specifically to increase research in these areas. Medics returning from the Vietnam War added competence and interventions were implemented in civilian pre-hospital care [7]. One of the pioneers was R Adams Cowley, who recognised the benefits of rapid management and early interventions in trauma victims outside hospital. Cowley based his argument on Vietnam where aeromedical services provided transport less than thirty-five minutes from definitive care, thereby increasing survival rates [8,9]. The assumption was that this would also be true in a civilian setting with rapid transport directly to definitive care within an estimated one hour, even though this was not validated at the time, and whether this would be exactly one hour was later questioned [10]. Through Cowley's innovative actions, the US first state-wide EMS was founded, transporting trauma patients directly to the shock and trauma unit.

Through Cowley's innovative actions, the first US state-wide EMS was founded, transporting trauma patients directly to the shock and trauma unit.

During this time, advances were also made in the medical field with Kouwenhoven and colleagues' report on cardiopulmonary resuscitation (CPR) in the 1960s. They demonstrated closed chest CPR examining "adequate cardiac massage without thoracotomy" where "anyone, anywhere, can now initiate cardiac resuscitative procedures". All that is needed are two hands [11]. This was a significant improvement.

In Ireland, Frank Pantridge developed the first portable defibrillator. At an early stage, Pantridge understood the value of defibrillation as early as possible, as the current available data showed that most cardiac arrests occurred outside hospital and were due to ventricular fibrillation [12]. These advances in both trauma care and research on CPR laid the foundations of modern pre-hospital care. This was further emphasised when attracting public interest in the potential of modern pre-hospital care that was seen in TV shows at the time, in which EMS heroes were saving lives on the streets [7].

PRE-HOSPITAL EMERGENCY CARE IN SWEDEN

In Sweden in the 1960s, the focus was still on transport vehicles with stretchers operated by taxi, tow-truck organisations and fire departments and others who were interested in the transport business. However, investigations in Sweden were initiated into future ambulance types and the development of pre-hospital care [13]. As in the US and the United Kingdom (UK), the introduction of more interventions required increased competence and skills. A supervisory authority in Sweden monitoring pre-hospital emergency care was also needed and, in 1968, it was decided that the counties were responsible for the EMS in their individual county [14]. As a result of county responsibility, EMS organisations developed at different rates. In the 1970s, a Swedish pioneer, cardiologist Stig Holmberg in Gothenburg, identified the need for advanced life support (ALS) ambulances with more equipment and increased competence. Compared with the basic life support (BLS) ambulances, the ALS units were staffed by registered nurses (RN) and equipped with manual defibrillators, electrocardiograms (ECG) and drugs. They responded to critical assignments with the emphasis on patients with chest pain and cardiac arrests. A randomised study of these ALS units reported that, if patients with a suspected myocardial infarction (MI) were assessed and cared for by the RN in the ALS unit with a defibrillator and drugs, long-term survival increased in this group compared with the standard BLS units [15]. In the 1980s, the ALS units were developed still further and the BLS units were also given more equipment, such as equipment to measure vital signs (VS). Studies were conducted in the pre-hospital setting on the early administration of

thrombolysis in patients in whom there was a high suspicion of an MI, where a cardiologist also staffed the ALS unit. The ALS unit included patients for direct admission to the cardiac care unit (CCU) and it studied the role of pre-hospital thrombolysis in patients with a suspected MI [16].

Over the years, ambulance vehicles and equipment were developed and the two-tier system was abandoned. Vehicle and equipment requirements in order to provide pre-hospital emergency care were regulated nationally [17]. Today, Sweden's EMS system consists primarily of one ambulance type which is defined as an ALS unit, able to provide advanced emergency care beyond the scope of basic CPR.

A single-tier system has advantages, as it is able to respond to and manage patients without delay. However, a two-tier system can be an advantage in urban settings where an ALS unit is used solely for critical incidents, thereby reducing the staff required for specialist assignments [18]. Sweden, together with Ireland and Greece, has historically had the highest proportion of ALS ambulances when comparing types of units used, of all EU member states [19]. The lack of the two-tier BLS/ALS concept in Sweden has led to a fleet of ALS units which respond to patient complaints of all kinds. The increased resource allocation of has led to that many EMS organisations in Sweden operate with a differentiated fleet of vehicles with the ALS units as the backbone and additional resources, such as single responders (SR), to assess lower priority calls or as a first responder awaiting ambulance or physician response units (rotor aircraft, cars) to aid with critically ill patients. The differentiation of responding units is one way of meeting the wide range of patient presentations in contact with the Swedish emergency number (112). The definition of pre-hospital emergency care in Sweden is fairly broad and has been defined as: health care undertaken during transport in an ambulance or in conjunction with an ambulance and carried out by professionally trained and employed personnel [17].

COMPETENCE IN THE SWEDISH EMS

The professional competence in the EMS varies internationally and the best configuration has not been agreed upon [20–22]. Sweden followed many other countries in the early days of pre-hospital care and had similar educational pathways, even though the US was early in formalising an education leading to emergency medical technicians (EMTs) [4]. In Sweden in the mid 1970s, a healthcare education was required to be employed in the EMS [14], after a political debate where a motion in 1973 stated "Unnecessary deaths in Swedish ambulances. More than one in five patients could be saved…". Even though the counties were responsible for the EMS within their individual counties, the

service could still be provided by a local company, especially in rural areas where assignments were still carried out with "only a driver, without anyone to focus on the patient" [23]. In the 1980s, the educational requirements increased to a minimum of an assistant nurse (20 weeks). However, in order to ensure competence at the scene, a nurse anaesthetist, an intensive care nurse and nurses specialising in cardiac care were employed in the pre-hospital ALS units to care for certain patient groups [24,25]. Nurse anaesthetists were common, later together with a physician to staff mobile intensive care units (MICU) to be sent out to an accident scene in order to provide specialist care at the scene [25]. Over time, the demand was increased for greater formal competence to ensure patient safety and quality of care in all ambulances and for all patients in contact with the EMS. In 2005, Sweden's National Board of Health and Welfare specified that every ambulance in Sweden must be staffed by one registered nurse responsible for assessing the need for pharmacological drugs and their administration under general directives authorised by the responsible senior physician within the local EMS organisation [26–28]. In Sweden, it is also specified that only registered healthcare professionals such as RNs are authorised to assess and recommend self-care [29]. In addition to the National Board of Health and Welfare's minimum standard, many EMS organisations in Sweden require an additional one-year master's course specialising in pre-hospital emergency care [30,31].

ORGANISATION OF THE SWEDISH EMS

All health care in Sweden is tax funded and free to residents of Sweden, regardless of the type of disease. In Sweden, the twenty-one county councils are responsible for providing health care for the residents within the county, including the EMS. The EMS can be organised within the body of a university hospital, county or contracted to a private entrepreneur. In the study organisation, the EMS is organised under the university hospital. Since the EMS are organised under the counties, with different geographical, demographic and economic conditions, there are no national mandatory guidelines, even though there is agreement on using the same triage system in most counties. Recommended guidelines published by Swedish senior ambulance consultants provide the foundations for the guidelines in the counties and they are edited with local variations. This leads to slightly different aims regarding the achievement of objectives where there has been a great deal of emphasis on delays, aiming at different measurements in different regions. However, reporting on quality indicators at national level has attracted interest in recent years with the development of a national EMS quality registry.

THE PARADIGM SHIFT

Over the past few decades, increasing attendance at the ED has been continuously reported. ED crowding is regarded as a worldwide public health problem with patient safety at stake [32]. The reasons for seeking emergency care are multifactorial; they include but are not limited to increasing age, lack of social support, reduced alternative options and the patients' own concern over their health situation [33–35]. The negative side-effects of a crowded ED are well documented and have been reported to be the underlying cause of increased mortality, medication errors, worsening outcomes, delayed care and reduced patient satisfaction [36,37].

In order to reduce time to definitive care in time-sensitive conditions, the EMS in Sweden have implemented "fast tracks". The EMS nurse at the scene decides whether the present patient complaint is eligible for care on a fast track, thereby bypassing the ED in order to save time among patients with stroke and myocardial infarction (MI), for example, or to reduce the wait in the ED, thus minimising the risk of complications among patients with hip fractures or low-acuity patients requiring hospital admission. Patients with an MI have, for example, been reported to suffer from less adherence to guidelines, a worsening outcome with a recurrent MI if attending a crowded ED with non-ST-elevation MI (NSTEMI) patients [38]. On the other hand, patients with STEMI have been reported to have shorter reperfusion times and lower mortality if they bypass the ED [39,40].

Delays in the ED also predicted a longer time to operation in older frail patients with hip fractures. Furthermore, patients with hip fractures waiting in the ED ran a greater risk of not receiving the appropriate analgesics [41]. Even though a hip fracture is not regarded as an immediate time-sensitive condition, there is evidence of better recovery and fewer adverse events if the time to operation is reduced [42]. In several EMS organisations in Sweden, the EMS nurse writes an X-ray referral and via X-ray the patient sustaining a hip fracture is taken directly to the ward. In a randomised study by Larsson and colleagues, the fast track directly to X-ray, bypassing the ED, when the EMS nurse suspected a hip fracture, reduced the time to X-ray and ward by two hours compared with when patients were transported to the ED [43].

However, many of the emergency care contacts have also been attributed to low-acuity presentations both in the ED and consequently also in the EMS. Dihn and colleagues reported that, of 11 million ED visits, nearly half the presentations were regarded as low acuity, of which many patients arrived by ambulance [44]. The number of EMS assignments have increased over the last

decade and, in the western part of Sweden, there has been an increase of 25% among primary assignments since 2010.

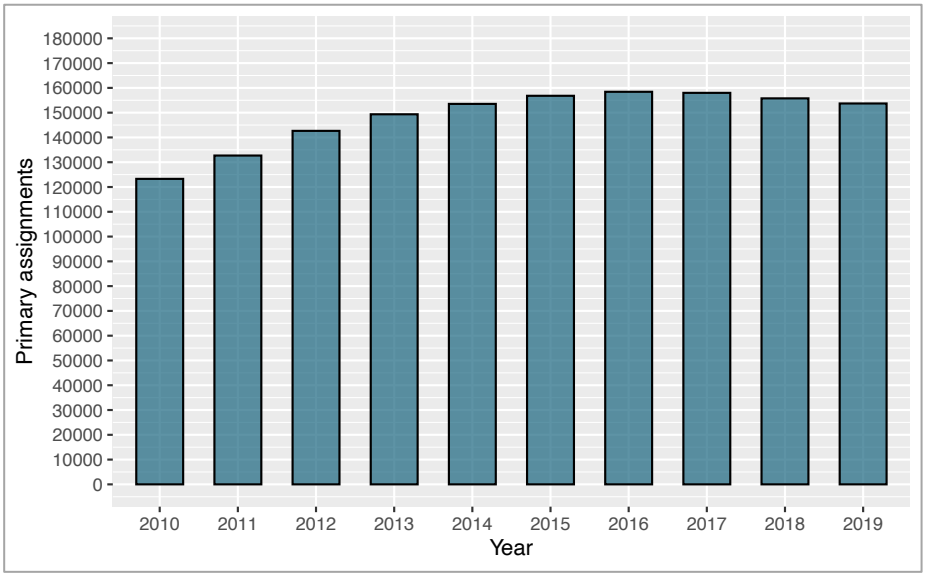


Figure 1. EMS primary assignments in the VG Region in 2010-2019

The mandatory transport of low-acuity patients to the ED has an impact on resource availability in the EMS, also affecting the high-acuity patient groups. For example, delays in pre-hospital cardiac arrests have increased over the years from six minutes in the 1990s to a median of 11 minutes in 2019. The rate of ventricular fibrillation as the initial rhythm has also decreased during this time [45].

One reason behind the increasing EMS response time could be the occupancy of transport with patients of low acuity. As a result of several factors, including increased competence, a higher frequency of assignments and the introduction of guidelines/triage, a new role for the Swedish EMS nurse has emerged. Releasing patients at the scene has been associated with a decreased time per assignment and the ambulance is therefore ready more quickly for more emergency assignments [46].

The American philosopher Thomas Kuhn (1922-1996), in his work *The Structure of Scientific Revolutions*, describes the term "paradigm'" and when a "paradigm shift" occurs. Kuhn defines normal science as puzzle solving, which is described as familiar and straightforward.

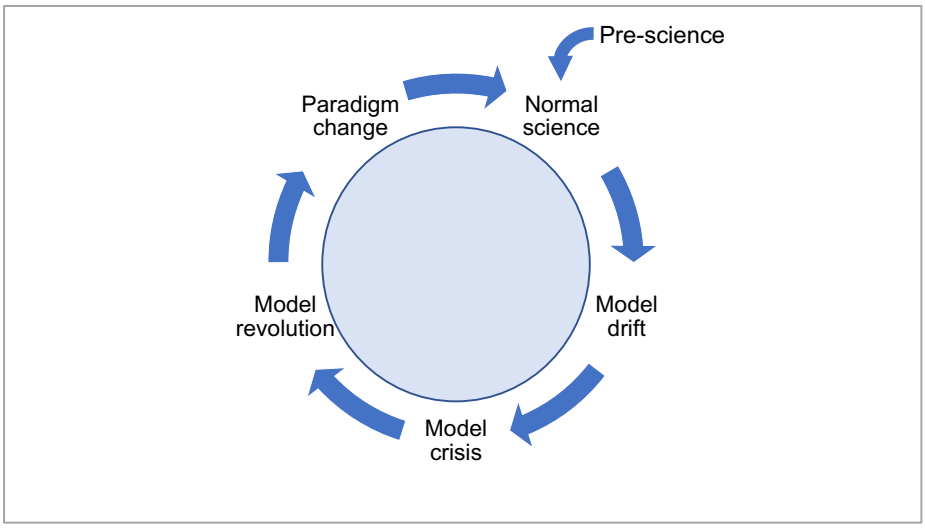


Figure 2. Adapted from the Kuhn cycle in The Structure of Scientific Revolutions [47]

On the other hand, extraordinary (revolutionary) research involves questioning and the revision of existing practice. "Paradigms gain their status because they are more successful than their competitors in solving a few problems that the group of practitioners has come to recognize as acute." [47]. The EMS research on assessments to a lower level of care can be considered to be in a new phase towards a paradigm shift. Assessing patients at the scene has developed at different paces internationally, as patient-safety concerns were raised in this new line of work and early studies reported that paramedics were unable safely to decide which patients could remain at the scene instead of being transported by ambulance to the ED [48–50]. However, the practice of patient assessment at the scene has shifted the focus from the former models of transporting all patients to the ED towards non-transport decisions becoming current practice, with new questions arising about how to identify patients as candidates for a lower level of care, and the competence needed [51]. A referral to a lower level of care other than the ED is part of many EMS systems internationally, including patients of all ages. In a systematic review by Ebben and colleagues, non-transport rates ranged from four to 94 per cent, with five to 19 per cent ED presentations within 48 hours after an initial EMS assessment. Further, all-cause mortality was found be up to six per cent within 72 hours. The authors concluded that the level of competence needed to make appropriate non-transport decisions has not been fully clarified, combined with limited instruments and supportive tools [52].

The EMS patient population is regarded as an unselected population with assignments that span all the specialities, from patients with a limited need for care to severe multi-trauma. This is challenging for the EMS nurse and various guidelines and national/local protocols have been developed in order to assess and treat patients in the pre-hospital setting. However, adherence to guidelines varies with the type of patient presentation [53]. Moreover, the EMS nurse has to rely on professional judgement in the variety of presentations where guidelines/protocols on assessment or treatment are less suitable, in patients presenting with diffuse vague symptoms, for example.

Appropriate decisions on transport to hospital are important for patients in need of hospital resources and the decision-making process is complex, with several factors influencing the decision [54,55]. Appropriate decisions are not agreed upon internationally, due largely to the lack of a new model, which is required when attempting to answer these questions [47].

This has also been addressed and formalised by the Swedish government in an investigation where Sweden has to adjust its healthcare system towards "god och nära vård" meaning modern, equal, accessible and effective health care [56]. With an ageing population, the aim is to initiate the care in primary care as the base of sustainable health care. In the light of this relatively rapid development of the pre-hospital field of practice, we have to admit that former paradigms appear to be being replaced with a new one.

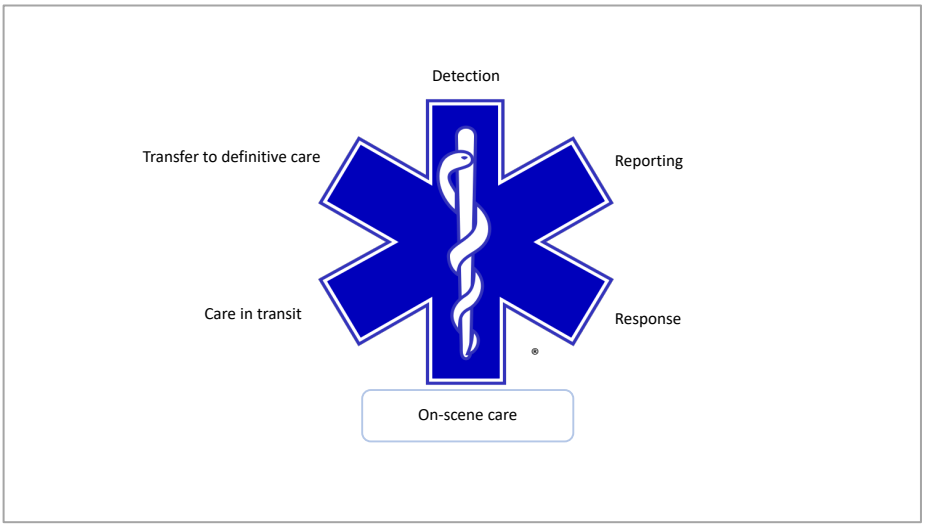


Figure 3. Re-defining the star of life, adapted from the Star of Life [57]

On-scene care has become more than the current definition “The EMS personnel arrive and provide immediate care to the extent of their possibilities” [57]. This is where the EMS nurse manages patients with a broad spectrum of complaints and, together with different parties, finds the best possible solution to meet the patients’ needs at the most appropriate level of care. Within this scope of practice, there is no “care in transit” and the definitive care may be in primary care where the patients arrange their own transport, if the patient remains at the scene after assessment and is referred to nurses in a nursing home or is treated by the EMS nurse at the scene and given advice on self-care.

PATIENT ASSESSMENT

EMERGENCY MEDICAL DISPATCH CENTRE

In Sweden, the first contact with the EMS and the dispatch centre is by telephone through the Swedish state-owned emergency number 112. In Sweden, emergency medical dispatch centres (EMDC) have traditionally been organised under a state-owned company (SOS Alarm). As of today, there are several counties in Sweden managing their own EMDCs and one aim is to increase competence in the first contact with patients. However, during the time of this study, SOS Alarm EMDCs handled all assignments regarding both patient priority and ambulance dispatch. The operator at the EMDC in the west of Sweden uses a criteria-based system (CBD) developed in the US, adapted for Nordic conditions and introduced in 1997 [58]. The dispatch operator assesses the patient’s ailment and assigns an index to the assignment, such as “chest pain/cardiac disease” and a priority level of 1-4. Priority 1 is regarded as life threatening and an ambulance is dispatched with lights and sirens, priority 2 is urgent but not life threatening, priority 3 can wait but is assessed as being in need of an EMS nurse’s assessment and/or ambulance transport. Priority 4 is assigned to patients assessed as having no medical need or monitoring during transport which is carried out by EMTs [58]. The EMDC operators assessing patients over the telephone have the formal qualification of assistant nurses or registered nurses.

PATIENT ASSESSMENT AT THE SCENE

The initial patient assessment by the EMS nurse is based on a field diagnosis-driven assessment. By collecting objective data and a patient history, it is possible to reason logically and determine possible causes of the patient's ailment [59]. The assessment is not only dependent on the objective measurements but also takes the patients' needs into consideration, which is derived from both the nurse's intuition and experience. Theories presented by Elstein and colleagues back in 1978 argue that the clinical decision-making derives from a process of multiple steps [60]. First, data are gathered and from these data one or more hypotheses are created. In the EMS the objective recording is performed in a structured manner and is often, including the patient interview, conducted in a primary and a secondary survey.

According to the guidelines recommended by the association of Swedish pre-hospital senior consultants, the initial assessment is made up of X – exsanguinating bleeding (former catastrophic bleeding), A – airway for example obstructed, stabilise in trauma; B – breathing respiratory sounds, type of breathing; C – circulation, external bleed, pulse frequency, quality, D – disability, level of consciousness, pain and E – exposure, avoid hypothermia. This approach is widely accepted by expert consensus and is used in a variety of settings when assessing a patient. It is also recommended in Sweden [61,62]. However, before initiating the primary survey, scene safety is the first priority.

The ABCDE algorithm has been implemented for a rapid initial assessment and to maintain equal quality between patients. If the patient is critically ill, a decision has to be made at an early stage on whether to call for assistance from either more persons or greater skills, or both. After the first assessment, there is time for the second survey, including a directed anamnesis with information gathering and a more thorough examination identifying, asking questions about signs and symptoms, onset, provocation, severity of pain and so on [63]. Even though agreed upon as a concept, conducting the primary and secondary survey, explicitly what is included in the survey is not based on consensus from an international standpoint [64]. There have been discussions about whether the current secondary survey is obsolete and could be updated to better cover the current competence level and scope of practice. For instance, it is argued that, when taking the patient's medical history, the current secondary survey does not follow any order or reminders of specific questions that enhance the opportunity to formulate a working diagnosis [65].

The next step is based on the EMS nurse's interpretation of the information and the search for data that will further strengthen some of the hypotheses that have been raised. Furthermore, a decision or intervention is undertaken on the

basis of the formed hypothesis. An appropriate assessment demands a solid base of both knowledge and experience [66]. It has been suggested that the novice in comparison with the expert makes a decision somewhat differently, where the novice have difficulties to move beyond data collection and uses analytical capabilities, while the expert uses intuition based on earlier experience [67,68]. Moreover, the expert might only use hypothesis-deductive testing in complicated cases, whereas in the majority of case pattern recognition is used [68].

CLINICAL DECISION-MAKING

Pat Croskerry describes this pattern recognition with a model of two systems, System 1 and System 2, as one of two possible ways of interpreting a situation when a clinician is assessing a patient. Type 1 is a decision-making process based on heuristic intuition and Type 2 is a process based on a systematic, analytical approach [69]. A System 1 approach is connected to intuition and is effective in most cases and the EMS nurse considers patient characteristics, illness characteristics but also current problems in the environment, for example, workload, other patients, availability and so on. In the EMS, the nurse who assesses the patient has a limited timeframe for collecting enough evidence to form a working diagnosis which is based on the recognition of a specific pattern.

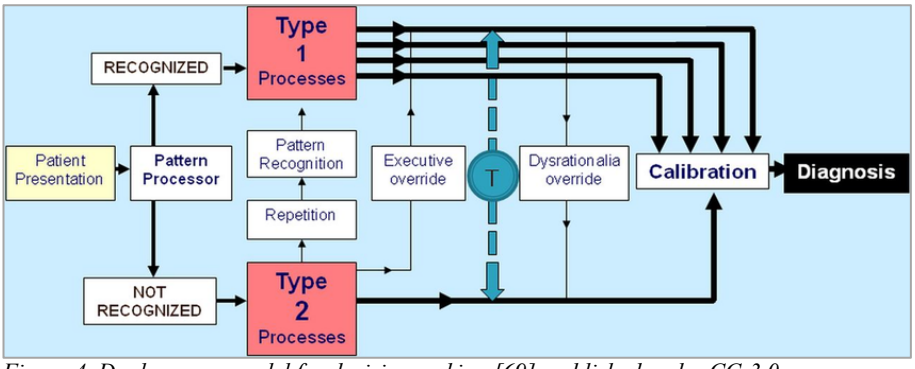


Figure 4. Dual process model for decision making [69], published under CC-3.0.

Croskerry argues that the experience of the clinician is the culprit when it comes to how the information is interpreted. Most EMS nurses would interpret an ECG with ST- elevation in a patient with chest pain as a suspicion of a MI. Moreover, this type of pattern recognition is what many of the decisions in medicine, regardless of location, are based on.

However, Croskerry states that the pattern needs to be there in order to be recognised. For this reason, a presentation with atypical symptoms will become a threat to patient safety [69]. As an example of this, Brieger and

colleagues reported that, if patients with an acute coronary syndrome presented without chest pain (since dyspnea can be the only sign and symptom in older patients), the error rate increased, with a worsening outcome for these patients [70].

The problem in the pre-hospital setting is that not all patients with time-sensitive conditions have clinical signs and symptoms recognised by the EMS nurse when pattern recognition (System 1) is applied. As a result, System 2 processing is required in many cases and, given the unselected patient population, this is a challenge. The System 2 decision process is an analytical, slow process based on training, education and critical thinking. This process requires access to cognitive function to a greater extent. It may be easy to override System 2 to System 1 in situations where the EMS nurse experiences fatigue, high levels of stress or becomes biased in some way, for example, anchoring, where a decision has already been made beforehand and pattern recognition is used in order to confirm the decision. However, as often discussed in trauma scenarios, the rule of thumb is to take a step back to see the whole scene in order to make use of the System 2 decision process [69]. Thus, with the aim of making more decisions that are less prone to errors, an override of System 1 into System 2 is advised [71].

THE PRE-HOSPITAL ASSESSED CONDITION

Based on clinical decision-making, the EMS nurse has to formulate a pre-hospitally assessed condition. Over fifty of these conditions/symptom presentations are described in the recommended national guidelines for pre-hospital assessment and care [61]. In the advanced trauma life support (ATLS) concept assessing critically ill patients, it is stated that “the lack of a definitive diagnosis should never impede treatment” [72]. In a previous study of a unselected EMS population, a total of one-third of the patients were later diagnosed in hospital with non-specific diagnoses [73]. Instead of specifying a certain diagnosis with uncertainty with limited tools, the EMS nurse may, in the pre-hospital setting, need to formulate a field diagnosis including possible conditions from which the patient may suffer. This is particularly important in the EMS nurse’s new role of assessing patients as requiring different levels of care.

Example 1. The patient is an eighty-year-old woman with osteoporosis and impaired ability in movements who falls and sustains a trauma involving the ankle. The patient has a lateral swollen left foot and ankle and is unable to stand on the foot, with pain on passive movement. It is difficult to determine whether it is a fracture or ankle sprain and further examination including X-ray is needed for a definitive diagnosis. However, if the patient has a displaced

fracture over the distal tibula and fibula, the diagnosis is already fairly clear in the pre-hospital setting.

The EMS nurse needs not only to focus on the suspected fracture but also in the assessment to collect and evaluate additional information, such as the reason for falling, if it is associated, for example, with cardiovascular or neurological conditions or due to an infection. For example, six symptoms are described that characterise sepsis, where muscle weakness is one of the symptoms [74]. On many occasions, the EMS nurse is also the only healthcare provider that meets the patients in their own home and the evaluation therefore also needs to contain an assessment of frailty, including an evaluation of hazards in the home environment increasing the risk of falling.

Example 2. A bystander witnesses a 55-year-old male falling down in the office with what looks like some form of seizure. They call the emergency number 112 and the dispatcher assesses the situation based on a quick set of questions: breathing, yes, but still unconscious. Based on the index, this is assessed as a priority 1 call with lights and sirens. At the scene, the EMS nurse finds the patient in a supine position with clammy skin and unconscious.

After the initial assessment and support from possible deviating vital signs, the nurse has to consider possible and likely causes of the event based on objective symptoms and signs, information from the witness and any information the environment can give [75]. If intoxication, what type? antidote? septic shock? myocardial infarction? bypass the ED directly to the cath lab? or low b-glucose, due to diabetes and treat and release at the scene. In this case, the patient was administered glucose due to low p-glucose and regained consciousness and was released at the scene with a recommendation to visit primary care for a check-up and information about the event. In a scenario like this, reasoning about different possible causes of unconsciousness is practised and taught in the pre-hospital academic postgraduate programme – for example, by using the abbreviation husk-midas: herpes encephalitis, uremia, status epilepticus, Korsakoff syndrome, meningitis/sepsis, intoxication, diabetes mellitus, respiratory insufficiency (andningsinsufficiens in Swedish), subarachnoid haemorrhage.

A crucial point in the pre-hospital assessment is whether a time-sensitive condition can be ruled out, if the assessed condition needs hospital resources or if the patient can be safely referred to primary care (PC) or stay at home with self-care advice or be released after pre-hospital medication. However, when there are atypical signs and symptoms or when the symptoms are vague or beyond the scope of expertise, it tends to be more difficult to discriminate at the scene with limited resources and with little or no access to PC.

In a study in the ED of older patients presenting with vague symptoms, infections were present in 24-60% of the cases, whereas 14% had a cardiac aetiology and nine per cent had a neurological disease [76]. The authors suggest that more investigations are useful in the workup towards an appropriate diagnosis in older patients with vague symptoms and they conclude that the normal training on classical symptom presentations is not enough in the education when assessing older patients with vague symptoms [76].

Emergency medicine is regarded as a complex, advanced discipline which is associated with high rates of diagnostic errors with rates up to 12% [77]. Hussein and colleagues reported that, of ED diagnostic errors, 86% were related to a delayed diagnosis and 14% a misdiagnosis. The authors concluded that modifications of the system are needed [78]. This is in line with the report entitled "To err is human" that concluded that many of the errors that occur in health care are based at system level [79]. In a similar way, Croskerry suggests that all errors including diagnostic errors are at system level, even including the employer's responsibility for educational development and competence requirements set by the employer [80].

In a crowded ED, there is a need to discriminate patients based on the severity of their condition in a systematic fashion. For this reason, triage systems have been developed in order to support the nurse in the patient assessment. If signs of deterioration are identified at an early stage, the opportunities to start treatment and reverse the condition increase before it becomes critical. In Sweden, this is also in line with healthcare legislation that states that patients in the greatest need should be prioritised [81].

PRE-HOSPITAL TRIAGE AND TRIAGE SYSTEMS

The origin of triage stems from war times in the French army, where the chief surgeon in Napoleon's army, Dominique Jean Larrey, introduced frontline triage in order to save more lives [82]. The purpose of triage systems is still valid today, i.e. when the demand exceeds the available resources, a sorting algorithm is needed to attend to the most critically ill patients first. Engaging in some 25 campaigns and 400 battles, Larrey practised and refined triage. For example, in the 18th century, Larrey already defined the level of care, where patients with minor injuries should not be cared for in the frontline hospitals (ED) but could, based on the medical condition, be sent back to other hospitals (primary care) to limit the load on the frontline, thereby prioritising critically ill patients [83,84].

Figure 5. Dominique Jean Larrey (1766-1842) the founder of triage [85], published under CC-3.0

Field triage in mass casualty trauma has been practised for a long time in a similar way to Larrey's triage model in order quickly to assess and transport the most critically ill to the most appropriate healthcare facility from the scene of the accident. However, in the pre-hospital setting, a significant amount of preventable harm to patients is associated with clinical decision-making [86,87], not only concerning mass casualty situations but also in single day-to-day patient assessment. The requirements of a triage system are that it must be safe, reproducible and efficient [88]. The triage system should also be of relevance to the assessment of the individual patient. There are several major triage systems in use worldwide in the EDs, with the Manchester triage system (MTS), emergency severity index (ESI), Canadian triage and acuity scale (CTAS) and South African triage scale (SATS) as the most common. All these systems are based on the same principle of a level of severity based on emergency signs and symptoms, resource allocation, deviating vital signs (VS) or a calculated VS score. They are all based on expert opinion and as such there is no general consensus or gold standard for what constitutes a critically ill patient [89].

In Sweden, the rapid emergency triage and treatment system (RETTS) for adults was introduced in the EMS a decade ago and it is used for triage in the majority of the counties in Sweden to aid the EMS nurse in the patient assessment. More recently, it has also been used to support the EMS nurse in the paediatric assessment with a paediatric version. The RETTS is a five-level triage system developed at Sahlgrenska University Hospital. The RETTS was

later trademarked and is licensed and maintained by Predicare AB. The system was initially developed for triage in the EDs to stratify patients based on severity and regarding the individual medical risk without taking account of the total number of patients in the ED. It is similar to the MTS, with charts of the most common ED presentations, but the RETTS includes VS for each patient presentation and has specific emergency signs and symptoms (ESS) accompanied by each triage level on each chart.

When the RETTS is used in the ED, several recommendations are proposed after the patients are triaged; they include a different set of blood samples depending on triage level and RETTS condition at the nurse's discretion, even if this part is not possible in the EMS. The RETTS triage system includes more than 50 charts in separate systems for both adults (RETTS-A) and paediatrics (RETTS-p) (< 16 years of age). Each chart contains a number of ESS codes for each colour (level of severity), together with VS, which forms the patient triage. The triage level is determined in two steps: the patient's VS and through the ESS code. The highest colour of one of these two becomes the final triage colour, where red indicates a "life threatening" condition. Orange indicates that the patient has a "potentially life threatening" condition. The red/orange group is regarded as an acute process directly. Triage level yellow indicates that there is no increased medical risk from waiting and green can wait longer than yellow. The blue colour indicates that the patient may not be in need of ED care [90].

In the EMS before the introduction of the RETTS, it was common to report a priority number (1-3) from the EMS clinician's perception of the patient's severity at the hand-over in the ED. However, it has been reported that five-level triage scales have greater accuracy when identifying critically ill patients, compared with scales with two or three levels, and a five-level triage in the EMS is favourable in order to identify severely ill patients [91–93]. Studies of ED triage systems, the ESI, MTS and CTAS, have reported moderate to good validity when identifying high- or low-urgency patients in comparison with a reference patient, albeit with great variability [94]. When comparing triage systems (Danish emergency process triage (DEPT); CTAS; ESI) used both by the EMS and in the ED, moderate agreement between EMS paramedics/EMTs and ED nurses was found [95–97]. Studies of the RETTS-A in the ED have reported an association between higher triage level and the risk of death, as well as an association between higher triage level and the risk of hospital admission. It is thus deemed reliable and the ED nurse's inter-reliability has been regarded as moderate to good [90,98]. However, in a recent study of age, mortality and the RETTS-A, increased short-term mortality was found in older patients, who were triaged to lower triage levels [99]. On the other hand, the RETTS-A was superior compared with the instrument of quick sequential

(sepsis-related) organ failure assessment (qSOFA) score in detecting sepsis [100].

In addition to adult triage versions, almost all major triage systems have either separately developed or incorporated a paediatric part within their triage system, which has been widely used in ED settings across the world. Studies of the MTS, ESI, CTAS and the Australasian triage scale (ATS) in the ED report moderate to good reliability and validity [101–111]. Inconsistency in triage has been reported among children triaged with the most acute level, the lowest level, children less than one year of age and children with medical complaints such as fever and dyspnea [109].

For the paediatric version of the RETTS in the ED, studies have reported good to very good reliability between nurses [112,113]. The RETTS-p identical to the ED version was implemented in the EMS in Gothenburg in 2014, in order to support the EMS nurse with patient assessment and with the identification of patients at risk of deterioration. The RETTS-p may also be regarded as stronger support in the pre-hospital assessment due the fact that even experienced EMS nurses encounter the paediatric population infrequently. The RETTS-p is constructed in the same way as the adult version but includes an age group chart for VS ranging from 0-2 months, 3-5 months, 6-12 months, 1 year, 2 years, 3-5 years, 6-11 years and 12-18 years.

VITAL SIGNS

The term “vital signs” was coined in the 19th century by Edward Seguin and it focused primarily on temperature and, at the time, the battle against infections. Together with temperature, heart rate and respiratory rate were included in vital signs, much later with the addition of blood pressure and level of consciousness [114]. The recording of VS is of importance in the identification of patients who are critically ill or who risk deterioration and for whom continuous monitoring is therefore required. In order to identify all patients at risk, in the RETTS triage, all patients should have their VS recorded, regardless of the main complaint. The VS that are recorded in the RETTS-A include respiratory rate (breaths/min), oxygen saturation (%), pulse rate/min, blood pressure (mm/hg), body temperature (Celsius) and level of consciousness according to the reaction level scale (RLS 85) or Glasgow coma scale (GCS).

It has been demonstrated that deviations in VS in the ED are associated with the risk of death in the short term and over 30 days [115]. The most predictive deviation in VS for the risk of death was unconsciousness, a high respiratory rate and low oxygen saturation combined with high age. The VS reflecting

consciousness and respiratory abnormalities have also been reported in other studies as independent predictors of short-term mortality and the need for intensive care unit (ICU) care [116].

Prediction levels for children are used in both the RETTS-p and other triage scales in the ED with different cut-offs for different age groups. For adults, the same VS cut-offs are used, regardless of age. It has, however, been suggested in studies that adjusted VS could be applied among the elderly for a better prediction of patient severity [117]. Furthermore, in-hospital VS monitoring has a history of combining deviating VS to produce a single composite score. There are many examples of early warning scores (EWS) aimed at different populations or patient diagnoses/complaints. The purpose of a scoring card is that each VS that deviates yields a certain score, depending on the extent of the deviation, and all the scores are summarised to produce a single composite score. EWS systems in hospitals have been shown to be reliable and have very good performance. This includes the area under the curve of the receiver operating characteristics (AUROC) of 88-93%, in predicting short-term mortality (48h) [118]. However, the impact on health outcome is less well known and the generic construction to cover all patient categories over specially created scores suggests that there is room for improvement in their sensitivity through the addition of variables aimed toward specific patient groups [118–120].

In 2012, the Royal College of Physicians developed the national early warning score (NEWS) with the aim of replacing all the local variations in other scores in the UK. The NEWS has since been widely adopted internationally and in Sweden it has also been a recommended scoring system for use in both the ED and in hospital.

In a previous study comparing in-hospital EWS systems, the NEWS has been reported to outperform another 33 scoring systems in predicting critical illness [121]. The NEWS has also been validated in several studies in the pre-hospital setting with good performance in predicting 24-hour in-hospital mortality [122–124].

The NEWS is divided into three categories of clinical risk: low, medium and high. Each category depends on the aggregated point of deviation in VS, where 1-4 is considered low risk, 5-6 or 3 points in a single VS is a medium risk and 7 and above is defined as a high risk. A NEWS score of 5 or more is regarded as a threshold for urgent assessment by a clinician with competence in assessing patients with acute illness to decide on the escalation of care involving a team of clinicians with critical care skills, such as airway management skills. Patients with a NEWS score of seven or more should immediately be assessed by a critical care outreach team and most often require

transfer to a higher level of care [125]. The Royal College of Physicians released an update in 2017, NEWS 2, which also considered oxygen saturation in patients with pulmonary disease and O2 supplementation, to score this patient group accurately and furthermore any new onset of confusion under the parameter of consciousness.

Physiological parameter	Score						
	3	2	1	0	1	2	3
Respiration rate (per minute)	≤8		9–11	12–20		21–24	≥25
SpO_2 Scale 1 (%)	≤91	92–93	94–95	≥96			
SpO_2 Scale 2 (%)	≤83	84–85	86–87	88–92 ≥93 on air	93–94 on oxygen	95–96 on oxygen	≥97 on oxygen
Air or oxygen?		Oxygen		Air			
Systolic blood pressure (mmHg)	≤90	91–100	101–110	111–219			≥220
Pulse (per minute)	≤40		41–50	51–90	91–110	111–130	≥131
Consciousness				Alert			CVPU
Temperature (°C)	≤35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	

Figure 6. Reproduced from: Royal College of Physicians. National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS. Updated report of a working party. London: RCP, 2017

In the NEWS 2 release, a single VS yielding a score of 3 and regarded as medium risk was omitted. As a result, a single score of 3 for any VS does not qualify for the medium or high trigger level, but should "prompt an urgent review by a clinician with competence in the assessment and treatment of acute illness" [125]. The background to this change was a number of studies that reported the unlikeliness that only one deviating VS would predict a life-threatening event. A single deviating VS was therefore thought to increase resource allocation by 40%; for example, the immediate attention of an ED team of physician, nurses and assistant nurse; increased monitoring and blood samples but only increase the detection of severity/adverse outcome by three per cent [126,127].

In the update, additional changes were made; for example, the acute onset of confusion now yields a score of three points similar to unresponsive patients. An alternative oxygen saturation score was also added. The alternative saturation scale should not be used in patients with pulmonary disease in

general but only in those patients with known hypercapnic respiratory failure. In the pre-hospital setting, most of the time, blood samples giving information on paO2, paCO2 and the presence of hypercapnic respiratory failure are not available and the original scale (scale 1 in NEWS 2) should be used [128].

EMERGENCY SIGNS AND SYMPTOMS

In a clinical situation after obtaining VS from the primary survey, the next step is aimed at the ESS part in the RETTS when gathering information from the anamnesis and other examinations, such as an ECG. In general, triage systems are based on a decision tree, but with only one univariate predictor fulfilling the criteria at each level. This predictor is used as a decision to predict the patient's severity and thereby the urgency of the care that is needed. With regard to prognosis and decision rules in triage, the RETTS uses its ESS to evaluate the severity of a certain main complaint. Moreover, certain actions have to be taken in order to be completely able to assess the patient in agreement with the RETTS.

In comparison, the MTS discriminators for the adult flow chart of "chest pain" are the following, indicating the highest priority, i.e. red level: airway compromise; inadequate breathing; shock [129]. In the RETTS for the same adult main complaint, "chest pain UNS 0.74" (R0.74 = International classification of diseases tenth revision – chest pain unspecified): the specific ESS for red level are the following: new left bundle branch block (LBBB); ST elevation; sudden onset of thoracic pain with vegetative symptoms such as sweating, cold clammy skin and/or a history of loss of consciousness (in later versions, previously unknown right bundle block (RBBB) has been added).

RETTS- A Emergency signs and symptoms

5. Chest pain/thoracic pain unspecified R0.74

Red symptoms – acute process directly life threatening
Left bundle branch block (LBBB) previously unknown ST-elevation Sudden onset thoracic pain with vegetative symptoms
Orange symptoms – acute process directly potentially life threatening
Onset of chest pain when in rest or with very mild effort Chest pain/thoracic pain and current dyspnea Chest pain and previous loss of consciousness Pathological ECG and chest pain Previous/on-going chest pain and vegetative symptoms
Yellow symptoms – acute process can wait
No new-onset chest pain and with normal ECG Moderate/mild pain and with normal ECG Risk factors
Green symptoms – acute process can wait
None of the above

Figure 7. RETTS-A example chief complaint "chest pain/ thoracic pain" emergency signs and symptoms, free translation and adapted from Widgren et al. with permission [90]

With the RETTS, a more detailed level is defined which requires more thorough information-gathering in order to make use of the RETTS. The ESS may be one way to increase the opportunity to identify time-sensitive conditions at an early stage, even if there are no abnormal VS. It is therefore also important to review the information given by the patient or significant other that can reveal information on time-sensitive conditions [130]. Establishing a relationship including the patient is essential to increase the opportunity to acquire adequate information. In a recent study, the authors reported that, in a medical ED population, 80% of the patients could be diagnosed with basic skills, with history-taking as the most important part [131]. This is not new, as Sir William Osler encouraged his students over a hundred years ago to actually talk to the patients.

"Listen to your patient, he is telling you the diagnosis" Sir William Osler

AIMS

The overall aim of this thesis is to describe the characteristics of patients in contact with the Swedish emergency number and to evaluate and describe the EMS nurse's patient assessment and triage performance. The specific aims of the individual papers are listed below.

I. To describe patient characteristics, dispatcher's assessment, EMS nurse's assessment and management at the scene, utilisation of the RETTS for paediatrics and the outcome for children under 16 years of age

II. To examine the performance of RETTS triage in a pre-hospital setting and the agreement between the EMS nurse's on-scene assessment and final hospital diagnosis for children under 16 years of age transported to hospital

III. To describe patient characteristics in an EMS population of patients ≥ 16 years of age, evaluate the EMS nurse's assessment at the scene, the utilisation of the RETTS for adults and describe the frequency and assessed appropriateness of non-transport decisions

IV. Evaluate the performance of pre-hospital triage with the RETTS for adults, compare the performance of the EMS nurse's RETTS triage with the NEWS and NEWS 2 and evaluate the EMS nurse's field assessment in comparison with the final hospital diagnosis

METHODS

The study was conducted at a single site in an EMS organisation operating in the Municipalities of Gothenburg, Mölndal, Partille, Härryda and Öckerö, Sweden. The EMS organisation comprises nine EMS stations at different strategic geographical locations within a primarily urban catchment area. The EMS organisation covers an area of 900 km2 with a population of 660,000 inhabitants (at the time of the study) and with predominantly short transportation times. During 2016, the EMS carried out more than 80,000 ambulance missions, assessed by regional dispatch as one of priority 1 to 3. Of these dispatched missions, a total of 58,575 assignments involved an initial patient assessment defined as a primary mission. Approximately 3,150 (5.4%) of these missions involved children aged 15 years or younger. Within the geographical area, there are four hospitals, of which one is a dedicated children's hospital and one adult trauma centre. The EMS is organised under Sahlgrenska University Hospital and operates with a differentiated fleet of 22 units which comprises 18 ALS ambulances, two single responders, one physician-manned responder and one scene-command unit. Moreover, there are another ten non-emergency patient transport units staffed by EMTs. All other units are staffed by at least one registered nurse and, within the EMS organisation, the majority of the EMS nurses have undergone an additional one-year programme specialising in pre-hospital emergency care.

Data were collected in January-December 2016. Prospectively, the staff at each ambulance station within the study organisation had rehearsal training in the RETTS triage system at workplace meetings. Patient assignments were then reported to the digital EMS patient register, Ambulink, as per standard care. Retrospectively, data variables were collected and entered into a registry that we created with predefined variables of interest. Data were retrieved from five registries: EMS patient notes system (Ambulink) (assessment and triage), hospital patient records (Melior), ED information system (ELVIS), patient paper notes and the Swedish population registry (Folkbokföringsregistret) retrieving status on mortality.

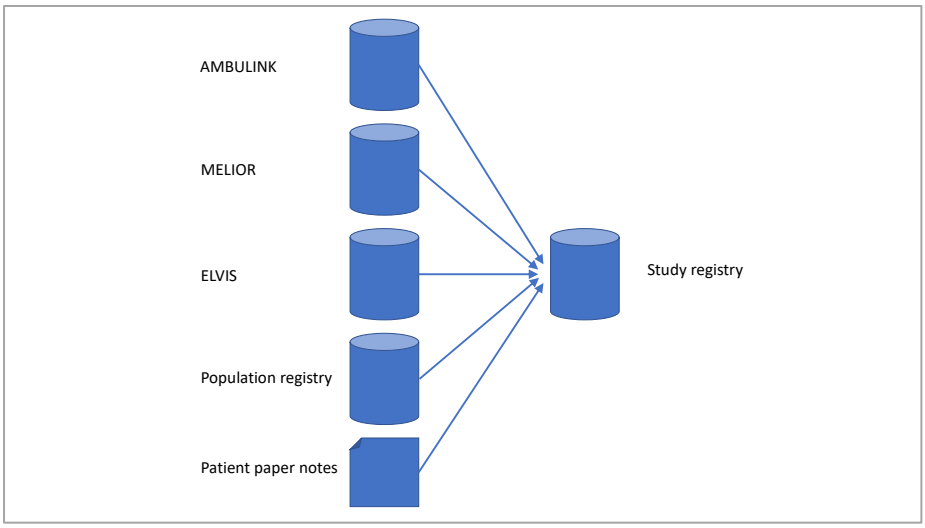


Figure 8. Included databases from which data were retrieved

The first 1,000 assignments each month, comprising patients in contact with the Swedish emergency number 112 and assessed as being in need of an EMS nurse at the scene (priority 1-3), formed the background population. A total of 716 children < 16 years of age were reviewed manually. For the adult population, 7,520 were reviewed manually as a consecutive convenient sample, approximately 625 primary assignments per month. No power calculation was made on outcomes and an arbitrary sample of a minimum of 5,000 cases was therefore decided on. This number was deemed sufficient to draw conclusions when comparing groups after discussion with our statistical expert.

Table 1. Summary of design, population and number of patients included in papers I-IV

	Paper I	Paper II	Paper III	Paper IV
Design	Prospective with retrospective analysis	Prospective with retrospective analysis	Prospective with retrospective analysis	Prospective with retrospective analysis
Population	Children < 16 years of age assessed at the scene by the EMS nurse. EMS Sahlgrenska, 2016	Children < 16 years of age assessed by the EMS nurse at the scene and transported to hospital. EMS Sahlgrenska, 2016	Adults ≥ 16 years of age assessed at the scene by the EMS nurse. EMS Sahlgrenska, 2016	Individual patients with triage colour ≥ 16 years of age assessed at the scene by the EMS nurse and transported to hospital. EMS Sahlgrenska, 2016
Patients	n=651	n=454	n=6712	n=4465
Main interest	Patient characteristics, level of care, outcome in hospital	EMS triage performance, EMS field assessment	Patient characteristics, level of care, outcome in hospital	EMS triage performance, EMS field assessment

In Paper I, the inclusion criterion was a primary patient assessment at the scene where 651 children under 16 years of age were included of which n=644 received an initial assessment by the EMS nurse and n=7 were re-assessed and transported by ambulance within 72 hours. In Paper II, the inclusion criterion was primary patients that were assessed as being in need of hospital resources and were therefore transported to the paediatric ED; this comprised a total of 454 patients. Paper III included primary patients with on-scene assessments of adults aged 16 years and older. In Paper III, a total of 6,712 patients were included of which 6,652 had an EMS nurse's initial assessment, where 60 patients were re-assessed and transported to the ED within 72 hours. In Paper IV, individual adult patients aged 16 years and older and assessed as being in need of hospital resources by the EMS nurse and triaged to a RETTS-A colour were included. A total of 5,340 patients were assessed by the EMS nurse at the scene as requiring hospital resources. Of these, patients that had multiple occasions during the study period were randomly selected. Another 145 patients who had VS missing and regarded as not being at random were excluded. Furthermore, 150 patients left the ED before being seen by a healthcare provider and were thus excluded. A total of 4,465 patients with a triage colour and full VS (imputed) were thus included.

PATIENT SAFETY

Patients receiving care from EMS providers are exposed to risks associated with the pre-hospital care environment and system of care. From its nature, it can be described as a high-risk environment providing complex care in often difficult circumstances with limited resources. However, no common language is used to define adverse events in the EMS setting, making general discussion and comparisons challenging. A previous study of adverse events was performed using an American assessment protocol when identifying adverse events [132]. The Swedish patient safety legislation defines an adverse event as suffering a physical or mental injury or disease, or mortality which could have been avoided if adequate measures had been taken when the patient was in contact with the healthcare provider [133]. However, there is a lack of more comprehensive definitions defining pre-hospital care in the literature. Bigham and colleagues define patient safety as the "reduction and mitigation of unsafe acts within the healthcare system" and they exclude "discussion of best practices for specific diseases such as…early identification of an acute myocardial infarction employing 12-lead electrocardiograph" [134]. This may also be important to incorporate in the new paradigm with the EMS nurse in the new role of assessing and triaging patients at the scene. It was therefore thought that patient safety would be jeopardised if the patient remained at the scene and was subsequently diagnosed with a time-sensitive condition or died at the scene after the initial EMS nurse's assessment. These cases were reviewed in detail. It was also felt to be a threat to safety if the patient was brought to hospital and triaged to level green or yellow with a time-sensitive condition or with VS at risk.

OUTCOMES

SEVENTY-TWO-HOUR FOLLOW-UP

We defined 72 hours from the initial time of arrival at the scene where the EMS assessment took place to ED admission under the following premises. The patient was initially assessed to remain at the scene but referred to primary care or with increased home care. If the patient either contacted the EMS within 72 hours or visited the ED by themselves within this time frame and with symptoms and signs that could be attributed to the initial contact, they were included as follow-up in 72 hours.

TIME-SENSITIVE CONDITIONS

There is no international consensus on how to define the group of diagnoses which are characterised by a more favourable outcome if delay until definitive care can be avoided. However, there is a widespread agreement that the delay to treatment is important for the outcome for patients with a number of cardiovascular diseases such as stroke, MI and peripheral artery disease (PAD). We therefore defined a time-sensitive condition as a condition where time to treatment is important in order either to limit organ damage or to avoid complications and the risk of early death [135].

To determine a time-sensitive condition, we have primarily relied on the International classification of diseases tenth revision (ICD) hospital diagnosis. In Papers I and II (paediatric population), a time-sensitive condition was defined as in previous studies by van Veen and colleagues [103,136]. In Papers III and IV (adult population), time-sensitive diagnoses were in agreement with the proposed list of time-sensitive conditions [135], for example, MI, stroke, anaphylaxis and sepsis. In a few cases, the final hospital assessment was expressed in the text as confirmed sepsis, but the ICD diagnosis stated pneumonia. These cases have been regarded as time-sensitive conditions. Only time-sensitive conditions that could be linked to EMS patient presentation (Appendices A and C) have been considered.

TIME TO DEATH

With few exceptions, there is no consensus in the EMS on any variables, on what to measure and what to report. One such exception is the Utstein criteria in pre-hospital cardiac arrests [137]. We reported on several time intervals with regard to time of death, such as 48 hours, seven-day, 30-day and one-year mortality. Mortality has been calculated as a crude mortality rate which is defined as the mortality rate from all causes of death in a population during a given time interval.

LIFE-THREATENING COMPLICATIONS

A follow-up for all adult patients regarding complications was performed up to 48 hours from the EMS nurse's patient assessment if brought to hospital. All patients were screened for the occurrence of complications in EMS records and hospital records and it was reported to the study database if patients had sustained any of the following: deranging vital signs: obstructive airway, respiratory rate < 8 breaths/min or > 30 breaths /min, oxygen saturation with supplementary oxygen < 90%, pulse rate > 130 beats /min, irregular pulse rate > 150 beats /min, systolic blood pressure < 90 mm/Hg, on-going seizures, level of consciousness equal to or above RLS 4, or a condition regarded as a

potential risk of death including cardiac arrest, ventricular arrhythmias, status epilepticus, severe heart failure, hypotension, unconsciousness and syncope. The chosen time interval of 48 hours was arbitrary, but it was regarded as the most appropriate time interval in order to predict the likelihood of a complication to the patient's actual condition that could be linked to the EMS assignment.

ADMISSION TO HOSPITAL

Admission to hospital was considered if the EMS nurse had assessed a patient at the scene and the patient's complaint required admission to in-patient care after the ED physician's assessment or if the patient was transported directly to a ward. The first day was counted as day 1. Cases in which the patient was admitted during the night and discharged in the afternoon have been considered as one full day of in-patient care.

EMS TRIAGE PERFORMANCE

DEFINITON OF A REFERENCE PATIENT

There are several challenges in the measurement of triage performance. In order to test a triage system, there are several steps of which the first step is determining the best proxy for prognosis [89]. While there is no consensus on what constitutes a true emergency, several variables and outcomes have been used to mimic a "gold standard", since no such standard exists [103]. An "emergent" patient was defined based on a combination of a time-sensitive condition and VS. This definition was then compared with the EMS nurse's triage according to the RETTS. A classification was considered appropriate if a triage assessment was found in one of the acute process RETTS triage levels orange (potentially life threatening) or red (life threatening) while also fulfilling the criteria of an "emergent" patient.

Pediatric population

In Paper II, we used an approach similar to that used in several studies validating the MTS [103,136]. An "emergent" reference patient was defined using both 1) a time-sensitive condition according to the paediatric definition and 2) VS associated with a risk of instability and death. The reference VS intervals for an "emergent" patient were obtained from the paediatric risk score of mortality III – acute physiological scores (PRISM-III-APS) (Appendix B). This scoring system was reported from a study including 32 paediatric ICUs [138]. The reference VS was compared with the last set of VS recorded in patients with a triage level. The VS that were included if present were: respiratory rate, oxygen saturation, pulse rate, body temperature and level of consciousness.

In the RETTS-p VS, oxygen saturation is measured as SaO2, whereas, in the PRISM III-APS, PaO2 is measured. SaO2 has been converted to PaO2 using a formula presented by Severinghaus [139], and a cut-off value of SaO2 < 91% as a value outside the reference indicates an increased risk of death. However, as reported in the Prism III – APS, the risk of death is lower in some of the VS and this has not been weighted. On the other hand, if admitted to the ICU with deviating VS considered to be associated with an increased risk death, it would be reasonable also to consider this risk in the pre-hospital arena.

Therefor a paediatric 'emergent' patient was defined as either having deviating VS according to the definition or having a time-sensitive condition. A true positive was then considered in cases where the EMS nurse triaged the patient to the red or orange level and the case was classified as "emergent" according to the definition.

Adult population

In Paper IV, we adopted a similar approach to defining a reference patient representing an "emergent" patient. We used either a time-sensitive condition or the NEWS (first version) to include both conditions and deviating VS. An aggregated VS NEWS score of five or above or a score of three in a single VP was defined as an "emergent" patient. An EMS triage level of red or orange was therefore considered a true positive if the patient was also classified as an "emergent" patient according to the definition.

COMPARISON BETWEEN THE EMS NURSE ASSESSMENT AND FINAL DIAGNOSIS

In Papers II and IV, a comparison was made between the EMS nurse's field assessment and the physician's final hospital diagnosis. The EMS nurse's field assessment was classified according to an instrument created by Herlitz and colleagues, which has been described in a study protocol [140]. Although never validated, it has been used in previous studies [141,142]. The instrument includes five main categories from A-E which correspond to different levels of severity and specificity of the final diagnosis according to the ICD code: A – defined diagnosis classified as time sensitive, B – defined diagnosis classified as non-time sensitive, C – final diagnosis expressed as a symptom, D – final diagnosis not specified, E – the patient remained at the scene. Since Papers II and IV only included patients who were brought to hospital, patients who were categorised to level E were excluded from the analysis.

Each main category was divided into six or five subcategories respectively for the classification of the EMS nurse's field assessment. These subcategories describe the level of agreement between the field assessment and the final diagnosis. Levels of agreement differed from "in agreement" to "not in agreement" to a "non-specified field assessment". All cases in which a categorisation was considered difficult have been jointly classified in the research group in order to reach consensus.

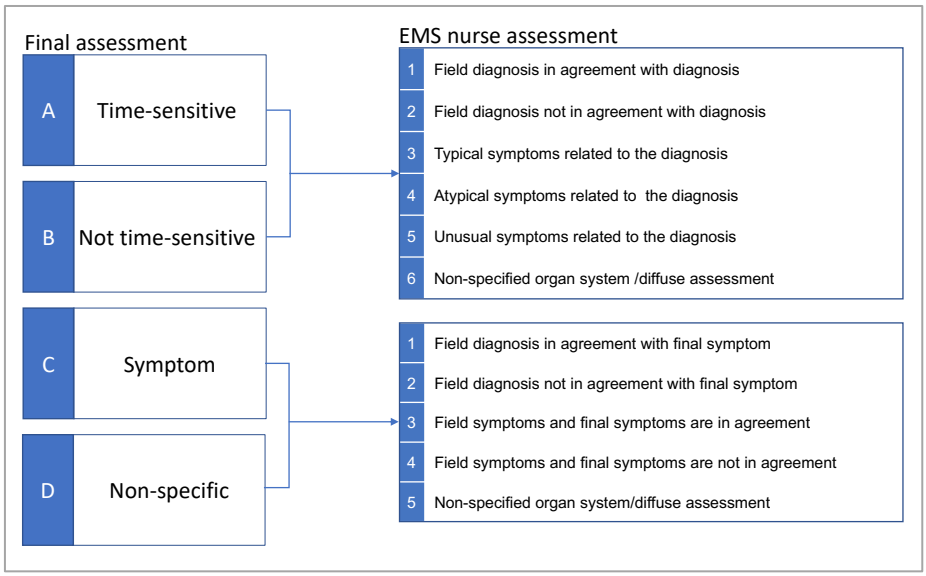


Figure 9. The instrument used for the EMS nurse's field assessment and final hospital assessment, adapted from Hagiwara et al. with permission [140]

A field assessment in paediatric assessments has been considered "appropriate" if classified as either "the field assessment (described as a diagnosis) is in agreement with the final diagnosis" (A1, B1, C1 or D1) or "the field assessment (described as a symptom) is in agreement (typical of or atypical of) with the final diagnosis" (A3, A4, B3, B4, C3 or D3). The remainder have been regarded as either less appropriate or difficult to assess.

In the adult population, a field assessment has been considered as "inappropriate" if classified as either "the field assessment (diagnosis) is not in agreement with the final diagnosis" (A2, B2, C2 or D2) or "the field assessment is not specified" (A6, B6, C5 or D5). The remaining subcategories were considered to be appropriate.

STATISTICAL CALCULATIONS

In Paper I, we used descriptive statistics presented as numbers or the median with percentages and 25th and 75th percentiles. We compared the groups assessed as requiring transport to the pED or non-conveyed, patients with full triage and non-full triage using the Mann-Whitney U test for continuous/ordered variables and Fisher's exact test for dichotomous/categorical variables. For association with age, Spearman's rank statistics were used for continuous/ordered variables and the Mann-Whitney U test for dichotomous/categorical variables. In analyses of associations with age, the actual age was used for p-value calculations.

In Paper II, data are presented with descriptive statistics as numbers and percentages. In addition to this, several binary classification tests using 2x2 tables including sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) and likelihood ratios (LR) were used in order to determine EMS triage performance when related to the predefined reference patient.

In Paper III, data are presented with numbers (percentages), the median and percentiles (25th, 75th). Fisher's exact test and the Mann-Whitney test were used for two-group comparisons. Age groups in quartiles were created based on the median patient age in the Swedish pre-hospital patient population. For continuous variables, Spearman's rank statistics were used to test for associations with any age (years) and the Kruskal-Wallis and Fisher's exact was used for ordered/dichotomous variables, respectively to test for differences between age groups.

In Paper IV, Fisher's exact test and the Mann-Whitney U test were used for group comparison for dichotomous and continuous/ordinal variables respectively. The RETTS orange and red triage levels were combined and formed a high-acuity group which was compared with a green/yellow group. In a comparison of individual triage colour and outcomes, absolute risk (AR) and relative risk (RR) were determined by binary classification on each triage colour compared with not being triaged to the specific triage colour. Binary classification was used to determine sensitivity, specificity, PPV, NPV, LR, AUROC, accuracy, over-triage and under-triage with the RETTS-A high-acuity triage level orange and red compared with the reference "emergent" patient. The presented age groups were defined by the median EMS population in Sweden. When comparing the RETTS-A with the specific outcomes; time-sensitive condition, hospital admission, complications and mortality, triage level orange and red were combined and represented high acuity, whereas RETTS green/yellow was considered low acuity. When comparing the NEWS

and NEWS 2 with the outcomes, the NEWS of medium-risk level and above was regarded as high acuity.

In all the papers, p-values below 0.01 have been considered significant due to the large number of tests. In the binary classification of the RETTS, we used 95% confidence intervals (CI) in Paper II and 99% CIs in Paper IV, due to the large number of variables in the latter.

NEWS CALCULATION AND IMPUTATION OF VITAL SIGNS

In Paper IV, both the NEWS and NEWS 2 have been calculated retrospectively on vital signs in order to produce scores. Since a full set of variables is required, this was done with imputations. Patients with four or more of the six vital signs missing were excluded. Otherwise, missing was considered to be missing at random (MAR) and multivariate imputation by chained equations (MICE) was performed. Fifty datasets were created for each missing VS and were then pooled and used in the calculation.

When measuring level of consciousness in the NEWS and NEWS 2, the AVPU scale was used. The AVPU is an acronym in descending order for Alert, Verbal, Pain and Unresponsive. A reduced level of consciousness is a sign of an emergency that is associated with several time-sensitive conditions. In the NEWS, a patient will yield the highest individual VS score regardless of the degree of deviating level of consciousness, which, in the NEWS 2, also includes acute onset of confusion.

In the RETTS-A, the standard scale for measuring the level of consciousness is either the RLS 85 or the GCS. A conversion has been performed to give a score in the NEWS with the support of a conversion table between the RLS, GCS and AVPU (Appendix E). According to RETTS-A guidelines, RLS 2-3 should lead to triage level orange. However, in the material, a small proportion of the patients classified as RLS 2 were triaged to level yellow by the EMS nurse, which is defined as “drowsy” or confused but talkative with light stimuli. After manual review, these patients were therefore assessed as confused when calculating NEWS scores.

OVER-TRIAGE AND UNDER-TRIAGE

In Paper II and Paper IV, under-triage has been defined as the proportion of patients subject to sub-optimal care, whereas over-triage has been defined as the proportion of patient being allocated resources that are unnecessary for the outcome, i.e. over-utilising resources. In Paper II and Paper IV, under- and over-triage have been calculated as 1 – sensitivity and 1 – specificity, respectively.

ETHICAL CONSIDERATIONS

This study was approved by the regional ethical committee in Gothenburg, approval no. 970-15. The prospective part included an educational intervention with the staff to increase their skills with the triage system which was already in use in the EMS organisation. The aim was to increase the quality of retrospective data collection. Patients were assessed, triaged and cared for according to regional and local guidelines and reported to the standard electronic EMS patient record system. As a result, there was no patient intervention and the included patients were retrospectively retrieved from the EMS patient record system.

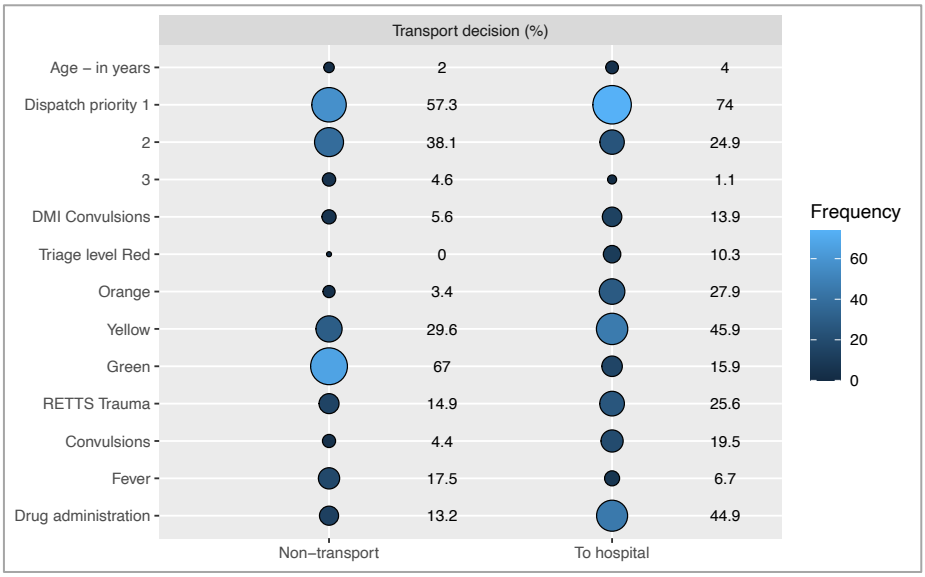
As it was a registry study, informed consent was waived and the requirement of informed consent at the scene for registry studies is most often not recommended by the ethical committees in Sweden for the following reasons. 1) Individual patients could never be identified in the analysis, since their identification number was translated to a code. Their integrity thus remained unaffected. 2) Some of the most severe cases could never be contacted in retrospect as they had either died or were in a very poor clinical condition. Furthermore, logistical reasons and language barriers would prevent communication with a number of patients. A requirement of informed consent would thus increase the risk of selection bias, thereby hampering the reliability of the data. 3) Approaching patients and/or relatives about these types of issue may create more anxiety than satisfaction and may therefore be regarded as unethical. All the data were coded with a number in the research registry and, as such, no personal sensitive information was collected.

RESULTS

PAEDIATRIC PATIENT ASSESSMENT

Among all the children under 16 years of age, the median age was three years, indicating that most EMS nurses' encounters and paediatric assessments are not only few in total but also deal with the very youngest.

Table 2. Children assessed to remain at the scene or transported to hospital



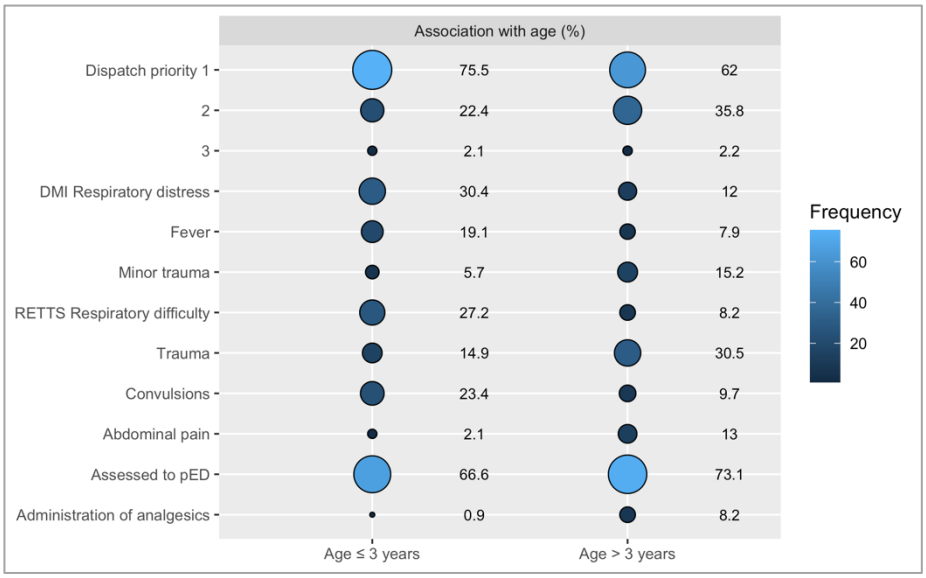
Patient age denoted in median years, all others in %

The EMS nurse assessed a total of 30% of those in contact with the Swedish emergency number (112) as being suitable to remain at the scene with treatment, self-care advice or referral to primary care. The dispatcher assessed a high frequency of children to priority 1 (69% in total), i.e. assessed as "life threatening" with an EMS response with lights and sirens, and 57% of the children who were assessed to remain at the scene were dispatched with a priority 1. Among all the children that received a triage colour, the EMS nurse triaged ten per cent to red triage level, all of which were transported to hospital, while the majority of the children that remained at the scene were triaged to level green. The most common symptom assessed by the dispatcher was respiratory distress, which may explain the large number of priority 1 calls, since the aim of the dispatch CBD system is to have perfect sensitivity but at the expense of low specificity. For patients triaged to respiratory distress by

the EMS nurse, there was no significant difference between patients that were transported or not transported.

The EMS nurse's decision on transport to hospital was associated with the RETTS triage of trauma including head, extremities, thorax and burns and convulsions. If triaged to RETTS fever, patients more frequently remained at the scene compared with being assessed as requiring hospital resources. Decreasing oxygen saturation was associated with a decision on transport, as well as a change in the level of consciousness deviating from the normal level of alertness, RLS 1 (GCS 15), whereas there was no difference between the two groups regarding respiratory rate, pulse rate and body temperature.

Table 3. Patient assessment and management and association with age



Younger patients were assessed to remain at the scene more frequently than older patients. This also indicates that older patients sustained more traumas and were thus assessed by the EMS nurse as requiring hospital resources. In the light of more trauma cases among the older children, this group was administered more analgesic medication compared with the younger group.

There was a significant difference in VS between children aged three years and below compared with the older children, but this must be related to the fact that normal ranges are related to age. However, we found that body temperature was higher, oxygen saturation lower and there was more frequently an altered level of consciousness among the youngest children. One explanation for this

may be the larger number of conditions associated with infections and symptoms of fever and convulsions, with a change in the level of consciousness.

Among the patients who remained at the scene, eight per cent were admitted to the pED within 72 hours. We found that only two of these patients were admitted to in-patient care and in one case the initial patient assessment at the scene was considered less appropriate. The RETTS for children appears to be utilised more extensively as prescribed in situations with older children and if transported to the pED.

In the transported group, there were five deaths within 30 days, 0.8% of all assignments. The most common physician hospital diagnosis was found under the ICD chapter of "Injury, poisoning and certain other consequences of external causes", in which fractures and superficial injuries were the most common diagnoses. Symptom-based diagnoses were also common, exemplified by convulsions and unspecific abdominal pain. This indicates that a number of children did not have any specific diagnosis, which indicates that the investigations did not reveal any specific abnormality and the patient could thus be discharged from the pED.

The ICD chapter of "Injury, poisoning and certain other consequences of external causes" was also the most common group of diagnoses among children without a full RETTS triage according to guidelines. Among all patients assessed by the EMS nurse, only 38% were triaged with a full RETTS including ESS code and all VS. The most common missing VS was respiratory rate. Patients with a full triage had a median age of six years, three times the median age of those with limited triage. There were more patients with limited triage in non-transported children compared with the group that was transported to hospital.

A total of 454 patients were assessed as requiring hospital resources by the EMS nurse and were thus transported to hospital. A total of 11% of them had deviations in VS associated with an increased risk of death and seven per cent had a condition that was regarded as a time-sensitive condition. However, only three per cent of the children received a specified hospital diagnosis that was considered time sensitive, such as sepsis, intoxication or intra-cranial bleeding.

Among patients who were assessed by the EMS nurse as requiring hospital resources, a total of 390 (86%) were triaged to a triage level. A yellow triage level was the most frequent among these and, among patients that were admitted to in-patient care, the yellow triage level was the most common.

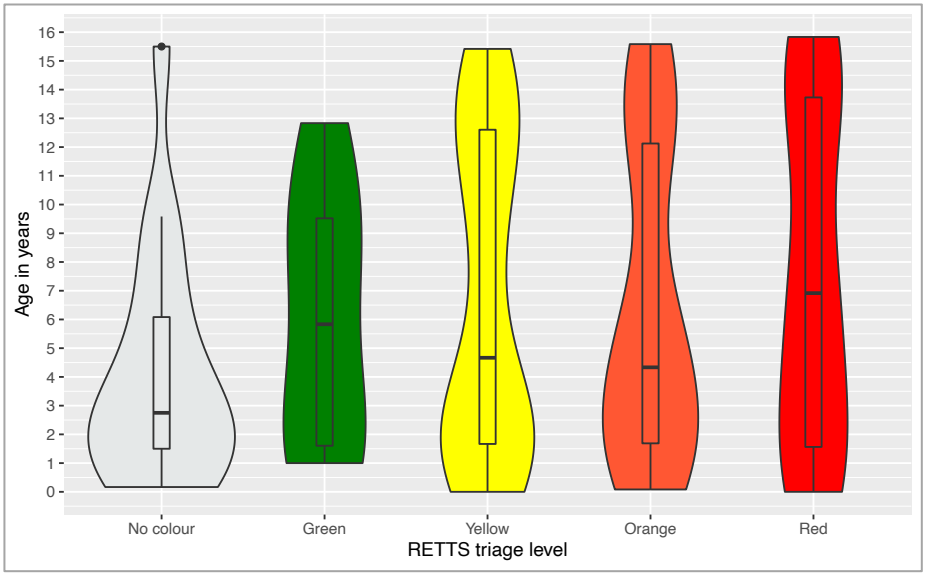


Figure 10. Age distribution and EMS RETTS triage level in hospitalised children. The dot in patients with no colour represents an outlier

We found that, among all patients assessed at the scene by the EMS nurse as requiring hospital resources, one in four was admitted to in-patient care and the median length of stay was two days. The most common conditions among hospitalised children were febrile seizures, infections, commotio and fractures requiring surgery. There was a higher age among hospitalised red-triaged children, whereas, if the triage colour was missing, the age was lower. The proportion of children requiring hospital admission increased with increasing nurse triage level. Children with triage level red had the highest percentage of hospital admissions (55%). However, a relatively large proportion of patients triaged to red were discharged from the pED. Overall, a total of 32% of the patients who were transported to the pED were discharged from the pED, with no intervention other than an examination by a physician or pED nurse and the administration of over-the-counter medication.

EMS TRIAGE PERFORMANCE IN CHILDREN

The patients who were transported and assigned to a triage level were classified, depending on whether they met the criterion of deviating VS or were assessed with a time-sensitive condition. Among all the patients triaged with a colour (n=390, Fig.10), 149 (38%) were triaged to red or orange level, indicating (according to the RETTS) a "life threatening" condition or a "potentially life threatening" condition. An emergency process should therefore be initiated promptly at the pED. The remaining 241 patients were triaged to yellow or green (low acuity).

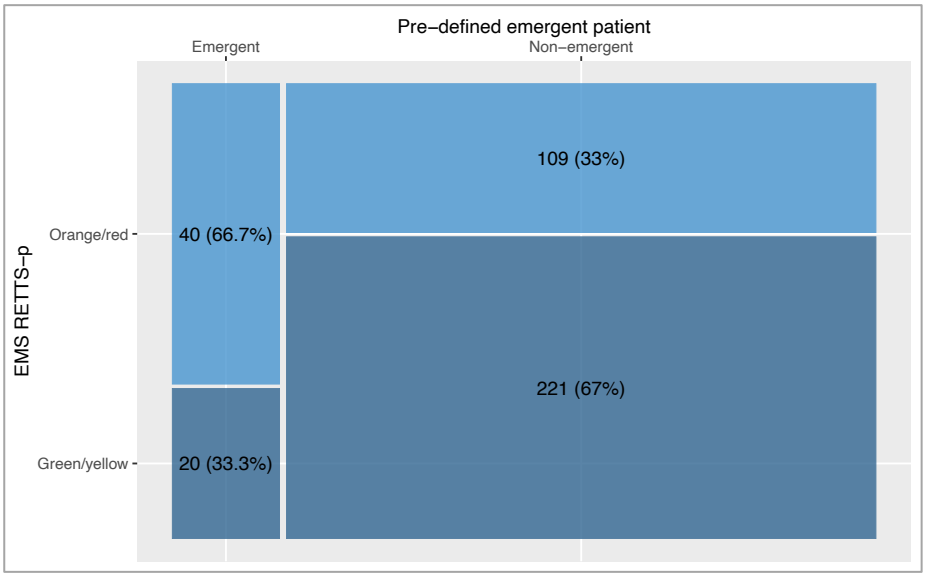


Figure 11. Classification of the EMS assigned RETTS-p acuity level

In total, sixty patients (15%) were classified as "emergent" patients and of those forty patients were triaged to the red/orange (high acuity) level. The sensitivity was 67%, giving an under-triage of 33%. Of the patients classified as "non-emergent" according to the reference patient (n=330), a total of 221 patients were also triaged to the RETTS-p yellow/green, with a specificity of 67% and an over-triage of 33%. If triaged to the yellow or green level by the EMS nurse, the probability that the patient would also be classified as "non-emergent" was 92% (NPV). Likewise, the probability that a patient triaged to the red or orange level would also be classified as "emergent" was 27% (PPV).

Among yellow/green triaged children who were classified as “emergent” according to the definition, deviating VS was more frequent than time-sensitive conditions. The most common deviating VS were high pulse rate and high body temperature. Seventeen of the under-triaged cases were found in the yellow triage level and three cases in the lowest level of green. The most common hospital diagnosis found among children who were under-triaged was infectious diseases, including febrile seizures with a viral origin. However, one patient with sepsis was also found in this group.

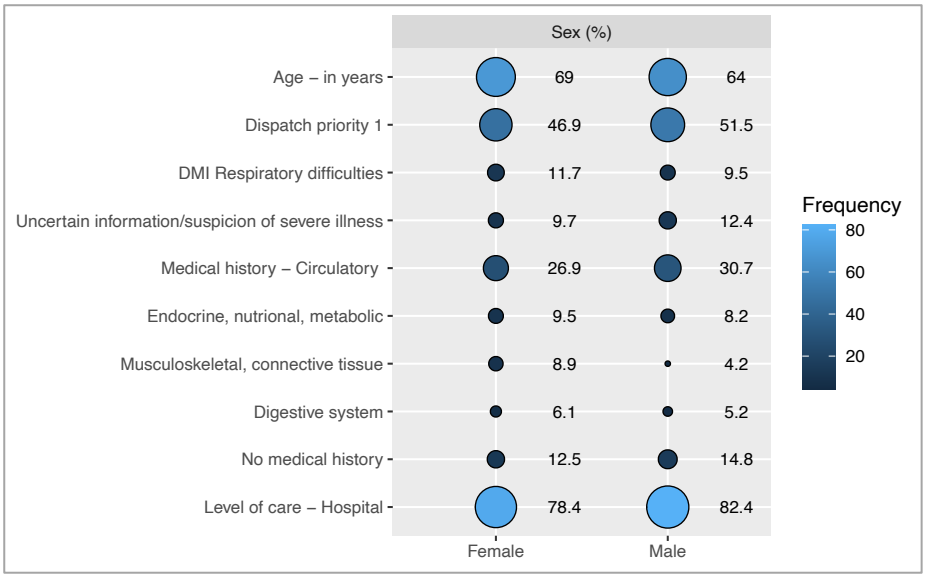
Among children who received a final physician diagnosis we also classified the EMS nurse field assessment regardless of RETTS triage level and compared the level of agreement between pre-hospital field assessment and in-hospital physician diagnosis. In total there were 412 patients who received a final diagnosis and were classified with the final diagnosis instrument. Among them there were thirteen diagnoses that were classified as time-sensitive. In total, the EMS field assessment was considered in agreement with the final physician-based diagnosis in 80% of the assignments.

ADULT PATIENT ASSESSMENT

In the adult cohort, a total of 6,712 patients were included that were in contact with the Swedish emergency number 112 and assessed as being in need of an ambulance and who were assessed at the scene by an EMS nurse. However, sixty of these patients were assessed by the EMS nurse a second time in the defined follow-up period of 72 hours. A total of 6,652 patients therefore received an initial assessment, of which 1,312 (20%) remained at the scene with self-care advice, EMS nurse treatment/intervention, referral to home care or referral to primary care.

Among all the patients, the median age was 66 years and most of them had a past medical history of one or more diagnoses. The most common past medical history was circulatory including hypertension, stroke and myocardial infarction. A history of a psychiatric disorder was also common, for example, anxiety, depression and substance abuse.

Table 4. Differences between females and males in the adult population



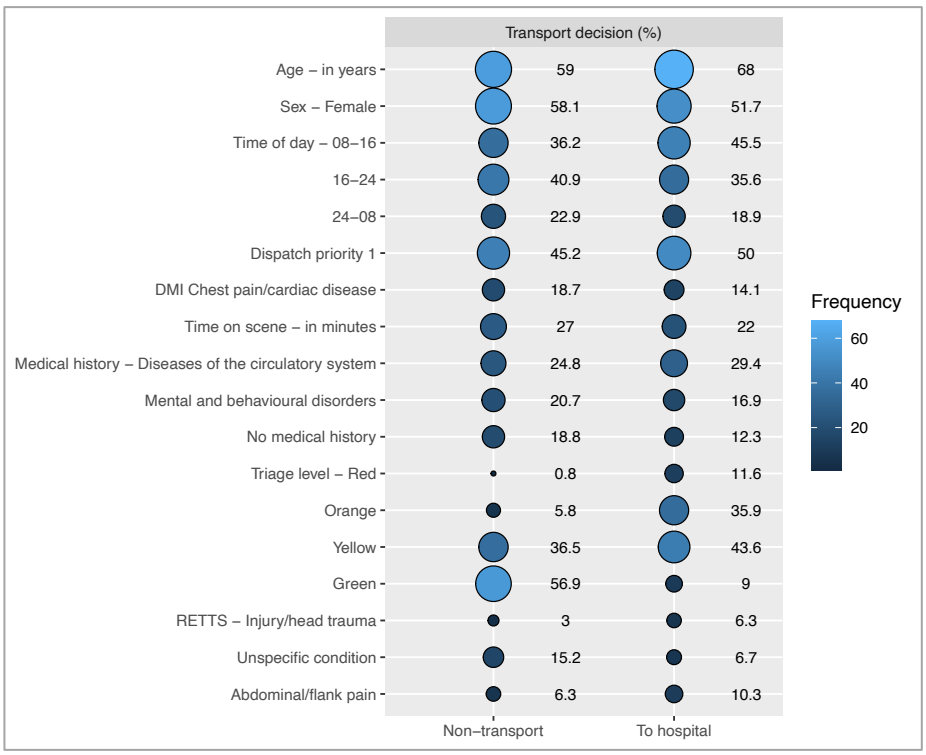
Patient age is denoted as the median number of years, all others in %

Females were five years older and more often had a medical history of endocrine and metabolic diseases, musculo-skeletal diseases and digestive system diseases, whereas males more frequently had circulatory diseases. Males more frequently had no medical history, which may be explained to some extent by their lower age. However, a larger proportion of males were

given priority 1 by the EMDC and males were more often assessed according to the dispatch medical index (DMI) as "uncertain information/suspicion of severe illness", whereas females were more often assessed as "respiratory difficulties".

Among all patients, the most common DMI was "chest pain/cardiac disease" and a total of 49% of the cases were assessed as "life threatening" priority 1 by the dispatcher. The vast majority of the transported patients were transported by ambulance (93%). It was more common for male patients to be assessed as requiring hospital resources compared with females, who remained at the scene to a greater extent.

Table 5. Patients assessed to a lower level of care and patients transported to hospital



Patient age is denoted as the median number of years, all others in %

Overall, the non-transported patients were almost ten years younger compared with patients assessed as requiring hospital resources. Most of the patients who were assessed by the EMS nurse as needing to remain at the scene made contact after office hours, 16-24, and during the night, 24-08. The most common DMI among patients who remained at the scene was "chest pain/cardiac disease",

explained to some extent by the fact that this was the most common DMI overall. On the other hand, DMIs of "extremity/ wound/minor trauma", together with "abdominal pain", were associated with transport to hospital.

In a similar way, the EMS nurse's assessment at the scene included "abdominal pain" and "injury head/trauma", according to the RETTS, as frequent conditions among patients who were transported to hospital, whereas "unspecific condition" was the most frequent of all the RETTS-A chief complaints (15%) among patients who remained at the scene. In the most common RETTS triage group, "chest pain/thoracic pain", there was no significant difference between transport to hospital (10%) and non-transport (12%). This indicates that patients assessed with this chief complaint included a broad spectrum of patient presentations.

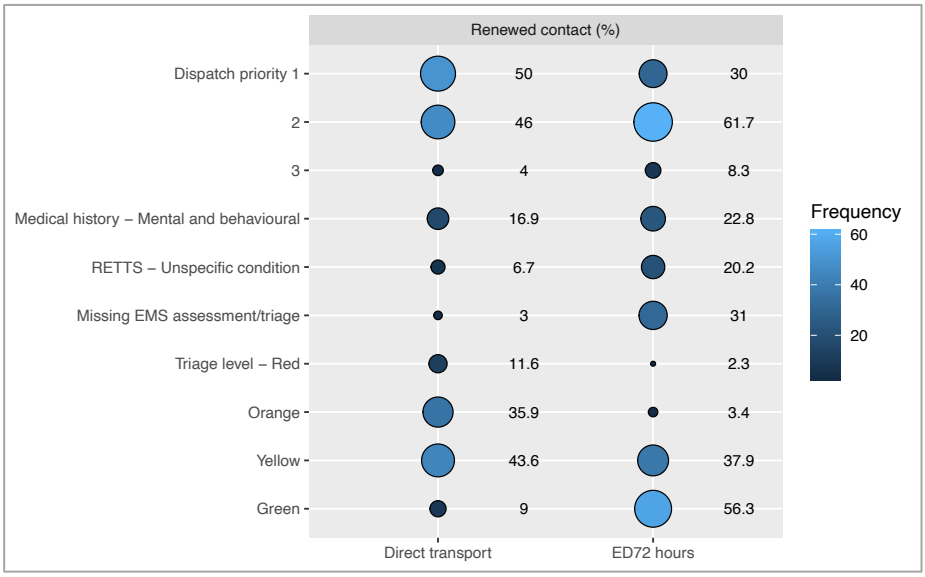
Past medical history also differed between the groups, with more patients transported to hospital with a past medical history of circulatory diseases, whereas a psychiatric diagnosis or no prior medical condition were more common among those who remained at the scene. The EMS nurse appeared to take time on the assessment of patients who remained at the scene, with a longer median time at the scene in these cases.

As expected, more VS deviated from normal in the transport group compared with non-transport, although four per cent remained at the scene with an change in their level of consciousness, which could be explained by the influence of alcohol.

Given that the majority of triaged conditions were assessed as requiring hospital resources, thereby resulting in transport by an ALS ambulance resource, only 19% of all transported patients received intravenous medication and 34% received any medication. This indicates that the majority of all the patients transported apparently required an EMS nurse's assessment and competence or monitoring during transport to hospital but no medication.

For those patients who remained at the scene with self-care advice or with a referral to primary care, 126 patients (9.6%) were admitted to the ED within 72 hours. Among them, 60 patients were sent another ambulance and were re-assessed by the EMS nurse at the scene. Of these, 55 patients (44%) were transported by ambulance, another five were re-allocated to patient transport and the EMS nurse therefore left the scene. The remainder transported themselves by their own means. Among patients admitted to the ED within 72 hours, the need for ambulance transport was reduced from 93% to 44%.

Table 6. Difference between patients initially assessed as requiring transport to hospital and patients with renewed contact within 72 hours



This was also reflected in the dispatcher priority, where 50% of patients who were initially assessed by the EMS nurse as requiring hospital resources were assessed with "life threatening" priority 1, but, in the ED72 group, the corresponding percentage was only 30%. This indicates that, even though they were initially assessed on the telephone as "critical", the patients now raised less suspicion of a "life threatening" condition.

Patients admitted to the ED within 72 hours had a higher frequency of a medical history of "mental and behavioural disorders" compared with the initially assessed patients. The most common RETTS triage group among those who had an ambulance at the scene within 72 hours was "unspecific condition" with no change between the first and second assessments (20% both times). In the first assessment, a total of 31% did not receive any triage level at all. Missing triage decreased to 3% at the second assessment.

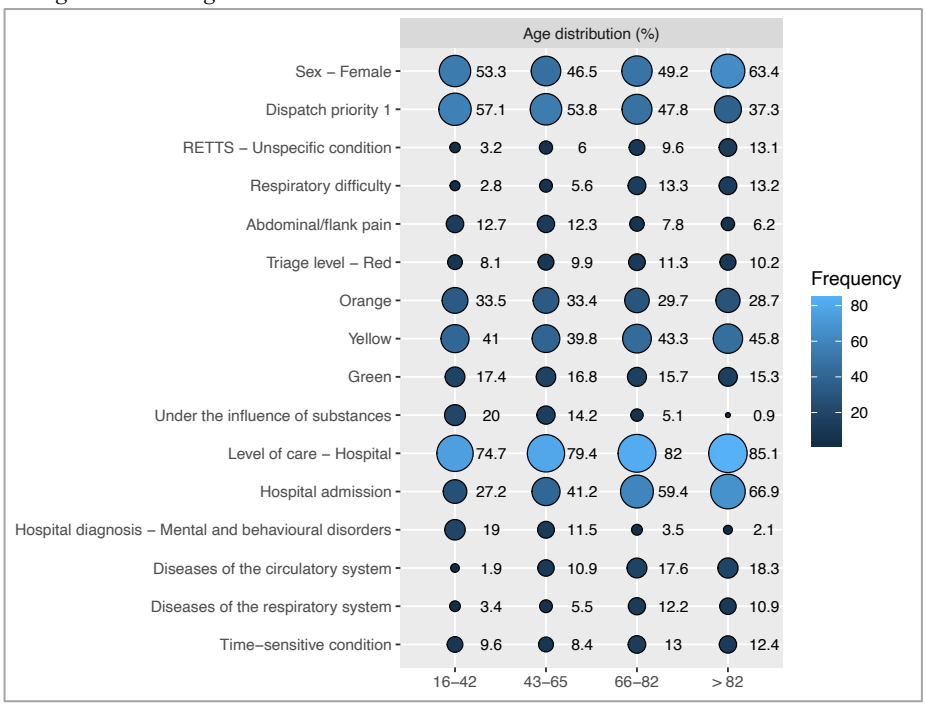
There were no differences between the ED72 hours group and the patients with an initial assessment and direct transport to hospital regarding management in hospital, final diagnosis, length of stay or all-cause mortality. However, of those who received a triage colour in the ED72 group, all colours increased between the first and second assessments, except for the green level which decreased from 56% to 9%. This indicates that the second assessment according to the RETTS triage found more patients with deviating VS or a more severe ESS colour. The most common hospital diagnosis in this group described a symptom such as dyspnea or chest pain. However, 10% of the

patients in the ED72 group were later diagnosed in hospital with a time-sensitive condition. Of the diagnoses defined as time-sensitive where direct transport may have benefited the patient, stroke and sepsis were most common.

Mortality for the patients with renewed contact did not differ from that of patients who were initially assessed and transported to hospital. Mortality within seven days was 1.2% among all patients who remained at the scene. In most of these cases, this was a joint decision between the EMS nurse, relatives and responsible family physician in cases of terminal illness or other conditions assessed as the best option for the patient to remain at the scene in end-of-life care. However, the assessment was considered inappropriate in five cases, and the outcome may have differed if the patient had been transported to hospital.

We also examined patient characteristics in relation to age. The age categories were divided from the median age in the EMS population (65 years) in Sweden, which was also similar in this cohort (66 years).

Table 7. Age distribution and patient characteristics, EMS nurse's assessment, and hospital management and diagnosis



The third quartile (66 to 82 years) included most patients. Despite the fact that past medical history becomes more severe with increasing age, the proportion of patients who received the highest priority at dispatch was the other way round, i.e. decreasing with increasing age. As a result, among patients in the youngest age group, 57% received priority 1 as compared with 37% in the oldest age group.

In the EMS nurse's assessment at the scene, there were trends in patient presentation and RETTS triage. If younger, triage of "abdominal/flank pain" was more common, whereas triage of "unspecific condition" and "respiratory difficulty" increased with increasing age. Younger patients were more frequently triaged to specific chief complaints and ESS codes than the oldest patients.

As many as 20% of the patients in the youngest age group were under the influence of substances such as alcohol (most common) or drugs, compared with fewer than one per cent in the oldest age group. The most common past medical history, if any, among the youngest patients was mental and behavioural disorders (46%). Moreover, the vast majority (68%) of the youngest requested help in the evening, 16-24, or at night, 24-08, whereas the majority in the oldest age group requested help during office hours, 08-16. The proportion of patients assessed as requiring hospital resources increased with increasing age.

The proportion of patients who required hospitalisation increased markedly, with increasing age being more than twice as high in the oldest age group compared with the youngest age group. As a result, the youngest age group were more often managed in the ED, including labs and the prescription of drugs, and they also left the ED, without being seen, more frequently.

A final diagnosis of "mental and behavioural disorders" was more common among younger patients. In fact, in the age group below 42 years of age, one in five patients was diagnosed with "mental and behavioural disorders", which also a included a diagnosis of intoxication. Despite this, time-sensitive conditions were more common among the older patients and they also suffered from a higher occurrence of complications within 48 hours, including deviating VS.

Adherence to the RETTS system was relatively high, considering the EMS nurse's assessment of not transporting almost 20% of the patients. Among all patients, 77% were triaged with both ESS and all VS according to guidelines. If patients had a limited triage with fewer VS recorded, they could still obtain a triage colour based on a single or more VS or by the ESS level alone. The most common missing VS were diastolic blood pressure and body temperature.

Among all patients, a limited RETTS was associated with an increase in time-sensitive conditions. This indicates that the full triage of patients is more frequently performed when required and when there is enough time.

Examples of patients with limited triage were those who were not hospitalised and given diagnoses in the ICD chapter of "Injury, poisoning and certain other consequences of external causes" and "Mental or behavioural disorders". In the ambulance, the EMS nurse also limited the triage if the patient was under the influence of alcohol or drugs or was triaged to "injury head trauma", whereas the most complete triage assessments were found in patients triaged with "abdominal/flank pain" and "respiratory distress".

EMS TRIAGE PERFORMANCE IN ADULTS

In patients assessed as requiring hospital resources and triaged to a colour level, 13% were triaged to red. Overall, the median age was 69 years and, if triaged to yellow/green, the patients were older compared with red/orange-triaged patients. There were also more females in the lower level groups (yellow/green).

The EMS nurse triaged 77% of patients to the red level among those who were initially assessed at dispatch as priority 1 (life threatening). The most frequent EMS nurse RETTS assessment at the scene for red patients and in total was "chest pain/thoracic pain", with no difference across the other triage levels. Time during the day was associated with triage level, with more red/orange-triaged patients in the evenings and nights compared with patients triaged to a lower level.

If patients were triaged to red/orange, the time at the scene was longer than yellow/green and the red group had the longest time. These patients were also more commonly administered medications, where bronchodilators and steroids were frequent. This indicates that the on-scene management of B problems before transport to hospital was relatively frequent among these patients, including recording an ECG at the scene.

Upon arrival at the ED, eighty per cent of the red-triaged patients were hospitalised, with a decreasing frequency in lower triage colours, with the lowest percentage among green-triaged patients (31%). The most common hospital diagnosis among patients assessed by the EMS nurse as requiring hospital resources was symptom based and was found in the ICD-10 chapter of "Symptoms, signs and abnormal clinical and laboratory findings", of which yellow- and green-triaged patients received this diagnosis in this chapter most frequently. Patients triaged to red or orange more frequently had a specified

final diagnosis found in “diseases of the circulatory system” and “diseases of the respiratory system”.

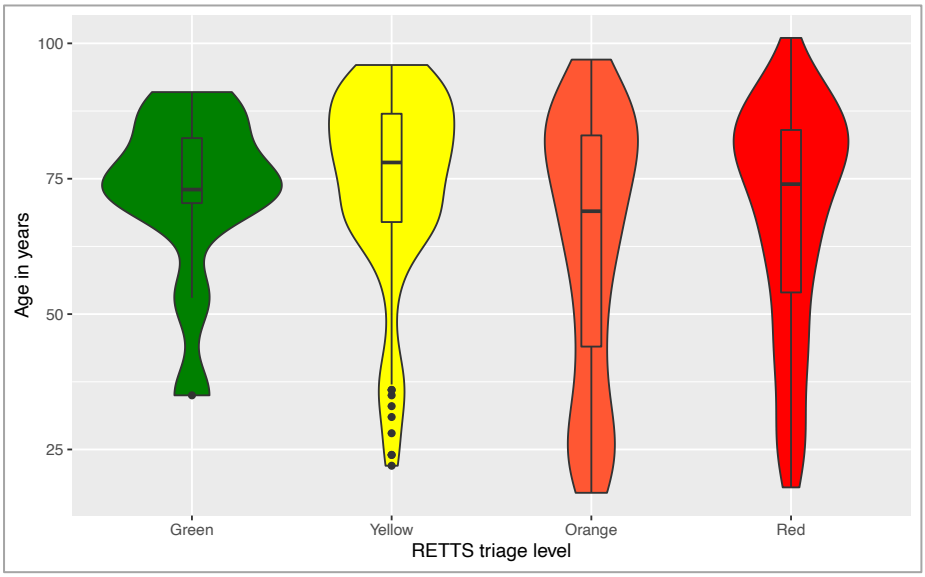


Figure 12. Distribution of age among patients with a time-sensitive condition and EMS triage level. Dots in the figure represents outliers

The most frequent triage colour among all time-sensitive conditions was orange. Red-triaged patients ran a three times higher risk of having a time-sensitive condition than if not triaged to red. If triaged to level green, the risk of having a time-sensitive condition decreased by 73% compared with not being triaged to green level. However, older patients with a time-sensitive condition were more frequently triaged to a lower level compared with younger patients. Red-triaged patients had an absolute risk of 26% for a time-sensitive condition and an almost thirteen times higher risk of deviating VS and/or complications than those not triaged to red. This is expected, as deviating VS and the occurrence of complications within 48 hours were considered from ambulance arrival and a red VS upon arrival in the ED was therefore included. The occurrence of complications decreased in the low-acuity group to a very low risk if triaged to yellow or green level.

No patient died within 48 hours among those who were triaged to green. The risk of dying within the subsequent seven days was also very low among low-acuity patients. On the other hand, the relative risk of dying within 48 hours was six times as high when triaged to red versus not triaged to red and the risk of dying within the next 30 days was three times as high.

We compared the RETTS-A in the EMS against a pre-defined reference patient "emergent" patient where the RETTS-A red/orange level was regarded as a true positive. The sensitivity was 81% and the specificity was 64%. The over-triage was thus 36% and the under-triage was 19%. In patients who were triaged to red or orange, the PPV was 49% and, for yellow and green patients, the NPV was 89%.

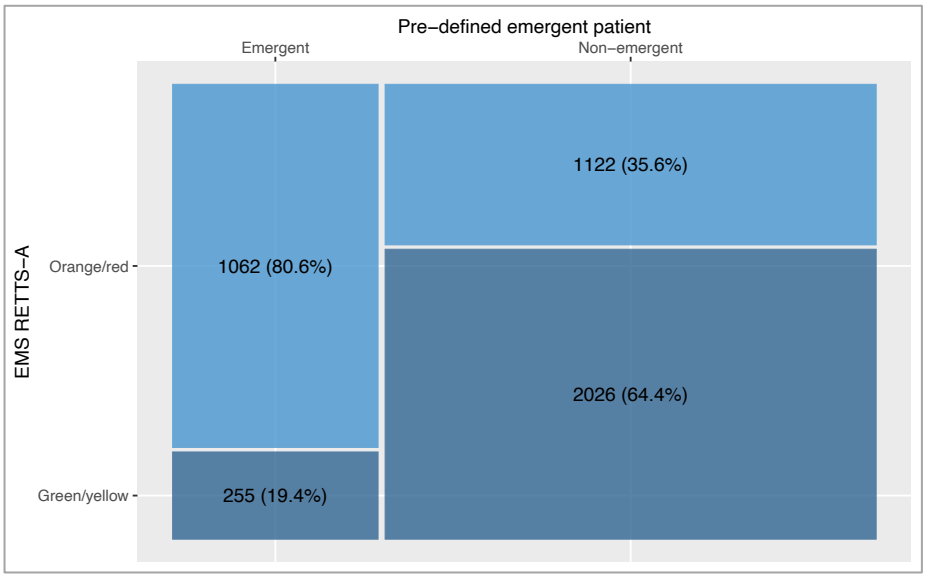


Figure 13. Classification of the EMS assigned RETTS-A acuity level

If the patient was more than 65 years old, the PPV increased compared with the younger group (59% vs. 38%), with a lower NPV (85% vs. 94%). The diagnostic accuracy was higher in the older group, indicating a higher proportion of red/orange patients who had a time-sensitive condition or deviating VS according to the reference compared with the younger patients. However, the older group also had higher under-triage (23%) with a corresponding lower over-triage (13%), compared with the younger group.

We also compared the performance of the RETTS-A when utilised by the EMS nurse at the scene with the NEWS score, which has been validated for early death and critical illness in both pre-hospital and hospital settings. We compared the RETTS-A, NEWS and NEWS 2 on the following outcomes; time-sensitive condition, occurrence of complications within 48h, hospital admission and all-cause mortality. We found that the sensitivity of the RETTS-A was higher for detecting a time-sensitive condition (73%) compared with the NEWS (35% and 37%). However, the specificity was higher in the NEWS 2 (83%) compared with the RETTS-A (54%). On the other hand, after

calculating the NPV, i.e. the probability that a patient who is triaged yellow or green is also a "non-emergent" patient, it was higher in the RETTS-A (94%) compared with the NEWS and NEWS 2 (91% and 92% respectively). Conversely, the PPV for the occurrence of complications or deviating VS within 48 hours was higher in the NEWS (35%) and NEWS 2 (39%) compared with the RETTS-A (19%). The sensitivity of predicting admission to in-hospital care was higher with the RETTS-A (59%) compared with both the NEWS (34%) and NEWS 2 (30%). However, the PPV was lower for the RETTS-A (62%) compared with the NEWS (76%) and NEWS 2 (83%).

Regarding the prediction of the short-term risk of death, there was no difference between the RETTS-A, NEWS and NEWS 2, although the RETTS-A had lower accuracy due to lower specificity compared with the NEWS and NEWS 2. When comparing the prediction of 30-day mortality, the RETTS-A had higher sensitivity (73%) compared with the NEWS (61% and 54%). However, there were no differences between the RETTS-A and NEWS regarding specificity and PPV and accuracy was lower in the RETTS-A than in the NEWS and NEWS 2 in terms of predicting 30-day mortality. There was a similar NPV, i.e. the probability of low acuity (test negative) and not dying within 30-days, in the RETTS-A compared with the NEWS and NEWS 2.

We also compared the initial assessment from patient records with the final hospital diagnosis by using the previously described instrument categorising patients depending on whether the final diagnosis was time-sensitive, described only as a symptom or not specified. Of the included 4,465 patients brought to hospital, 4,168 (93%) were diagnosed in hospital either in the ED or when discharged from in-patient care. Among them, 11% were diagnosed with a specified disease defined as a time-sensitive condition; 64% were diagnosed with a specified disease but not defined as a time-sensitive condition; 19% had a diagnosis equivalent to a symptom and, finally, six per cent of the patients were diagnosed with a non-specified assessment. We found, based on the EMS patient notes, that the field assessment was considered appropriate in 82% of the cases. When examining only time-sensitive diagnoses, the EMS nurse's field assessment was considered appropriate in 84% of the cases.

DISCUSSION

Why is there such high diversity between patient assessments at dispatch and at the scene?

The EMDC has a difficult task to assess the patient over the telephone during a very short period of time. Symptom presentation and/or scene description from bystanders or significant others further complicates the "voice only assessment". Previous studies have reported that, in 87-89% of the cases, a person other than the patient contacts the EMDC [143,144]. In order safely to assess the patients over the telephone, a substantial safety margin is exercised with the aim of perfect sensitivity but at the expense of low specificity. Over-triage of 78% and under-triage of five per cent in CBD systems used at the EMDC have been reported [145,146]. However, a systematic review reported low to very low evidence of the accuracy of EMDC systems and suggested that general standards should be agreed upon to create conformity in reports [147]. While over-triage is needed, resource allocation in resource-restricted pre-hospital organisations is a concern, particularly when medical preparedness is simultaneously considered [58]. For instance, in cardiac arrest, the 30-day survival decreases if the pre-hospital response time increases and this is found regardless of bystander CPR and initial rhythm [148].

Another aspect, a high frequency of "life threatening" priorities determined at the EMDC, is the EMS work environment and patient safety. Alarm fatigue is a term defining the high frequency of alarms from monitoring equipment in hospitals. It has been reported that a high percentage, up to 99%, are false alarms or alarms that do not require an intervention [149,150]. This leads to reduced preparedness which impacts patient safety, with a higher risk of neglecting patient deterioration due to the frequency of noise pollution leading to alarms being shut off [150].

A comparison can be made in the EMS, where a high level of over-triage may lead to "alarm inflation" for the EMS nurse responding to patients from the beginning of the shift to the end of the shift and with very few patients considered to be suffering from a time-sensitive condition or deviating VS. If constantly assessed with the highest priority levels at the EMDC, this may instigate a reduction in preparedness. The implementation of modern computerised clinical medical decision-support systems (CDSS) to support patient assessments on the telephone may improve the accuracy of the assessment. A study from Uppsala in Sweden, using a dispatch CDSS, reported safe assessment over the telephone of patients who were assessed to a lower level of care. Moreover, identified adverse events were associated with over-ruling the CDSS [151]. However, using a CDSS also requires competence

[152,153]. As a result, in Swedish EMDCs using CDSS, the requirements have been set with RNs as the lowest educational level to work with these systems. However, a CDSS does not have to contain complex algorithms in order to support the decision-making process, as a CDSS has been defined as a system that gives advice in a specific case with at least two components of input data [154]; for example, in a study from Sweden implementing a CDSS with ten questions put to patients with chest pain in contact with the EMDC. Three of these questions were the most important in predicting acute coronary syndrome (ACS) or a life-threatening condition; intensity of pain, localisation of pain and a history of ACS [155]. This indicates that fairly simple methods can be utilised to reduce priority-1 assignments in this relatively large category of patients assessed with chest pain, while, at the same time, not jeopardising patient safety.

Why was there a difference between the sexes regarding dispatcher priority and level of care in adults?

More females remained at the scene compared with males and females were also less frequently given a "life threatening" priority. Several reasons may explain this finding. First, the interpretation of the female symptoms may play a role. If symptoms in women were interpreted differently and thus assessed as being less severe, women would be given a lower priority. A higher proportion of women who remained at the scene has also been reported in a Finnish study [156]. However, this does not fully explain why men had higher priority, although they were five years younger and younger patients were given higher priority. One contributory factor may be that men had more cases with "uncertain" indices, which gives higher priority. Furthermore, men had more trauma and more cases that could not be ruled out at the scene and thus required transport to hospital.

It has been suggested that sex- and age-based protocols should be used at the EMDC when assessing patients with abdominal pain, but this strategy has previously been reported as an overuse of ALS resources. Introducing questions targeted at severe abdominal pathology has been proposed in order to reduce the allocation of ALS units with the highest priority [157]. In a Swedish study of patients with a confirmed MI, there was a greater probability that men would be dispatched with priority 1, even though no difference in dispatch priorities was found when all the patients with chest pain were included in the analyses [158,159]. The authors conclude that males should be "over-prioritised" due to the fact that they were found more frequently with ischaemia on ECG, central chest pain, hospital admission and a diagnosis of MI [159]. It has also been reported that, in trauma, men were allocated to an ambulance with higher priority when adjusting for trauma severity [160]. Do

women suffer from symptoms that are different compared with men or are the described symptoms not presented as dramatic among women? Vital information for an accurate interpretation of the symptoms may simply be lost.

In the paediatric population, one third remained at the scene and one third were discharged from the pED without interventions. What is the implication of this finding?

The most frequent EMS nurse's triage assessment in non-transported children was "respiratory difficulties" and "fever". The majority of these assessments took place in the evening and at night. In many cases, these children are also assessed over the telephone as "life threatening and an ambulance is dispatched with the highest priority. A large number of non-transported young children have been reported in other studies as well [161]. Some of the EMS contacts were also associated with paediatric general health care, where self-care advice was sufficient to ease parental worries about a child's behaviour. Among the patients that remained at the scene, very few visited the pED within 72 hours. Further, only one per cent of the non-transported patients were admitted to in-patient care, which is fewer than in other studies that have reported that between two to nine per cent of these cases require hospitalisation [162,163]. Our finding suggests that the EMS nurse's assessment to remain at the scene is relatively safe.

A fairly large proportion of patients who were transported to the pED were examined by a nurse or a physician and discharged from the pED without any interventions. This indicates that, when in doubt, safety precautions were taken so that children were transported to hospital. Contributory factors may be that parents were not comfortable about remaining at the scene or that the outcome of treatment initiated at the scene was still uncertain and the time that was required to evaluate at the scene exceeded the possible time to remain at the scene. A referral to and contact with primary care may have been feasible in this situation, combined with follow-up to reduce parental concern. Furthermore, previous studies have reported that parents requested transport to hospital even if it was not warranted from a medical perspective [164]. Parental ignorance could be a reason for this and the importance of informative teaching when meeting these parents at the scene should not be ignored. However, this is also dependent on the arriving EMS nurse's competence. Furthermore, the EMS nurse who arrives at the scene has not witnessed the event that led to the decision to dial 112. For example, in the youngest, it has been reported that, in apparent life-threatening events (ATLE), the EMS meets a totally normal child in more than 80% of the cases. The most common causes of ATLE are gastrointestinal reflux diseases, respiratory infections and seizures [165,166].

The recommendation is that these children should be monitored for up to 24 hours [166].

From an EMS nurse's perspective, the primary objective in events like these is not to find the cause of the event but rather to use competence and history-taking to assess whether the young children require the resources of specialised care or if their needs can be met at a lower level of care. In an urban setting, a differentiated fleet with, for example, a dedicated paediatric unit in close collaboration with paediatricians may aid in reducing the resource allocation of ALS ambulances with maintained parental safety at the scene and/or a referral to accessible PC that needs to be available at the evening and weekend.

Why may it be important to use a triage instrument for children in the EMS?

The EMS nurse meets an unselected population of patients of all ages, with a broad spectrum of ailments. The assessment of a child in the EMS is a rare event which, in numbers in an urban setting, is approximately five children in every 100 patient assessments. Of all cases involving children, very few have a time-sensitive condition or abnormal VS. Even if the triage system was developed for the pED, there are several incentives to utilise a triage system in the EMS. Rapid triage in all children is recommended by the World Health Organisation (WHO) in order to identify children at risk of deterioration, as early as possible [167].

Using triage in all patients already in the pre-hospital setting when assessing children at the scene supports the EMS nurse in identifying children at risk in the first visual patient assessment with a healthcare provider. This may be relevant, especially as the competence level among EMS nurses regarding assessing children varies. Furthermore, using the same instrument when assessing patients may also favour the communication process in the patient transition from one setting to another. Although the triage system was developed in order to triage in the ED and, based on severity, to stratify patients for physician attendance, this is seldom the case in the EMS where one patient at a time is most frequently assessed.

The RETTS-p triage system could be further developed to include recommendations about the conditions and/or triage level that could be managed at a lower level of care and in which cases paediatric specialist care is needed. Another challenge with the RETTS-p triage is that it can be time consuming and complex at the scene to triage patients in a manual fashion with both VS according to age category and chief complaint and finding the most appropriate ESS code and the final triage level. Another more rapid system

used internationally is the paediatric assessment triangle (PAT), which has been evaluated and has shown high predictability in detecting "high-acuity" children at high risk of clinical deterioration [168]. However, even if a simple, easy-to-use system such as the PAT in the EMS may be useful, the downside of a system like this is its inability to determine severity among patients with normal clinical signs and more comprehensive systems such the RETTS-p may aid in the assessment of these children.

What was the relationship between the EMS nurse's assigned triage level in children and hospital admission?

Children in need of hospital resources were older and more commonly triaged with trauma and seizures. Among patients that were triaged and hospitalised, the yellow triage level was more common than any other level. Yellow is not identified as "high acuity", but these patients still had conditions where the needs could only be met by in-patient care for a number of reasons. Examples of these conditions were orthopaedic surgery of extremity fractures, the further evaluation of seizures, infections and commotio. There was an increasing proportion of hospital admissions among all the children who were triaged to a colour, where the red level had the highest proportion of hospital admission (55%). This is in line with another study of the MTS in the ED, where the corresponding figure was 54% but lower compared with the ESI with 84-100% hospital admissions at the highest triage level [108,109,111,169]. Hospital admission is often used as a proxy for a seriously ill child. However, as found in this study, there are patients in need of in-patient care that are not considered seriously ill, indicating difficulties using the prediction of hospital admission in the on-scene triage with the guidance of the triage system alone. Furthermore, the over-triage among triaged children also reflects the fact that a large proportion of the children in triage levels red and orange were not considered candidates for in-patient care. The triage system per se does not have a built-in function for recommendations on the level of care or for predicting hospitalisation or other outcomes. The function of the system is to stratify patients in a pED and, as such, this system has been implemented in the pre-hospital setting.

Why was the RETTS for paediatrics not applied in all patients and with a full set of VS?

The majority of the children who were triaged by the EMS nurse did not receive full triage. Full triage was most often found in the older children. although more commonly with a triage colour based on ESS and selected VS. Children who remained at the scene more frequently had limited triage. Children in contact with the EMS and not recorded with a full set of VS may hamper the field assessment and there is also the risk of an undetected deviation in VS. However, as only a few children were admitted to the pED within 72 hours after the initial assessment, this indicates that VS including full triage were based on an appropriate case selection.

This suggests that the EMS nurse measures certain VS where applicable and when it seems important. For example, if assessing a child in contact with the EMS after an isolated injury or when giving self-care advice to worried parents, a measurement of all VS may not be important. The instrumental collection of VS without any purpose in children can be avoided in selected patients, as these interventions could completely destroy a child's trust in health care. Especially in some of the younger children, a violation of the child's integrity may be avoided if the recording is of very little concern. In a study of VS recordings in a general practitioner's (GP) office, it was uncommon to record VS with the exception of body temperature and particularly uncommon if the child was in good condition [170].

Less frequently recorded VS in younger patients have also been reported in a Danish study with recommendations on training in clinical observation and the documentation of VS [171]. Even though it may be appropriate to assume that recording all VS in all patients at all times, regardless of the reason for contact, is a good thing, a prior study of MTS did not reveal any increase in performance when VS were added systematically to the instrument [172]. Recordings of VS may be within the normal range due to physiological compensation. For this reason, observations in addition to the patient's presentation including skin colour, work of breathing, body tone, alertness – behaviour and capillary refill time may give the EMS nurse information. However, in the most critical cases, for example, a child with a foreign body partially obstructing the airway, temperature measurement will not move the assessment forward, as the A problem needs to be resolved and the patient is already at the highest acuity level and is given the full attention of the medical staff upon EMS arrival at the pED.

Can the EMS nurse's triage/guideline adherence improve still further?

While the finding relating to adherence to the RETTS was similar to studies of ED and EMS triage [173–175], there is room for improvement. It has been reported that adherence to guidelines is not optimal in the EMS and increased adherence to triage guidelines in trauma assessments has been reported to increase the number of true positives [176,177]. There are a number of factors which may contribute to lower adherence. One of them is that guidelines often consist of written manuals with several hundred pages, further complicating the already complex pre-hospital setting [176,178]. The assessment at the scene with paper-based memory notes and booklets with triage algorithms that should subsequently be entered into the electronic patient record system does not simplify the situation.

Furthermore, when deciding not to triage a patient to a certain colour, there is uncertainty about the process that leads to a decision of this kind. For instance, a critically ill patient receives the highest priority without the need for a triage system in cases with deviating VS or with a STEMI found on the ECG recording. For example, an unconscious patient with suspicion of a time-sensitive condition already gives information to the EMS nurse that the patient requires immediate attention on arrival in hospital.

At the other end of the spectrum is the patient who remains at the scene with symptoms that are not possible to find in the RETTS charts or at such a low degree of urgency that they do not apply for a RETTS triage. In fact, the RETTS in the EMS fulfils a purpose other than that for which it was originally developed. One example is support on the decision relating to transport or acting as guidance when assessing the patient at the scene, irrespective of the time spent waiting for a physician in the ED. However, in some cases, definitive care may be provided by the EMS nurse at the scene, even if triaged to the highest triage levels. For example, the hypoglycaemic patient with p-glucose below 3.5 mmol/L yields at least orange triage level in the adult RETTS.

In order to increase accuracy in the RETTS triage system, the system has been further developed, aimed at different specialties such as obstetrics with different VS cut-offs and psychiatric patient triage. This further complicates the triage in the pre-hospital setting, when assessing an unselected patient population. Taken as a whole, it may be that the triage process is too complicated when conducting the on-scene assessment and it most probably needs to be made more user friendly, especially when recording VS in the RETTS-p.

The implementation of a computerised clinical decision-support system (CDSS) in the ambulance with triage incorporated could be one alternative to increase adherence to the documented patient assessment including triage. According to the definition, the RETTS triage in the EMS is in fact a decision-support system when it is utilised. One example of two sources of input data is a deviating pulse rate and an obtained ECG interpreted as myocardial ischaemia and the system recommends that the patient should be triaged to at least orange depending on the situation, which explains why a high acuity level is recommended. However, the triage system does not offer support in any decision regarding treatment alternatives or recommended level of care when applicable. A computerised system specifically developed for the pre-hospital setting, including these options, may further increase adherence in the patient assessment at the scene. By using a CDSS recommendation on which examinations to perform, interventions could be proposed by the system. A previous study reported increased adherence to guidelines if a CDSS was used in the patient assessment [176]. A hospital meta-analysis of CDSS including 122 trials reported improvements in prescribing, test ordering, documentation and, in areas such as a referral for consultation, guideline compliance. In paediatrics, the improvement was higher, even though the authors concluded that there was an overall moderate improvement with high variability between studies [179]. However, the human factor plays a role, as a CDSS is dependent on input. This is important when designing a CDSS aimed at addressing situations where the system would have the most impact. In the pre-hospital setting, a system of this kind may aid in the decision-making process. Furthermore, in order to learn when adherence is limited, we must find the reason why it was overruled and requirements for the EMS nurse to note why triage is over-ruled are advocated in a system of this kind. This would increase our knowledge of the cases in which there is room for improvement.

What does EMS over-triage and under-triage mean and what is the reason for it?

The primary aim of all triage systems is to detect true emergencies most appropriately. There must be a priority-based system in the pED/ED when the demand exceeds the resources available at any given point in time. Substantial over-triage and under-triage were identified in both children and adults who were triaged by the EMS. The primary aim of utilising triage in the EMS is not to identify a certain diagnosis but instead to support the EMS nurse in determining whether the patient represents high or low acuity.

There are a number of possible reasons for over-triage in children. Among patients triaged to red – “life threatening” or orange “potentially life

threatening", a limited proportion were found to be "emergent" cases. Over-triage has to be built into the system and it is possible to argue that this applies even more so in children, as it is better to "err on the safe side". However, the relatively large number of red- and orange-triaged children who were later considered "non-emergent" has implications. First, for the more experienced EMS nurse, it may induce a lack of trust in the system, since high-acuity triage cannot be resolved with alternative transport, as the RETTS is telling the EMS nurse that the patient has high acuity. Allocating ALS resources is therefore a problem in resource-restricted organisations.

This is also dependent on how the RETTS is used. Some EMS nurses interpret clinical findings differently from others and triage is therefore based on experience. Furthermore, from a pre-hospital perspective, over-triage reflects the current situation. Deviating VS may change over time, where the EMS is responsible for care for a short period of time compared with the often longer waiting times in the pED. This may reflect deviations in VS at the scene, indicating high acuity, resulting in over-triage. This has also been reported in a previous study where one third of the paediatric EMS assignments were regarded as lower urgency in hospital [171].

The majority of the under-triaged children were found with deviating VS compared with the "emergent" reference patient and the child was around one year of age. An infection of viral origin was the most common underlying disease. For example, in the one-year-old reference patient, the body temperature was < 33 or > 40 degrees Celsius, while the RETTS-p cut-off for high acuity was > 41 degrees Celsius. There is a greater risk of a serious bacterial infection (SBI) in the youngest patients presenting with fever [179]. In a pED study of children five years and below presenting with fever, 7.1% had an SBI. There is an increased likelihood of SBI if there is a temperature of > 39 degrees Celsius. However, a substantial number of SBIs were also found among patients with a lower body temperature [181]. Lower age, the duration of fever and origins such as urinary problems are important information, as a lower temperature alone is unable to rule out an SBI [180,181]. VS entered in the EMS electronic system should also include capillary refill time, especially in patients presenting with a suspicion of infection. In the current version of the RETTS-p, a capillary refill time of three seconds or more is an ESS associated with orange level in patients presenting with fever. Most of the children that were under-triaged in this study were discharged after treatment and intervention in the pEd. This indicates that the proportion of patients with under-triage where patients are critically ill and have a time-sensitive diagnosis is relatively low among all the children who are triaged and brought to the pED. However, assessing patients at the scene with fever and symptoms of

infection and deciding on triage and the level of care is challenging. In a previous study of younger children with a temperature above 38 degrees and blood samples taken, there was an association between the probability of SBIs and increased heart rate, respiratory rate and body temperature [182]. This further highlights the importance of measuring VS in the youngest children presenting with fever, together with capillary refill time. Infrequent encounters of paediatric assessments with a different set of VS reference intervals in the RETTS based on age call for accuracy in obtaining VS. Training in the measurement of VS and observations of signs and symptoms and utilising triage is needed. This should include paediatric management in general, not only focusing on the assessment of the most critically ill children.

In the adult population, the performance of the triage system in the EMS is considered moderate, with both relatively high over-triage and under-triage. In fact, among patients triaged to orange and red by the EMS nurse, there were more patients in the "non-emergent" category than in the "emergent" category when compared with the reference patient. One example may be the large cohort of patients with chest pain as the chief complaint that are often triaged to the orange level due to signs and symptoms (ESS). The lack of other tools such as blood samples or a risk score system makes it difficult to triage these patients. In general, this may create resource allocation needs with ALS ambulance transport, resource allocation in the ED, the continuous monitoring of patients and closer ED nurse surveillance, including a number of blood samples taken at the discretion of the ED nurse on the basis of triage colour and chief complaints. This has been described as capacity problems, as the individual risk assessment is still valid for every single patient. However, the triage level in the EMS is the level on which the ED staff act until high acuity is ruled out.

Even though there was a large degree of "non-emergent", high-acuity triaged patients, under-triage was also present in one in every five patients. Almost all these patients were found at one level below high acuity, the yellow triage level. These patients were commonly triaged by the EMS nurse to "unspecific condition". This classification was found more frequently in the older patients, with more specific chief complaints found in the younger patients. This indicates that the elderly had more comorbidity and/or presented with vague symptoms which were difficult to interpret, especially when VS were within normal range or only slightly deviant.

This indicates that age should specifically be considered within the ESS in order to improve the triage, i.e. the risk of a time-sensitive condition in an older patient is not the same as the risk in someone 25 years old. Furthermore,

assessing older patients should also take frailty into consideration. This is important because there is a link between frailty and adverse outcomes and frail patients are more often admitted to the ICU [183]. This is even more important with the "close care" concept in Sweden ("nära vård"), with fewer patients transported to hospitals if not in need of specific hospital resources. This concept would require even more individual assessments at the scene by the EMS nurse, even though the triage scale reveals high acuity.

It appears that all triage systems perform with limited accuracy, regardless of the type of triage system and regardless of the type of ED and country where they are used. Furthermore, the same type of problems have been found in all triage systems, with high variability regarding weaknesses in performance when detecting critically ill patients [184]. This highlights some key aspects in both the paediatric and adult triage system. So, even though updated versions are released annually or even more frequently, the often added information which is designed to reduce under-triage also have an impact on over-triage, with the concept of not missing any patient at risk, and this has implications for resource allocation. This concept increases the risk of a reduction in preparedness.

What should be regarded as acceptable rates of pre-hospital under- and over-triage?

Acceptable rates of over- and under-triage have not been agreed upon in Sweden. It is easy to understand that this is a difficult challenge. As a result, no consensus has been reached at national level. The impact of high rates of over-triage on crowding out patients in greater need of faster access to care is a difficult message to convey. Furthermore, discussions about the increasing EMS response times in out-of-hospital cardiac arrests need to be addressed. Reducing high-acuity triage which demands transport in an ALS ambulance, where some of these patients can be transported by other alternatives or be visited by a geriatric team in their homes, may reduce delays in true emergencies without additional resources.

Interestingly, in the US, with rigorous on-scene decision protocols, there have been discussions about the level of trauma hospitals to which patients need to be transported. The American College of Surgeons (ACS) has declared "general agreement" on an acceptable over-triage of 25-35% to reach an under-triage below 5% as a landmark in trauma patients [185]. However, trauma care in the US often uses the Cribari matrix method (CMM) to calculate over-triage and under-triage. With the CMM, over-triage is defined as 1-PPV and under-triage as 1-NPV. This means that calculating the RETTS over-triage and

under-triage with the CMM would result in over-triage of 73% for children and 51% for adults, with under-triage of 8% in children and 11% in adults. However, the CMM is used in decisions on trauma, so the caveat is that a large number of low emergency patients will help to reduce under-triage. Moreover, the CMM may not be recommended if interest focuses on examining the true under-triage rate [186].

Furthermore, deciding on hospital type (trauma level) in comparison with the required resources at that hospital may be different and more straightforward than a detailed analysis of ESS with many chief complaints. This indicates that further analysis is needed to evaluate selected chief complaints where there is over-triage, as well as chief complaints associated with under-triage, to try to learn from them. The question is whether training in triage and patient assessment can be directed at these groups. Discussions and learning based on patient outcomes in a systematic fashion are needed. However, supportive systems linking EMS data and hospital data with triage decisions and outcomes have often not been available and less is therefore known about adverse events in the EMS, for example. A prior study in Sweden which manually reviewed EMS patient records reported five per cent adverse events, which increased to 16% if the EMS nurse assessed the patient with the highest priority [132].

From an organisational perspective, the common way to assess an adverse event is to handle the ones that are reported to the system. The assessment relies on an individual interpretation of the potential adverse event which may contribute to a less effective system to learn from and to increase patient safety. As a result, filed adverse events most probably constitute only a proportion of the total spectrum of actual events. An alternative approach is to take preventive action that benefits the whole patient group.

Prior studies support these limitations and highlight the fact that the actions that are taken often focus on a single event, if known, and propose measures to avoid “it ever happening again”. At organisational level, the solution is to build more safety into the organisation [187]. One example in this kind of build is to change guidelines regarding triage decisions. However, knowledge is missing at a higher level, for instance, at regional level or national level. We should create global trigger tools to use at national level to learn from similar adverse events, in an aggregated form. The assessment is also dependent on the EMS nurse’s competence and training is needed in the assessment of older patients with vague symptoms where an analytical process is required in cases where patterns of a time-sensitive condition are not recognised. For example, patients who were initially assessed with dizziness but were subsequently diagnosed with a stroke have been further evaluated in detail in order to increase our

knowledge of this group and to identify risk factors that could be useful in these patient assessments in the future [188,189].

Can feed back on the EMS nurses field assessment be improved?

At individual level, feedback is needed to learn and to develop as an expert in pre-hospital health care. Considering the fact that the EMS nurse's field assessment may be the single factor that determines whether or not the victim will survive, the lack of feedback is remarkable. Many of the objectives measured in the Swedish EMS are still about response times and the number of assignments. Even though it is crucial to target decreasing delays in cardiac arrest, until now there has been limited focus on qualitative measurements, exemplified by the follow-up of assessments made by the EMS nurse in complex cases.

Unfortunately, legislation on access to patient data has been interpreted differently in the regions in Sweden. In some regions, it is possible to log in to the hospital data system and get feedback on hospital assessments in cases, in which the EMS nurse has been involved, which then creates a learning scenario for the individual. However, in order to create more systematic feedback and education, data systems which can support by providing more general feedback need to be created. To realise a goal of this kind, a number of prerequisites need to be fulfilled. First, we need to agree upon appropriate quality indicators to follow and we also need to define what constitutes quality care in the pre-hospital emergency setting.

For example, can the 72-hour follow-up be the subject of discussion? If the EMS nurse informs the patients that, if their symptoms do not disappear or if there is recurrence of symptoms, new contact needs to be made. If new contact is made within a stipulated time frame, should this be regarded as a negative outcome? These potential quality indicators should be developed and agreed upon on at least a national level. The new national Swedish EMS register (AMBUREG), where all regions report to the register, represents a start in this line of work. Through consensus and the registration of variables that are important for both patients who are assessed as requiring a lower level of care and patients who are in need of resources in specialised hospital care, there is potential for improvement in pre-hospital care. An approach of this kind has previously been taken in cardiac arrests where consensus was reached on uniform reporting to enable a better comparison between different systems and countries [137].

Can the education in EMS triage be further improved?

The triage system is used in the specific situation of patient assessment and as such it cannot overrule the EMS nurse's assessment but instead provides support in the decision process. There are several factors associated with triage education.

Firstly, triage education is required not only when introducing new employees but also in a continuous fashion, especially after updates in the triage system. Education is, for example, needed in order to explain why certain new additions to the triage system were introduced and the rationale behind these additions.

Secondly, when adverse events are investigated, aggregated data could form the basis for learning more about specific chief complaints in the triage system and the caveats to consider when assessing certain patient groups. For example, it is possible to consider avoiding the more general utilisation of the ESS code of "uncertain condition" in older patients. Furthermore, signs and symptoms that are more complex need to be addressed, although the latter may be more closely linked to medical clinical competence and have less to do with triage education.

One example is the assessment of a patient with the chief complaint of "chest pain". The ESS triage colour working order is from top to bottom and there is a need to record an ECG and to rule out LBBB and RBBB and ST-elevation found at red level and then confirm whether there are signs of an "ischaemic ECG". If there are ECG signs of STEMI, the correct triage level is red. Many of these interpretations can be made by the EMS nurse with support from the cardiac care unit (CCU) or from the ED physician on call.

This requires competence and a study of ED nurses using the ESI triage system reported relatively low triage accuracy, with 60% of cases correctly classified, with under-triage of 27%, albeit with high inter-reliability. The authors suggested that infrequent exposure to certain complaints may play a role [190]. However, factual knowledge has been described as the most important factor in triage decision-making. In fact, the number of years in emergency care and experience of the triage system were of less importance [191].

Why are not more patients admitted to primary care?

One of the main challenges in Sweden is access to primary care (PC) in order to meet the patients' need for an appropriate level of care. Among patients over 16 years of age who were assessed at the scene by the EMS nurse, fewer than five per cent were actively referred to PC and assessed by a PC physician. More patients who remained at the scene were younger and remained during out-of-office hours, when PC was not accessible. Throughout the manual review of patient records, a recommendation was made in many notes that, if the symptoms did not resolve, contact with PC should be made the following day(s). However, with limited access to PC, only contacts that were made by the EMS nurse, in order to arrange an appointment in PC, were considered. This limited access is one reason for the dichotomous decision on either to remain at the scene or to be transported to hospital. It has been reported that patients often try to find other solutions before contacting emergency care [35] and Booker and colleagues reported that patients with a chronic illness did not wish to visit PC as they were afraid of instantly being re-referred to the ED [192]. Instead, after having contacted the EMS, they were treated and released at the scene [192]. However, patients benefit from continuous care instead of single ED presentations [193,194]. Providing continuous care for these often older patients with chronic illness is a priority for the primary physicians who know the patient and contact outside office hours should be provided, if needed.

However, increased access to PC without further actions would not resolve the problem. Admission to PC has been described as complex, waiting in a phone queue to be assessed and judged for qualification as a PC can [195]. This may cause anxiety for patients with chronic conditions who are assessed over the telephone with an appointment several days later. Moreover, this is one reason why patients with low-urgency presentations contact the EMS. As a result, in order to release ALS ambulances more quickly to increase availability, other transport solutions to the ED have been implemented for patients with conditions that could be managed by PC but require a physician's evaluation the same day.

However, there are still many patients whose needs could be met at a lower level of care but who are transported by an ALS ambulance to the ED. The rationale behind this is multifactorial. Firstly, it could be on the patient's request with a strong belief in the transport organisation when the EMS staff meet the patient with a suitcase at the entrance. Secondly, there are patients requesting an ambulance on the street, where the EMS nurse makes the decision. The lack of general guidelines on how to conduct a follow-up on non-

transported patients is a problem. Moreover, in their assessment, the EMS nurses may be uncertain about how to manage the patient and thereby transport to the ED. The situation may be particularly problematic in an urban setting with a closer geographical distance to the ED where the transport of non-emergent patients to hospital may be more convenient in some cases. In more rural areas where PC may be the closest healthcare facility, the EMS may have better co-operation. In this case, it may be a more natural process to stop by and get help with assessments of whether or not ED care is needed. Introducing a GP on call to aid in referrals to secondary care may be one suggestion, even though studies from Norway report a fairly high frequency of secondary referral [196]. It seems reasonable that the physician in PC is notified that the EMS has been at the scene and assessed the patients with chronic illnesses for whom the GP often has primary responsibility. In order to establish "close care" with "customer" involvement and quality at the appropriate level of care, the above suggestions seem reasonable.

Are there chief complaints/ESS codes considered problematic in future EMS triage assessments?

There are patient presentations that are more complex than others in the triage system from a pre-hospital perspective, especially when utilising triage in new ways. Stroke/TIA is a specific complaint which is categorised as a field diagnosis and, whenever stroke is suspected, consultation with a hospital neurologist is encouraged in all cases where the EMS nurse's suspicion is aroused. It has been reported that the accuracy of stroke recognition in the pre-hospital setting is relatively high [197,198]. When there is a suspicion of stroke, additional protocols are used in the assessment. However, in order to use the protocols/checklists, the EMS nurse has to suspect stroke/TIA. It appears reasonable for the EMS nurse to look for the pattern recognition of System 1 behaviour in these situations when looking for signs and symptoms to rule in the time-sensitive condition of stroke. However, if the patient suffers from another chief complaint such as dizziness, this work-up is demanding because the uncertainty is much greater and the spectrum of underlying conditions is wide. The fact that most of the patients assessed by the EMS nurse to the chief complaint of "dizziness" are not time sensitive further complicates this assessment [188].

A common chief complaint is chest pain comprising nine per cent of all patients who are triaged by the EMS nurse. Our result suggests that there is no marked difference in triaging to "chest pain" according to the RETTS for patients assessed as requiring hospital resources as compared with those who were not transported. This complaint is complex, with underlying causes that

range from a large number of non-emergency conditions to an MI [159,199]. The opportunity to transmit an ECG and get help with the interpretation of the ECG is used frequently but on very few occasions among non-transported patients. Previous experience indicates that, within this triage group, causes other than MI are more common [200].

Dyspnea is also a common EMS presentation with a broad spectrum of underlying etiologies that may be chronic, time-sensitive or relatively harmless. It has been reported that more than 400 different final hospital diagnoses may explain the symptom of dyspnea [201]. In these cases, the EMS nurse conducts a patient assessment and the triage system still functions as a support, but other factors also play a role in the assessment. The problem arises when pattern recognition is not possible and, with a limited set of diagnostic knowledge and the lack of blood tests and so on, further support for the EMS nurse's assessment becomes problematic.

There are cases where a patient is not perceived as requiring hospital resources. For example, the median time from symptom onset to contacting the emergency number 112 when suffering from dyspnea is 50 hours [201]. This indicates that many of these patients wait for a long time before making contact. In patients with a prolonged time from symptom onset to contact, a risk of cognitive bias may be introduced in the assessment.

According to a pre-hospital study from Canada, clinical judgement and decision-making are two primary issues relating to patient safety in pre-hospital care [134]. In complex assessments involving older patients with more diffuse long-term symptoms, it appears that assessment errors have more to do with intuition and judgements based on that. It is also suggested that this kind of approach could be de-biased with analytical reasoning [202–204]. In this case, an EMS triage instrument may have input, to support de-biasing and help the EMS nurse to avoid anchoring, or confirmation bias. However, the triage process is still dependent on the EMS nurse's perception of the situation and the establishment of a patient relationship where the patient feels comfortable about revealing information that is important for the decision-making process.

Is it important to detect the underlying aetiology already at the scene?

Patient assessment in the EMS should generally not require a final diagnosis to be obtained. It has been recommended in guidelines and by senior pre-hospital consultants that symptoms should be described and communicated instead of a diagnosis. However, on-scene assessments require some form of reasoning about possible aetiologies behind the symptoms. In order to decide on the level of care and who is in need of treatment or transport to hospital, more than a symptom description is required. As a result, in some cases, the formulation of an hypothesis, including analytical and non-analytical processes, is essential [205]. All the pieces of the puzzle need to be put together. For instance, when taking a medical history and assessing the patient, the direction should be towards the "why" and not only being content with mechanical information about the symptom and treating the symptoms [206]. This would rely more on System 2 logical reasoning and not System 1 pattern recognition [69].

We agree on the difficulties associated with diagnostic reasoning, especially in the pre-hospital setting with limited tools. This was shown in our study, as, in one in five patients, the field assessment in adults was considered inappropriate compared with the hospital physician's diagnosis. This highlights the problem, even though non-transported patients had very low short-term mortality and a low risk of suffering from a time-sensitive condition. To avoid premature closure and anchoring, structured diagnostic assessments for clinical scenarios that are common should be introduced and incorporated in a CDSS.

Patients with abdominal pain constitute a group of patients who are often transported to hospital but often without any need to use hospital resources. The question is whether the pre-hospital assessment can be further improved in order to avoid some of these transports. The decision process starts with a thorough history-taking, which has been described as crucial in order to obtain an accurate diagnosis [207]. In a prior study, more than one third of the ED patients were diagnosed with "non-specific abdominal pain" [208]. It is most likely that some type of decision-support tool is required to further improve the pre-hospital assessment of these patients.

What competence is required to triage patients to the optimal level of care in the pre-hospital setting?

The required competence in the EMS in Sweden is an RN. However, each organisation in Sweden has the opportunity to set its own requirements with higher formal competence. This seems reasonable from a professional and patient safety perspective. In the in-hospital specialised care, a formally higher competence, such as nurses specialising in anaesthesia, is a basic requirement in order to be employed. This is a paradox, considering that nurses working in the hospital environment with required specialist competence also have all the available resources.

The nursing profession in comparison with the internationally more common paramedic system may serve as a better option when caring for patients in the pre-hospital environment in particular, where nurses have been trained to have a more holistic approach to patient care. For example, the factors influencing decisions are based on knowledge in order to make appropriate decisions. An experienced RN with prior hospital experience of similar patient situations may have the opportunity to make appropriate decisions in the pre-hospital context [209]. This has also been addressed at theoretical level, where novices have less capability to consider various alternatives compared with more experienced professionals [210].

Concerns have been raised in relation to safety in on-scene decisions by the EMS. However, many of these studies have drawn conclusions on theoretical assumptions or desk scenarios. In recent years, there has been growing evidence that EMS nurses are able safely to decide on the level of care but with supporting protocols and a low threshold for consultation [211,212]. For instance, nurse practitioners (NP) have been part of the ED in the US and UK for four decades. The NP autonomously assess and manage patients in the ED. Furthermore, in the EMS, advanced practitioners have been introduced in several countries. They all have an additional academic education, increasing their assessment skills theoretically and practically. The Netherlands also employs nurses in the ambulance but not without additional pre-hospital education and training. In a study from the Netherlands comparing ambulance nurses (AN) and physician assistants (PA) primarily educated in the medical field managing patients autonomously in EDs, PAs and ANs assessed and treated patients in a similar fashion at the scene. However, although the PAs applied a medical diagnostic approach in the assessments, the most important lesson was that the PAs realised that they needed to discuss the patient and, as a result, the PAs consulted more specialists regarding the patients' complaints [213].

Ambulance nurse competence has been described on several levels, with the formal competence of the additional academic programme in pre-hospital care as the first level. In addition to the formal competence, organisational work experience, including feedback and the opportunity to reflect on clinical aspects, has been shown to be important for competence development [214].

With patient presentations of uncertainty, such as clinical decisions on the level of care, it has been emphasised that diagnosing and clinical reasoning should be seen as a team effort and not as a task for the individual clinician [215]. Increased contact with a specialist should therefore be encouraged and made possible, even more so in the digital era with all kinds of digital solutions available to support the EMS nurse in on-scene patient assessments. However, it is difficult for the specialist to give directions on transport to hospital and we must therefore initiate discussions on the information that is needed to support an on-scene decision. In some hospitals, this has been implemented when bypassing the ED if there is a suspicion of a stroke. In this case, protocols including a scoring system for neurological assessment, including VS before contact with a on-call neurologist, have to be followed. It is also important to gather information on the time of onset of symptoms and other information that is required for the neurologist to decide whether or not to bypass the ED. It can be argued that similar protocols could be introduced for other patient groups aiming at 1) direct in-hospital admission; 2) referral to PC; 3) remain at the scene or 4) transport to the ED. Furthermore, new alternatives are emerging in several regions with the opportunity to refer older patients to a geriatric team, after the EMS nurse's assessment, including a physician and an RN who visit the patients in their homes. Consultation and feedback with teams of this kind may also lead to the EMS nurses increasing their knowledge base. This kind of collaboration should therefore be encouraged.

Can the communication between the EMS and the hospital improve?

Historically, the EMS has only been authorised to transport all patients to the ED, as every single patient has been thought to require hospital care. The development of fast tracks to bypass the ED has been beneficial for the patient and has also given confidence to EMS nurses in order to co-operate with the CCU or neurologists in patients with stroke. We found that only eight per cent of the patients assessed as requiring hospital resources bypassed the ED. However, sometimes, even though appropriate assessments at the scene have been made, the ambulance has been redirected to the ED due to lack of beds on the specific ward. This has led to reduced adherence to some of these fast tracks, particularly direct admission to a stroke ward [198].

For some patients assessed at the scene, the EMS nurse has no alternative other than transport to the ED if out of office hours and the patient may be fragile without a network and a complaint that cannot wait a number of days for a PC appointment. Many of these patients are brought to hospital with a complex situation not suitable for rapid management in a crowded ED. This can cause frustration among hospital staff handling PC patients. There is a risk to patient safety in the handover process with bias, missed clinical deterioration and often delayed investigations [216,217].

It has been reported that only one third of the information given by the EMS could be recalled by physicians in trauma patients [218]. Moreover, in the handover, distinct medical problems are more easy to communicate, whereas difficult cases, including complex situations regarding patient care, are more problematic and improvements in the handover process have been described as having a "common language" [218,219]. This indicates that a system used in co-operation with the ED, together with a structured reporting tool in handovers, such as the recommended situation; background; assessment and recommendation (SBAR), should be used in both verbal and written form. Using the same triage system increases the possibility of a common understanding of what a patient assessed as having a specific condition and a certain colour in the triage system means and the ED nurse then acts on the recommended guidelines for the triage system. The utilisation of guidelines to increase uniform information in the handover, regardless of patient presentation, has also been recommended [219].

While more co-operation is seen in some areas in Sweden, especially in rural areas where the nearest facility is a walk-in care centre and the distance to hospital is longer, the vast majority of patients in rural areas do not have access to PC for issues that are considered to be less urgent but need to be managed within 24 hours. In spite of the Swedish government's new health plan "nära vård" (close care) that states that, using a person-centred approach, the first step in health care should be initiated in PC, there is therefore a demand for greater involvement and increased co-operation with PC. When co-operating with PC or home care teams or mobile geriatric teams, it would be beneficial to agree on communication instruments similar to those used by the EMS versus the ED.

Can the RETTS be used by the EMS nurse to decide on the level of care in adults?

The RETTS triage in comparison with the main triage systems is designed for ED use and has been developed by expert opinion within that context. The five-level structure is intended to be applied in the ED. The aim of the RETTS was not to triage patients to a lower level of care in the pre-hospital setting. Despite this, the RETTS is used in the Swedish EMS to assess patients as needing a lower level of care but with local variations.

In the study organisation, the recommendations were that green-triaged patients may be appropriate to remain at the scene and selected RETTS chief complaints triaged to yellow may be transported by an alternative means of transport. However, among the patients triaged to green at the scene, more than two in five were assessed as requiring hospital resources and one-third of these patients were admitted to in-patient care. This suggests that the EMS nurse makes a distinction in patient assessment between different green-triaged patients and, as some of these patients may have other needs, the only alternative was to assess the patient as requiring the assistance of the ED. However, with increased opportunities to bring PC or geriatric teams to the patient, transport to the ED may have been avoided.

Among the patients who were brought to hospital and triaged to green level, there was no risk of short-term death and a very low risk of a time-sensitive condition, indicating that green-triaged patients can be referred to PC. However, frailty needs to be considered and an instrument of this kind needs to be implemented in situations where patients are assessed as requiring a lower level of care. Referring green-triaged patients to PC is supported by another Swedish study in which the EMS nurse, after the assessment of non-urgent patients (green level), consulted a PC physician which resulted in a significantly reduced number of transports to the ED [221]. This may also be possible in selected yellow-triaged patients after consultation with a physician on call.

Why does the RETTS-A perform better compared with the NEWS and NEWS 2 regarding time-sensitive conditions and admission?

The performance of the RETTS in adults is dependent on both the ESS and the VS and, when combined, the highest of them becomes the final triage level. There are several patient assessments in which the patient is assessed with relatively normal VS, but where the ESS part indicates that there is a risk of a time-sensitive condition. This is the advantage of the RETTS compared with the NEWS, which is recommended in several countries as a tool to assess the severity of patients in the pre-hospital setting. However, we found that the majority of the cases identified with a time-sensitive condition did not reach the NEWS medium risk level or above. This was also reflected in the prediction of hospital admission where the RETTS showed a higher sensitivity compared with the NEWS and NEWS 2. On the other hand, the diagnostic accuracy was inferior with the RETTS, due to the fact that many patients in the orange/red group (high acuity) did not have a time-sensitive condition or deviating VS in many cases because that triage level was determined on the ESS alone. However, the triage system is designed to determine conditions in patients. For example, mammography examinations have been shown to have high sensitivity with lower specificity due to false positives [222]. At this point, as it is difficult to differentiate between benign and malignant tumours in certain situations, referral to a specialist is advised. The EMS triage can be seen as the first step in the pre-hospital setting. Increasing the accuracy of the assessment in certain common chief complaints has been proposed. However, it is difficult to rule out conditions using information that is based on symptoms alone. Introducing risk prediction instruments in order to better stratify patients in the pre-hospital setting, together with point-of-care tests, may increase triage accuracy without any increase in the risk.

When can a NEWS score add information to the patient assessment?

When measuring VS in the RETTS for adults, the reference intervals in each triage level are the same, regardless of age. Moreover, all VS in the RETTS are equal in comparison with each other, meaning that, if a patient has a regular pulse rate of > 130/min, they are triaged to the “life-threatening” red level and the patient remains at this level, regardless of whether the other VS are within normal range. While this may be appropriate in the pre-hospital setting, as the patient is in need of continuous monitoring and access to a physician, there have been discussions about how “life threatening” one deviating VS may be.

There have been suggestions about the introduction of a triage level above the red level in order to include only those who “are dying and can’t wait”, thereby introducing a true five-level scale in the ED [223]. Moreover, studies of the NEWS 2 have led to the removal of a single VS abnormality from the medium level of risk [125]. Furthermore, odds ratios for the short-term risk of death have been shown to be much higher after deviations in the respiratory rate compared with blood pressure abnormalities in an unselected ED population [115].

This indicates that a weighted score may be an alternative, not only for finding specific cases with critically ill patients but also for finding patients at risk of deterioration, such as the national recommended NEWS scoring system. For example, a patient with a slight deviation in several VS gives a higher score than a deviation in a single VS, since it may give the EMS nurse more information at the scene. Using a weighted system like the NEWS in the pre-hospital setting may lead to some patients with an infectious disease being identified at an earlier stage in the chain of care. Even a lower score may indicate that the patient may need further evaluation.

In an ED study of the early detection of patients with sepsis, a NEWS score of ≥ 5 points was superior to both a qSOFA score of ≥ 2 and a RETTS red-triage level in screening for sepsis with organ dysfunction [224,225]. Weighted VS such as those used in the NEWS may be an alternative to identify patients at risk of deterioration, to a greater extent. Previous studies have also reported increased accuracy in the NEWS 2 low-risk group if the point-of-care test lactate in combination with the NEWS score is implemented [226]. A combination of weighted VS, signs and symptoms and point-of-care testing in collaboration with a physician on-call may aid in the decision on the most appropriate level of care for a greater number of patients.

METHODOLOGICAL CONSIDERATIONS

This thesis was conducted as an observational study and has several limitations that need to be highlighted. Prospectively performed educational interventions and continuous reminders over time in order to increase compliance with the RETTS triage seemed relevant. However, these EMS patient data were entered as per standard care and were retrieved retrospectively. We are unaware of the effect of the educational intervention and whether it increased triage utilisation in the EMS. Secondly, the ambition to triage all patients may have declined over time.

We recruited a consecutive sample consisting of the first one thousand assignments each month in order to include seasonal variations. The sample size was arbitrarily determined by convenience. However, over ten per cent in the sample from the total number of primary missions appears representative of the EMS population. This study was conducted in a mainly urban area with short transport times to hospital and a case mix of patients who may be more characteristic of an urban population. As a result, it may be problematic to extrapolate the results to rural areas. Moreover, evaluating triage systems developed initially for sites other than the one that was explored may be problematic. Furthermore, variations in triage performance have been reported when implementing triage systems in a new country and healthcare organisation [227].

The paediatric population was small and, even though the results were similar to those of other paediatric triage systems, such as the MTS in the ED with ten thousand children included, regarding over-triage and under-triage and information on missing triage levels, there is a risk that small changes in the triage level could have an impact on the result. The manual reports were paper based and subsequently entered into the electronic EMS patient record system which created a potential bias. There is also a risk of selection bias when evaluating the RETTS triage colours against different outcomes. However, at the scene, the EMS nurse most often only assesses and triages one patient at a time and generally has more time per patient than the ED triage nurse. The EMS has no insight into patients admitted to the ED and their triage levels. This may increase the focus on the individual patient triage, whereas the ED nurse may overrule the triage system to solve logistical problems in the ED.

Triage is a dynamic process during which the patient's condition can deteriorate or stabilise. The latter may be influenced by different interventions provided by the EMS nurse. In this thesis, the final triage assessment level has been considered and it is then the level that is reported to the ED when handing

over the patient. This would then have an impact on patients with deviating VS, such as anxiety disorders that would otherwise have resulted in unnecessary over-triage in the adult population.

Missing data are always a problem when retrospectively reviewing data and have to be managed. Some studies consider missing VP as VP within the normal range [172]. In this thesis, complete cases have been reported, as adherence rates have also been reported and considered when evaluating the triage system. While this may introduce a selection bias, the RETTS colour has been used in cases with an incomplete set of VS. However, assuming that a non-recorded VS is always normal may introduce even more bias.

Since a full set of VS was required in the last paper, imputed data were used. This approach is a prediction, as we cannot know the true values of the missing data. Moreover, some of the excluded patients, albeit few in number, may have suffered from an event in some of the outcomes. However, when comparing time-sensitive conditions, the percentage was similar between the patients in Paper III, including all the patients transported to hospital with a time-sensitive condition, and the included individual patients with imputed data in Paper IV. This suggests that the patients for whom the imputed data set was used consisted of a representative group of EMS patients who were transported to hospital. Imputed data sets are recommended and may avoid the selection bias that an analysis of only complete cases will introduce [228].

ED ADMISSION IN 72 HOURS

The 72-hour follow-up was chosen because it is a common “benchmark” in hospitals for patients discharged from the ED [229]. In most cases, a condition that lasts for more than three days from the initial contact may be considered less acute and therefore outside the scope of emergency care. However, the outcome can be discussed, as the initial assessment may be completely appropriate in the current situation and the patient may be recommended to remain at the scene and renew contact if the symptoms do not subside.

TIME-SENSITIVE CONDITIONS

The term “time sensitive” is debatable. For example, in the RETTS, the terms “life threatening” and “potentially life threatening” are used. One argument is that a patient can have a life-threatening disease, even though it is not considered to be an acute emergency. Furthermore, the term “time-critical conditions” has also been used. This may have meant that some further diagnoses will be included in a definition of this kind, as not all conditions that are time dependent are life threatening. Unstable angina pectoris or a transient

ischaemic attack (TIA) are two examples of diagnoses which we consider to be time-sensitive but which may not be regarded as life threatening.

The definition in this thesis differs from Ivic and colleagues' definition of serious conditions [230]. In their definition, they also include a number of conditions in a wider scope and all of them may not be regarded as time-sensitive in comparison with previously proposed time-sensitive conditions [135]. Either way, an international consensus on time-sensitive, including serious conditions, is required, with particular emphasis on the resources that are needed to establish the diagnosis. This is especially true of time-sensitive conditions such as a TIA. Evidence supports the consideration that this condition is urgent and needs to be managed in TIA-specialised clinics which can reduce the rate of actual strokes and disabilities [231]. Only diagnoses which could be associated with the patient presentation in the EMS have been considered and time-sensitive conditions that were acquired after hospital admission have been omitted.

MORTALITY

In Papers I, II and III, the population has been defined as the total number of primary EMS assignments, including patients during the study period who contacted the EMS on multiple occasions. Calculating the death rate based on the total number of assignments yields a lower mortality rate than when a calculation of mortality is based on the number of individuals as the denominator. However, there was no difference in the calculated mortality, regardless of the method used, in the paediatric population due to the small number of deaths and the limited number of children in contact with the EMS on multiple occasions.

In the adult population, there was a small difference ranging from 0.2% in short-term mortality to 1.8% in one-year mortality when comparing the two methods. It is not uncommon to report mortality rates when using all EMS assignments in the denominator [123,230,232]. However, in Paper IV, only unique individuals were included in the analyses. The reason for this was that mortality was used as a proxy when comparing the RETTS with the NEWS, rather than reporting on overall incidence.

HOSPITAL ADMISSION

Admission to hospital has been reported as an outcome in many studies as a proxy for illness. As a result, the theory of "if admitted to hospital the patient must be ill" is applied. However, this outcome can be discussed, as this is also a healthcare organisational issue which differs between countries. For example, in order to reduce crowding in the ED, it has been suggested that, if

the patient needs a thorough investigation, this is not an ED task and the patient should therefore be admitted for further investigation. In this way, admission to hospital may not always represent patients in need of hospital resources. Furthermore, among green-triaged patients, one third were admitted to in-patient care. It could be that they deteriorated or that findings in tests indicated further investigation in hospital. However, the finding that many of these patients were admitted for reasons other than high-acuity care indicates that "hospital admission" may be problematic for proxy use.

At the other end of the most critically ill patients, ICU care has not been used as a proxy for an "emergent" patient in this study for a number of reasons. Primarily, the lack of ICU beds in Sweden in general has led to prioritisation and the use of intermediate wards. As a result, patients who are not expected to benefit from ICU care are less frequently admitted to the ICU. The use of an outcome of this kind thus becomes problematic. Furthermore, a systematic review reported on 33 different outcomes used in triage systems with variability when assessing triage validity and using different definitions of a reference patient further complicating external validity [233]. This highlights the difficulty involved in comparing different triage systems.

OVER-TRIAGE AND UNDER-TRIAGE

Evaluating triage performance is difficult and the variability in patient assessments and triage is a concern and may affect the triage level. In this thesis, over-triage and under-triage have been calculated as 1 sensitivity and 1 specificity. This way of calculating under- and over-triage is common and has been reported in several studies of triage systems [103,234,235]. Using the Cribari matrix may introduce a high risk of bias. In EDs and EMS with a high frequency of patients with low-urgency cases and triaged to green/yellow, this leads to an underestimation of under-triage [186].

EMS NURSE'S FIELD ASSESSMENT COMPARED WITH PHYSICIAN'S HOSPITAL DIAGNOSIS

A number of differential diagnoses can be related to an EMS field assessment if described in symptoms, particularly in the elderly with more vague symptoms and co-morbidities. The EMS nurse's field assessment was noted as symptoms or as a more specific field diagnosis, such as suspicion of a stroke. Due to the difficulty involved in comparing assessments in the adult population, all EMS patient assessments were considered to be appropriate after excluding inappropriate assessments, deciding on a diagnosis that was incorrect, for example.

CONCLUSIONS

PAEDIATRIC PATIENT ASSESSMENT

One third of all children were assessed as requiring a lower level of care. Non-transported patients were younger, assessed with fever or respiratory distress, whereas older patients triaged with trauma or convulsions were more frequently transported. Very few children were admitted to the paediatric ED within 72 hours after an initial assessment to remain at the scene, with no adverse events. Among the transported children, one in three patients was discharged from the paediatric ED with no intervention. Children appear to be safely assessed by the EMS nurse, despite using the triage system to its full extent. The RETTS-p triage system may aid in the patient assessment at the scene, but it appears to be of limited use in cases when the child is identified with a critical illness or is unaffected at the scene.

Among children transported to hospital and triaged, there was over-triage of one third of "non-emergent" cases with similar under-triage in the "emergent" patients. Three in four patients were considered non-emergent if triaged to red or orange. The most common condition in under-triaged patients was infections. These patients were found in the yellow triage level, one level below high acuity. The EMS nurse's field assessment was in agreement with a physician's final assessment in four of five patients. There appears to be room for improvement when triaging certain subgroups in the EMS.

ADULT PATIENT ASSESSMENT

In adults, one in five patients was not transported and this was more common if the patients were female, with a medical history of psychiatric disorders or no medical history. Patients that were assessed as requiring a lower level of care were almost ten years younger. One patient in ten was admitted to the ED within 72 hours and one per cent were subsequently diagnosed with a time-sensitive condition. Time-sensitive conditions accounted for a total of eleven per cent among all patients admitted to the ED. All-cause seven-day mortality was two per cent among all patients. Of non-transported patients, deaths were often negotiated by the physician, home care and relatives in order to provide the best end-of-life care at the scene. However, a few avoidable deaths that may have been assessed more appropriately were found.

The RETTS triage system was utilised with a full set of VS in four of five patients. Among triaged patients assessed as requiring admission to hospital,

one in eight was triaged to the highest triage level (red). The risk of short-term mortality, admission and time-sensitive conditions all increased with higher triage levels. The EMS nurse's triage showed over-triage in over one-third and under-triage in one in every five patients. Older patients were overrepresented in the under-triaged group and were triaged more frequently with an "unspecific condition". Overall, patients triaged to the lowest levels (green or yellow) had no or very little risk of short-term mortality. The RETTS-A had a higher probability of detecting a time-sensitive condition than the NEWS.

The patient assessment and decision process is multifactorial and age, sex, past medical history and type of presentation all appear to influence the EMS assessment process. An increased number of the patients assessed and transported to the ED by ambulance could be referred to and managed by a physician at a lower level of care or transported by other means. Improved assessment tools at the scene and increased opportunities for consultation and education focusing on older patients including frailty may further improve the on-scene patient assessment. The results may be useful when addressing resource allocation issues and policies aimed at increased patient safety and in finding other ways of providing more efficient care for certain patient groups.

FUTURE PERSPECTIVES

One of the many problems with the current triage systems is their static construction and their lack of capability for adaptation. In the ED with the aim of assessing severity and the risk of deterioration with different sets of triage levels, current systems may apply. However, when utilising a triage system in the pre-hospital setting, the challenge is not only to assess patient severity, and with that the expected time spent waiting for a physician in the ED, but also to assess patients as needing a lower level of care that also can include treatment and/or referral to PC.

In order to achieve a more individual directed patient assessment, a CDSS with machine learning (ML) capabilities is proposed. The system would then take account of the individual patient and all the medical history and, when entering information, all the combined calculations including appropriate biomarkers of the situation would propose a level of severity and also desirable proposed actions, including eventual medical treatment. Furthermore, there should also be a proposal from the system on the level of care at which the patients could be managed. It is also important to take patient involvement into consideration. Feeling secure in their home environment with the appropriate resources allocated to the patient appears to be a promising concept.

Several studies of ML models have already been published and have outperformed current guidelines and human decisions in many areas. Predicting MI and grouping into low, intermediate and high risk, or predicting sepsis ahead of time have shown excellent performance and are better than current scoring systems [236,237]. Moreover, a study from Denmark reported that the operators do not recognise 25% of cardiac arrests on the telephone and are thereby unable to initiate telephone instructions on CPR. When using an ML system that responded to the caller's voice, the ML performed better in identifying cardiac arrests. The dispatcher was then given information on cardiac arrest beforehand [238]. If the ambulance can be dispatched at an earlier stage, the chances of survival increase. Moreover, if some patients could be assessed safely, without the need to dispatch an ambulance, this would be an advantage.

Furthermore, ED triage with a computerised ML triage system has shown better coherence as compared with manual paper-based guidelines and performed better than standard ESI triage in the level 3 patients (equivalent to level yellow if using a five-level triage scale) [239].

A CDSS may also reduce variability between EMS nurses, as factual knowledge and patient experience, as well as errors due to misclassification, play a role in triage decisions.

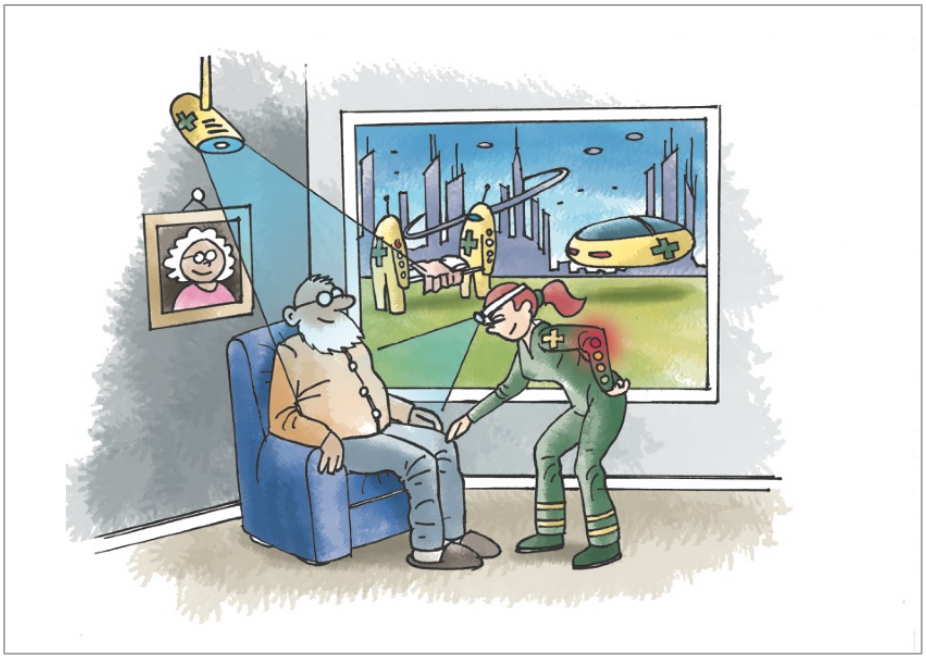


Figure 14. The future of EMS patient assessments, illustration: Pontus Andersson

In order to fully utilise a CDSS in the EMS, increased competence in the patient assessment process is needed. The CDSS prediction is dependent on the available information entered into the system. This requires training in patient assessment and the improvement of clinical reasoning skills. Using on-line simulation scenarios is feasible and reduces cognitive bias [240]. However, to increase the potential of a CDSS, additional tests may have to be provided. As of now, there is a limited set of objective measurements and the predictive value of some of them can be discussed. For example, the initial measured VS missed a substantial proportion of critically ill patients aged 75 years and older [117]. The use of VS adapted to the elderly in combination with biomarkers is suggested, together with tools assessing frailty. In Sweden, the transition to increase the on-scene care in co-operation with PC instead of transport to the ED would increase the demand for digital solutions. Further, introducing consultations with specialist physicians, such as paediatricians, in order to aid with patient assessments at the scene, will most probably also increase the parents' feelings of comfort and safety. Furthermore, as introduced in several regions, for example dedicated psychiatric units and

single responders specialising in psychiatric, paediatric and geriatric patients may increase the efficacy of person-centred care while maintaining patient safety.

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APPENDICES

APPENDIX A

Paediatric time-sensitive conditions [103,241]

Meningitis
Sepsis
High-energy trauma
Substantial blood loss
Aortic dissection
Signs of dehydration > 10%
Near/ drowning
Electrical trauma
Apparently life-threatening event (ALTE)
Intoxication
Burns ≥10 %
Inhalation trauma

APPENDIX B

Life-threatening paediatric vital signs according to the paediatric risk of mortality III – acute physiology score (PRISM III-APS) [138]

Age categories:

Neonates (N) 0 - < 1 month

Infants (I) 1- < 12 months

Children (C) 12- < 144 months

Adolescents (A) > 144 months

The vital sign cut-off for each age category and the mortality risk ratio in parentheses

1. Saturation all ages: PaO2 < 61mmHg (4.196)

2. Respiratory rate/min: N > 100, I > 100, C > 80, A > 60 (2.501)

3. Heart rate/min: N < 75 > 194, I < 75 > 194, C < 55 > 164, A < 55 > 134 (3.493, 2.915)

4. Level of consciousness all ages: GCS < 8 (19.114)

5. Body temperature all ages: < 33 > 40 (30.940, 5.805)

APPENDIX C

Adult time-sensitive conditions [140,242]

Medical	Traumatic injuries
Aortic rupture	Cardiac contusion
Aortic dissection	Cardiac tamponade
Any form of shock	Diaphragm rupture
Cardiac arrest	Oesophageal rupture
Failing heart conducting system	Flail chest
Heart failure including pulmonary oedema	High energy trauma
Intoxication	Massive haemothorax
Myocardial infarction	Obstructive airway
Pulmonary embolism	Open pneumothorax
Septicaemia	Pulmonary contusion
Tia/stroke	Tension pneumothorax
Unconsciousness	Thoracic aortic rupture/dissection
Unstable angina pectoris	Tracheobronchial rupture

APPENDIX D

Deviating vital signs red/orange level according to RETTS-A (2016 version)

	Red	Orange
A	Obstructive airway	Threat to airway
B	Respiratory rate > 30 /min Respiratory rate < 8 /min Oxygen saturation with supplementary oxygen < 90%	Respiratory rate > 25 /min Oxygen saturation < 90%
C	Pulse rate > 130 /min Irregular pulse rate > 150 /min Systolic blood pressure < 90 mm/Hg	Pulse rate > 120 /min Pulse rate < 40 /min Diastolic blood pressure > 140 mm/Hg*
D	Ongoing seizures RLS ≥ 4 GCS ≤ 9	Somnolence RLS 2-3 GCS 10-12
E		Temperature < 35 or > 41 °C

* Repeated measurements (embedded in ESS); RLS: reaction level scale; GCS: Glasgow coma scale, Predicare AB (www.predicare.se)

APPENDIX E

Conversion table between RLS 85, GCS and AVPU [243,244]

RLS 85	GCS	AVPU
1	15	A-alert
	14	
2	13	V-responds to verbal stimuli
	12	
	11	
3	10	P-responds to painful stimuli
	9	
4	8	P-responds to painful stimuli
	7	
5	6	P-responds to painful stimuli
6	5	P-responds to painful stimuli
7	4	P-responds to painful stimuli
8	3	U-unresponsive to all stimuli