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METHODS TO IMPROVE ACUITY ASSESSMENT FOR OLDER ADULTS IN THE EMERGENCY DEPARTMENT

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ACADEMIC DISSERTATION

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To Oiva and Steve

“There is no such uncertainty as a sure thing”

-Robert Burns

ABSTRACT

The purpose of acuity assessment, or triage, in the emergency department (ED) is to recognize critically ill patients and to allocate resources according to need. Evidence of validity regarding currently used triage instruments is limited, especially regarding older adults. Many triage methods utilize vital signs as part of the triage process. As age related changes alter the body's ability to respond to stress, vital signs alone are not always reliable in older ED patients. Other risk factors for older ED patients include geriatric syndromes such as frailty and presenting with a nonspecific complaint (NSC). With a rapidly ageing population and crowded ED's, more precise acuity assessment instruments for older ED patients are needed.

The main objective of this thesis was to assess the accuracy of the Emergency Severity Index (ESI) for older adults and to see if it can be improved by age adjustment. The secondary objectives were to explore the associations of an early warning score and local three level triage instrument with outcomes for older ED patients and to summarize and review current knowledge regarding patients presenting to the ED with nonspecific complaints.

Study I compares the accuracy of the ESI for adults under 65 and 65 years or over in a Finnish ED. Results of study I suggest that the ESI is associated with high dependency unit/intensive care unit (HDU/ICU) admission and 3-day mortality for older ED patients. Accuracy of the ESI is low in predicting 30-day mortality and hospital admission in both age groups.

Study II explores the effect of age adjustment on two triage methods for patients presenting in three Finnish ED's. Both the ESI and the local three-level method predict 3-day mortality adequately and 30-day mortality and hospital admission poorly. The ESI also predicts HDU/ICU admission. Age adjustment improves accuracy in predicting 30-day mortality and hospital admission.

Study III assesses the accuracy of an early warning score (NEWS2) and a local three-level triage methods for frail older ED patients. The NEWS2 and local three-level triage score predict 30-day mortality moderately and poorly, respectively. Both methods predict hospital admission poorly and HDU admission moderately. Neither the NEWS2 nor the local triage method predict ED length of stay (ED LOS) or ED revisits.

Study IV is a systematic review and meta-analysis of patients presenting to the ED with nonspecific complaints. The findings show that patients presenting with an NSC were mostly older adults. These patients have a higher in-hospital mortality rate, and their care require more time and resources than patients presenting with a specific complaint (SC). Hospital and ED LOS as well as hospital admission rates are increased compared to SC patients. NSC patients are triaged less often as urgent than SC patients and they seem to require more resources

In conclusion, the ESI seems to be sufficiently accurate in our population in all age groups. Its predictive performance was superior to our local three-level method. Age adjustment improved the performance of both tools without excessive overtriage. These findings indicate that the ESI can be used in our population, including for older adults, to improve standards of acuity assessment. The NEWS2 is not sufficient to predict ED outcomes for frail older adults. Patients presenting to the ED with an NSC have a higher risk of mortality and their care requires more time and resources than patients presenting with an SC. The certainty of evidence for the outcomes was moderate to high. Increasing awareness and knowledge about this common syndrome can be utilized when creating treatment protocols and patient pathways for these patients.

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original articles, which are referred to in the text by their roman numerals.

I. **Kemp, K.**, Alakare, J., Kätkä, M., Lääperi, M., Lehtonen, L., Castrén, M. Accuracy of Emergency severity index in older adults. *Eur J Emerg Med*, online ahead of print, December 22nd, 2021.

II. **Kemp, K.**, Alakare, J., Kätkä, M., Lääperi, M., Lehtonen, L., Castrén, M. Effect of age adjustment on two triage methods. *BMC Emerg Med* 22, 52 (2022).

III. **Kemp, K.**[1]**,** Alakare, J.[1]**,** Harjola, VP., Strandberg T., Tolonen J., Lehtonen L., Castrén M. National Early Warning Score 2 (NEWS2) and 3-level triage scale as risk predictors in frail older adults in the emergency department. *BMC Emerg Med* 20, 83 (2020).

IV. **Kemp, K.**, Mertanen, R., Lääperi, M., Niemi-Murola, L., Lehtonen L., Castrén M. Nonspecific complaints in the emergency department – a systematic review. *Scand J Trauma Resusc Emerg Med* 28, 6 (2020).

[1] These authors contributed equally

ABBREVIATIONS

ANOVA	Analysis of variance
ATS	Australasian triage scale
AUC	Area under the curve
AUROC	Area under receiver operating characteristic
BANC	Basel nonspecific complaint study
CI	Confidence interval
CFS	Clinical frailty scale
DGC	Decreased general condition
ED	Emergency department
ED LOS	Emergency department length of stay
EM	Emergency medicine
EMS	Emergency medical services
EHR	Electronic health record
ESI	Emergency severity index
EWS	Early warning score
FI-ED	Emergency department frailty index
GED	Geriatric emergency department
GDPR	General data protection regulation
GRADE	Grading of recommendations assessment, development and evaluation
HDU	High-dependency unit
HUH	Helsinki University Hospital
ICD-10	International classification of diseases, 10th edition
ICU	Intensive care unit
IQR	Interquartile range

ISAR	Identification of seniors at risk
LOS	Length of stay
MEWS	Modified early warning score
METTS	Medical emergency triage and treatment system
NEWS2	National early warning score 2
NHAMCS	National hospital ambulatory medical care survey
NRI	Net reclassification improvement
NPV	Negative predictive value
NSC	Nonspecific complaint
OR	Odds ratio
PPV	Positive predictive value
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
PROSPERO	International prospective register of systematic reviews
qSOFA	Quick sequential organ failure assessment
RCP	Royal College of Physicians
RCT	Randomized controlled trial
RETTS	Rapid emergency triage and treatment system
ROC	Receiver operating characteristic
SC	Specific complaint
SIGN	Scottish intercollegiate guidelines network
SPSS	Statistical product and service solutions
STROBE	Strengthening the reporting of observational studies in epidemiology
TRIPOD	Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis
TRST	Triage risk stratification tool

1. INTRODUCTION

The primary aim of emergency triage is to recognize critically ill patients who require immediate physician assessment and care from less urgent ones who are able to wait (1). The secondary purpose of triage is to allocate emergency department (ED) resources, such as beds, staff, imaging and laboratory testing, according to need.

Most modern triage methods are based on vital signs, such as heart rate, respiratory rate and body temperature. They are usually presented as ordinal scales of three to five levels. Five-level methods are widespread throughout the world and there is more research covering their validity and reliability than three level scales. These methods are not perfect - however, better tools have not yet been developed. (2,3)

Acuity assessment can be applied to many settings, including the ED. The field of emergency medicine in Finland is young and it was recognized as a specialty first in 2013. The same applies to other Nordic countries. There is a general lack of national guidelines, including recommendations for triage. Different methods are applied regionally, with many ED's utilizing local informal triage tools.

The European population is aging rapidly and with it, the number of geriatric patients in the EDs is increasing (4). Current triage methods seem to work less accurately on older adults (2). The physiological changes that occur with age alter the capacity of the body to respond to stresses such as acute illness or injury. Older adults also commonly take several medications. Both of these factors affect the vital signs, that are considered as part of many triage methods (5,6). In addition, the ability of the body and mind to locate pain and discomfort diminishes with age. Thus, an older person with an acute myocardial infarction or a hip fracture might not present with chest or hip pain but with a nonspecific symptom, generalized weakness or fatigue (7). It is therefore not surprising, that older adults frequently get undertriaged – they are

allocated to a less urgent triage class than their true need (8). This in turn increases the rate of adverse outcomes, mortality, hospital admission and length of stay, for older adults. Adjustments and additions to triage tools have been suggested an the attempt to improve triage accuracy for older adults, but the level of evidence has so far been insufficient (9).

The purpose of this dissertation is to study different triage and acuity assessment methods for older adults in the ED. This study reviews the literature on existing triage and acuity assessment methods for the general adult population as well as for older adults. The main objective is to assess the accuracy of three methods currently used in Finland, especially regarding the older adult population. This study presents a prognostic review and meta-analysis of the outcomes for older ED patients presenting with nonspecific complaints.

2. REVIEW OF THE LITERATURE

2.1. ACUITY ASSESSMENT IN THE EMERGENCY DEPARTMENT

2.1.1. Historical perspective on triage

Triage is, in short, a method of sorting (fr. "Trier"). It was first introduced by Baron Dominique Jean Larre (1766-1842), a surgeon in the Napoleonic Army, who developed a system where soldiers were attended to in order of urgency, regardless of rank. Following his method, treatment was initiated for the badly wounded prior to their transport to camp hospitals, even during battle (10). Triage techniques were then developed over the next two centuries especially during war-time, approaching modern methods during the Vietnam War (11). In addition to military use, triage was later applied to mass disasters and prehospital situations (12–17). Triage, which was initially designed for mass casualties in the field, is today also used for acuity assessment of individual patients in EDs (18). Thus, the term "triage" has two distinct definitions and uses.

The first versions of modern ED triage instruments were published at the end of the 20th century: the Emergency Severity Index (ESI) in the United States (19), the Manchester Triage System (MTS) in the United Kingdom (20), the Canadian Triage and Acuity Scale (CTAS) in Canada (21) and the National Triage Scale in Australia (later the Australasian Triage Scale, ATS) (22), among others. These five-level triage tools are the most widely used instruments in EDs today.

2.1.2. Appraisal of triage methods

The original purpose of triage was to recognize and prioritize critically ill patients in mass casualty situations. In the ED, triage aims to

recognize patients who need urgent treatment. In addition, many modern triage instruments have been designed to improve resource allocation.

There is no golden standard for validating triage instruments. Validation has most commonly been based on the ability of a triage instrument to predict negative outcomes such as mortality, hospital admission, and high dependency and intensive care unit (HDU/ICU) admission (2,3,23). There is variation between studies as to which survival times are explored, from ED mortality to 1-year mortality; larger studies seem to favour ED or in-hospital mortality (2). Choosing short-term mortality as the outcome might better reflect the capacity of the triage tools, considering their main purpose: that is, to decide which patients have life-threatening conditions needing immediate attention. The assumption in validity studies is that patients who are allocated to the more urgent triage categories are at higher risk of negative outcomes and, thus, need to be assessed and treated by a physician faster. (23,24)

Some studies have also explored triage tool efficiency. Efficiency is assessed based on resource allocation. The expectation is that patients in more urgent triage categories require more resources. Types of resources that might be required include, for example, imaging, blood and urine samples, need for intravenous fluid or drug administration, bedside procedures and consultations. Revisitation rate is another variable regularly evaluated in triage efficiency studies. Patients whose concerns are not resolved in the first visit might return to the ED, where they again require resources. In some cases, they might only require the attention of the triage nurse, if the reattendance is deemed redundant and the patient is redirected for example to primary healthcare. In the worst case, returning patients might have a serious condition that has meanwhile worsened having been missed during the first visit. Regardless of the case, fewer reattendances indicate increased ED efficiency, in addition to the obvious benefits for the individual patient.

Some studies have evaluated efficiency in terms of emergency department length of stay (ED LOS). However, it is not obvious what the ideal result for an efficient triage tool would look like. Patients in the most urgent categories are seen faster, so the waiting time from door

to doctor is short; simultaneously their care might be complicated, resource-heavy and require time. Patients with simple, non-life-threatening presentations in the least urgent categories can wait longer for treatment, yet their complaints are typically minor and require little time and few resources. Many EDs have indeed created fast tracks, where ambulatory patients with minor complaints are allocated to a separate queue with separate resources (mainly staff). Fast-tracking seems to reduce the ED LOS for these patients, without a significant increase in negative outcomes for high acuity patients (25,26). Simply finding differences in ED LOS between triage categories might not indicate actual efficiency of the tool. (23)

Many studies have also explored the reliability of triage instruments; the instrument is reliable if a repeated triage assessment of the same patient would give the same result. Reliability can be measured as inter-rater or intra-rater reliability. Inter-rater reliability indicates how likely it is that two triage nurses would allocate the same triage category to a patient, whereas intra-rater reliability indicates how likely it is that single triage nurse would allocate the same triage category to a patient twice. (23,24)

2.1.3. Modern triage

The most widely used and studied triage instruments in the world are the ESI, the Manchester triage system (MTS), the Canadian triage and acuity scale (CTAS) and the Australasian triage scale (ATS). Each of these tools consist of five levels of urgency. A description of each tool is presented below.

The Emergency Severity Index was developed in the USA and first published in 1999 (18). It is the most common triage method in use there (27), as well as in many other countries (28–30). ESI is fairly simple and can be implemented with little training. It utilizes vital signs to distinguish between mid- and high-acuity categories (31). Unlike other five-level triage scales, it does not specify the expected time to physician assessment. The ESI is based on four decision points) (**Fig 1**):

A. Does this patient require immediate life-saving intervention? Examples of interventions include airway management, emergency medications and other haemodynamic interventions. The patient is also considered as emergent given any of the following conditions: intubated, apnoeic or pulseless patient, patient in severe respiratory distress, patient has pulse oximetry less than 90%, patient has an acute mental status change (the patient is nonverbal and does not follow commands or the patient responds to painful stimulus only).
B. Is this a patient who should not wait? The patient is triaged as very urgent if their mental state is altered (confusion, lethargy, disorientation), they have severe pain (in subjective assessment), or the patient rates pain 7 out of 10 or higher.
C. How many resources will this patient need? The sum of different types of resources is calculated. Examples of resources include blood or urine testing, electrocardiograms, radiography (each modality is counted separately), intravenous access, administration of parenteral medication or fluids, specialty consultation or procedures.
D. What are the patient's vital signs? The ESI triage algorithm requires the measurement of heart rate, respiratory rate and oxygen saturation. For children under the age of three, temperature is also measured. If any vital signs are above or below the set limits, the triage nurse should consider moving the patient into category 2.

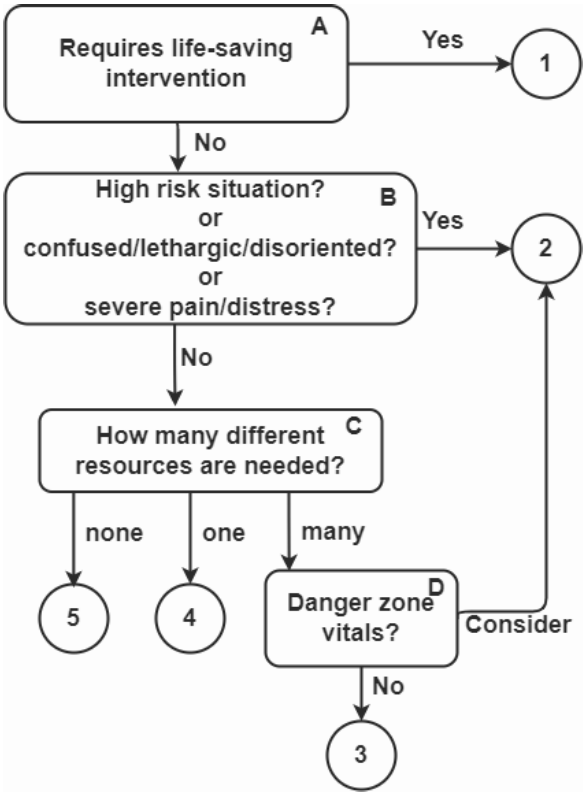

Fig 1 The emergency severity index triage algorithm. Triage category (1 to 5) is allocated based on the four decision points (31).

Based on the answers to the four decision point questions, the patient will be allocated to one of five categories. Category 1 is the most urgent, where the patient requires an immediate life-saving intervention such as airway opening, or the patient is in extremis. Examples of conditions in category one include, for example, the following: cardiac arrest, respiratory arrest, severe respiratory distress, pulse oximetry less than 90%, critical injury, unresponsive trauma patients or trauma patients requiring immediate fluid resuscitation, overdosed patients with a respiratory rate less than 6 breaths/minute, severe arrythmias with signs of hypoperfusion, anaphylactic shock and a flaccid infant.

Patients allocated to category two are at high risk of sudden deterioration, or in severe pain, based on the triage nurse's subjective assessment. Examples of high-risk situations include chest pain with

suspicion of acute coronary syndrome, a needlestick injury in a health care worker, signs of stroke, suspicion of ectopic pregnancy, fever in an immunocompromised patient, suicidal or homicidal patients, smoke inhalation or chemical exposure, severe burns, suspicion of sepsis or diabetic ketoacidosis, trauma or chemical injury to the eye, extremity injuries with neurovascular compromise, victims of domestic violence or child abuse.

Patients in categories three to five are stable, and the category is assigned according to anticipated resource consumption. The triage nurse must be familiar with general ED procedures and standards of care to correctly identify the resources needed. (31)

The Manchester Triage System is used in many European countries (32–36). It consists of 52 flowcharts and the presenting complaint of the patients determines which one is used. Each flowchart then uses key identifiers to determine the patient's triage category:

1. Emergent
2. Very urgent
3. Urgent
4. Less urgent
5. Non-urgent

The MTS also specifies the time for required medical attention: immediate, 10 minutes, 60minutes, 120minutes or 240 minutes, respectively. Vital signs are not included in the risk assessment, but measured after the triage decision. (32) The MTS is a licensed product with a fee and included in it is an electronic tool to aid in the triage process. The flowcharts are protected by copyright (37–39).

The Canadian Triage Acuity Scale is a less structured tool and relies more on subjective nurse assessment than other triage scales. In addition to the manual, there is also a computerized version of the CTAS (40). The CTAS consists of five categories:

I. Resuscitation: "Conditions that are threats to life or limb (or imminent risk of deterioration) requiring immediate aggressive interventions."

II. Emergent: "Conditions that are a potential threat to life, limb or function, requiring rapid medical intervention or delegated acts."

III. Urgent: "Conditions that could potentially progress to a serious problem requiring emergency intervention. May be associated with significant discomfort or affecting ability to function at work or activities of daily living."

IV. Less urgent: "Conditions that related to patient age, distress, or potential for deterioration or complications would benefit from intervention or reassurance within 1-2 hours."

V. Non-urgent: "Conditions that may be acute but non-urgent as well as conditions which may be part of a chronic problem with or without evidence of deterioration. The investigation or interventions for some of these illnesses or injuries could be delayed or even referred to other areas of the hospital or health care system."

The required options regarding time to physician assessment according to CTAS are immediate, ≤15 minutes, ≤30 minutes, ≤1 hour and ≤2 hours. The triage nurse assessment consists of recording and assessing the chief complaint, recording the vital signs, and a pain scale. The CTAS handbook gives examples of usual presentations for each triage category. (21)

The Australasian Triage Scale is used in Australia and elsewhere Oceania. It does not have a rigid preset algorithm, but is descriptive in nature (41). In an initial primary survey, the triage nurse assesses the condition of the patient and allocates the triage category for the unstable patients accordingly. If the patient is stable, the nurse identifies any predictors for poor outcome and makes the triage category decision. The ATS triage categories are:

1. Immediately life-threatening e.g., cardiac or respiratory arrest, severe shock, unconscious. Vital signs: RR <10, BP <80, GCS <9. Immediate response.
2. Imminently life-threatening, or important time-critical treatment, or very severe pain e.g., severe respiratory distress, stroke, major trauma. Vital signs: HR <50 or >150, GCS <13. Response within 10 minutes.
3. Potentially life-threatening or situational urgency or mandated by humane practice e.g., moderate blood loss or shortness of breath, psychotic behaviour. Response within 30 minutes.
4. Potentially serious or situational urgency, or significant complexity or severity, or mandated by humane practice e.g., minor head injury, minor trauma, mild haemorrhage. Response within 60 minutes.
5. Less urgent or clinic administrative problems e.g., minor symptoms of existing stable illness, scheduler revisit, social crisis. Response within 120 minutes.

The validity and reliability of these most widely used triage instruments have recently been assessed in two systematic reviews by Zachariasse et al. and Hinson et al. in 2019. The reviews covered 1,5 million participants in 17 countries located in Europe, North America, Asia and Australia (2,3). In both reviews, CTAS, ESI and MTS all demonstrated similar performance.

In their review, Hinson et al. reported high sensitivity for ED mortality and low sensitivity for in-hospital mortality for high acuity (categories 1-2) patients. Considering the short-term purpose of ED triage, ED mortality can be regarded as the principal outcome. As the length of hospital stay can often be days or weeks, inspecting in-hospital mortality gives perhaps less meaningful information regarding the validity of triage tools. In other words, patients in the higher triage categories were

more likely to die in the ED than patients in the less urgent categories. This is an indication of the validity of the triage tools: they were able to differentiate between critical and non-critical patients in the ED. Zachariasse et al. did not calculate sensitivity due to the low number of studies that reported mortality rates.

Sensitivity for ICU admission for the high acuity patients was moderate to good in both reviews. Patients in the more urgent triage categories were shown to require ICU admission more often than patients in low-acuity categories. This indicates that the currently used five-level triage tools are able to differentiate critically unwell patients from non-critical patients.

In their review, Hinson et al. reported that sensitivity for hospital admission for the mid- to high acuity patients (categories 1 to 3) was high in most studies. Zachariasse et al. reported moderate to high specificity for home discharge for low- to mid-acuity patients (categories 3 to 5). In summary, patients in the more urgent categories were more likely to be admitted to hospital and patients in the less urgent categories were more likely to be discharged home from the ED. This again indicates the validity of the currently used triage tools.

Hinson et al. also summarized reliability of triage studies in their review. Out of 42 studies, 11 reported perfect and 21 studies reported substantial inter-rater reliability. Moderate and fair reliability was reported in 11 and two studies, respectively. In other words, the triage tools seem not to depend on the user: another triage nurse would have been likely to allocate a patient to the same triage category as the first nurse. Zachariasse et al. did not report reliability in their review.

In addition to the previously described major triage tools, many other five-level adult triage scales have been described in literature. Examples include tools such as the Taiwan Triage and Acuity Scale (42), the South African Triage Scale and the Medical Emergency Triage and Treatment System (43) (subsequently known as the Rapid Emergency Triage and Treatment System). There are either few or single studies on these triage instruments, and they are yet to be validated internationally.

Many local and national three- and four-level triage instruments have also been described in the literature. The systematic review by Zachariasse et al. reported ten studies in which a local three- or four-level triage instrument was compared to an established five-level triage system. The review found that in seven out of ten comparisons, the established five-level triage system showed superior performance. Thus, it seems that the currently used five-level tools are more accurate than three-level tools; however, each three-level tool has been assessed in only a few studies. (2)

There is a lack of evidence regarding the efficiency of triage instruments e.g., ED length of stay, revisitation and the use of resources. Variability in the methods for exploring resource consumption leads to difficulties in making comparisons and drawing conclusions. Many studies have reported differences in ED LOS between triage categories, however, as discussed earlier, it is not obvious whether this indicates efficiency of the tool. These studies have often reported a bell-shaped curve for ED LOS, where mid-acuity patients have the longest passage times (35,44,45).

2.1.4. Triage in the Nordic countries

Emergency medicine (EM) is a new specialty in the Nordic countries. Emergency medicine was first recognized as its own specialty in Finland, in 2013 (46). Prior to EM, ED staff in Finland included physicians from internal medicine, general surgery, general practice, and many other specialties. Many EDs are currently in a transition period as the number of ED physicians is nationally increasing. Other Nordic countries followed Finland with EM training: Sweden in 2015 (47), Norway in 2017 (48) and Denmark in 2019 (49). Iceland, where EM is a two-year subspecialty, is in the process of establishing full specialty training (50).

Triage practice in the Nordic countries is variable. Swedish EDs have been developing a national triage scale, RETTS, since the mid-1990s. A recent study reported that over 90% of Swedish EDs utilize RETTS, and it has been documented in several publications. (51)

There is no recent data regarding triage use in the other Nordic countries. In 2011, 10% of Danish ED were using an established triage system such as the ESI or MTS, 25% utilized a local system - the Adaptive Process Triage (52) - and 40% used a non-validated system; 25% of Danish EDs reported using no triage system at all (53). In 2013 it was reported that in Norway, 50% of EDs were using self-composed scales and 27% were using an established five-level triage scale (the MTS or CTAS) (54).

There is no reported data on the use of triage scales in secondary care ED's in Finland. A thesis from 2014 reported on the use of an unvalidated five-level triage scale in urgent primary care (55). An informal survey on social media in 2018 revealed that four out of five university hospital ED's in Finland were utilizing the ESI; the others were using an informally structured three-level scale. In addition, at least three central hospital ED's reported using the ESI in the survey. None reported using the MTS or CTAS. (56)

2.1.5. Vital signs and early warning scores in the emergency department

Many triage systems rely on recording vital signs as part of the primary survey, but evidence regarding their ability to predict ED outcomes is limited (57). In individual studies, abnormal vital signs have been associated with mortality (58–63), as well as hospital (64) and ICU admissions(63).

Early warning scores (EWS) are a means to assess vital signs in a structured way. A numerical value, e.g., 0 to 3, is assigned to each vital sign. A larger value indicates an abnormal vital sign, whereas zero indicates that the vital sign is in the normal range. The sum of values then determines the level of response (**Fig 2**). The early warning score system was originally developed to improve the detection of and response to deteriorating patients in hospital wards.

The most commonly used early warning score currently is the National Early Warning Score 2 (NEWS2). A crucial part of the NEWS2 protocol is not only to score and record vital signs but also to establish

predetermined thresholds that trigger further action (65). Simply calculating a NEWS2 is meaningless if the appropriate action is not taken for an elevated score.

Physiological parameter	Score						
	3	2	1	0	1	2	3
Respiration rate (per minute)	≤8		9–11	12–20		31–24	≥25
SpO2 scale 1 (%)	≤91	92–93	94–95	≥96			
SpO2 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	91–100	111–130	≥131
Consciousness				alert			CVPU
Temperature (˚C)	≤35.0		35.1–36.0	36.1–38.0	38.1–39.0	39.1	

NEW score	Clinical risk	Response
Aggregate score 0–4	Low	Ward-based response
Red score Score of 3 in any individual parameter	Low-medium	Urgent ward-based response
Aggregate score 5–6	Medium	Key threshold for urgent response
Aggregate score 7 or more	High	Urgent or emergency response

Fig 2 The national early warning score system. Each vital sign is given a score from 0 to 3. The sum represents the level of clinical risk (60)

Since the launch of the NEWS2 for hospital wards, it has been also implemented in EDs. High NEWS2 values have been associated with increased mortality and cardiac arrest rates, as well as higher ICU admission rates in the ED (66–69). Even if the NEWS2 is neither

validated nor designed to be used as an acuity assessment tool in the ED, it can be used to monitor the deterioration of those patients already admitted to the ED (70).

2.2. OLDER ADULTS IN THE EMERGENCY DEPARTMENT

2.2.1. Epidemiology for older adults in the emergency department

The proportion of older adults in the world population is increasing. In 2019, there were 703 million people aged 65 or over, and this number is predicted to double by 2050 (4). The rate of older adults globally is predicted to increase from 9.3 to 16.0%. Finland has one of the oldest populations in the world, the estimated increase in the older adult population is from 1.2 million (22%) in 2019 to 1.6 million (29%) in 2050 (71).

Older adults have high ED visiting rates both globally (72–75) and also nationally in Finland (76), and the rates seem to be increasing (77). ED resource consumption is higher and ED LOS longer in the older adult population. Older adults require hospital admission and emergency medical services (EMS) transport more frequently. Results regarding ICU admission and triage category allocation have been ambiguous (72–74,77–88). The European Society of Emergency Medicine, the Royal College of Emergency Medicine (UK) and the American College of Emergency Physicians have set high priority to research in geriatric emergency medicine (89–91).

2.2.2. Geriatric syndromes in the emergency department

Geriatric syndromes have been described as common, serious health conditions in older people. They reduce the functional capacity and quality of life of the affected. The pathophysiology of geriatric

syndromes is multifactorial and complex. Risk factors include older age, and cognitive and functional impairment as well as impaired mobility (92). The most commonly described geriatric syndromes are pressure ulcers, incontinence, falls, functional decline, delirium and frailty (92,93). Prevalence of geriatric syndromes in the ED population is high (94–101).

Many descriptions of frailty have been presented in the literature. A common one describes it as a long-term state of vulnerability, where the individual is at increased risk of developing dependency or mortality when exposed to a physiological or psychological stressor (102). In other words, the affected person has limited reserves and the capacity to recover from even trivial health issues such as a minor injury or infection is diminished. Features of frailty include sarcopenia, weight loss and nutritional deficiency (103). In the ED, frailty is commonly assessed with the Clinical Frailty Scale (CFS) (**Fig 3**). The patient's baseline health is recorded as a numerical value from 0 (very fit; active people who exercise regularly) to 8 (very severe frailty; completely dependent on personal care) and 9 (terminally ill; people with a life expectancy of less than 6 months, who are otherwise not frail). (104).

Frail patients in the ED have increased mortality and hospital admission rates as well as longer hospital length of stay (105–113). The association between frailty and ED revisitation is uncertain (106–108,110). A few studies have reported increased prevalence of delirium and increased ICU admission rates for frail ED patients (109,112,114,115).

Delirium refers to a rapid-onset clinical state with disturbance in attention and cognition that is not explained by an another medical condition and that fluctuates over time (116). Patients with delirium in the ED have increased mortality, and they are more likely to be admitted to hospital. If admitted, their stay in the hospital is increased. A few studies have reported increased ED LOS, ICU admission and revisitations for ED patients with delirium (117–123).

Nonspecific complaints (NSC) are common in older ED patients; prevalence rates as high as 14 to 20% have been suggested (8,124). NSCs are usually not included in geriatric syndromes due to their

sudden onset and limited duration (125). The mechanisms behind NSCs, however, are similar to geriatric syndromes: age-related changes that affect the physiological capacity of the patient to respond to acute illness or injury (126).

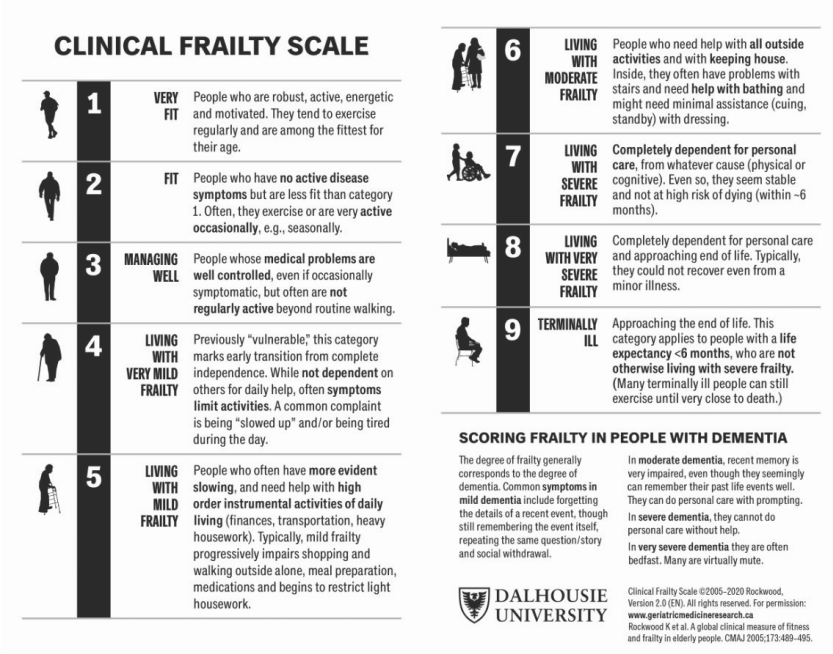

Fig 3 The Clinical Frailty Scale. A numerical value from 0 to 9 is assigned according to the patient's baseline health state. (Reproduced with permission) *(104)*

The term nonspecific complaint was first described by the Basel Non-specific Complaint (BANC) study group as "all complaints that are not part of the set of specific complaints or signs or where an initial working diagnosis cannot be definitively established" (7). By their definition, a true NSC presentation can only occur in patients allocated to ESI categories 2 and 3. This approach might risk excluding patients who would benefit from a structured NSC protocol as older adults with NSC's are frequently undertriaged (8). Another suggested definition for NSC is "rapid decline in physical and/or mental condition without signs or symptoms from a specific organ and without ongoing fever"(127). Other nomenclature, such as "generalized weakness", "decreased general condition", "home care impossible" and "acopia" among many

others have been used. Nonspecific complaint is becoming the universal term, however, there is a lack of consensus regarding the definition(128,129).

Many individual studies have reported inferior ED outcomes, including increased mortality and hospital admission rates as well as increased ED LOS for NSC patients (7,124,127,130–133). Increased rates of undertriage for NSC patients have also been reported (8,85,127,133). NSC patients have also been associated with lower utilization of ED diagnostic resources (134). Different models and diagnostic testing have been suggested to improve ED outcomes for NSC patients (125,135–139). There is, however, a lack of evidence regarding the epidemiology, outcomes and treatment pathways for this patient group.

2.2.3. Effect of age on vital signs

Many triage tools include vital signs in the primary survey. Vital signs, however, are affected by age. The heart workload is increased as the arterial walls stiffen, and higher systolic blood pressure is required to maintain tissue perfusion. Changes in the autonomous nervous system affect the capacity of the heart to increase its rate as a compensatory mechanism. Most older adults also take regular medication, such as beta blockers, which might affect vital signs. (5,6)

The respiratory system is affected by age as lung tissue degrades, the chest wall loses compliance, and the respiratory muscles weaken. This leads to reduced tidal volumes and increased respiratory rate. Molecular level changes in the lung tissue cause decreased response to hypoxia and hypercapnia. (6,140,141)

Compared to other adults, the core temperature of older adults is lowered, and thermoregulatory response altered. The exact reason is unknown; loss of subcutaneous fat and changes in the cardiovascular system have been presented as explanations. Decreased capability to mount fever diminishes the response to infection. (6,140)

Vital sign measurement for older adults in the ED was reported as moderately sensitive for negative outcomes in one study; abnormal

respiratory rate, blood pressure and heart rate, as well as low oxygen saturation and low body temperature, predicted mortality and ICU admission (142). Other studies have reported that normal heart rate and body temperature in older ED patients with suspected infection are predictive of not being admitted to hospital or the ICU (143); sensitivity of vital signs in predicting a cardiac arrest in hospital wards is lower for older adults compared to the nonelderly (144), and abnormal vital signs in the ED are associated with hospital admission(145). One study found that combing the NEWS with age improves the prediction of in-hospital mortality, but not ICU admission in older ED patients (146). In short, vital signs are predictive of negative outcomes in older adults, but the evidence is scarce.

2.2.4. Emergency triage for older adults

Accuracy of triage instruments for older ED patients has been explored in a few studies (2). Two studies reported on the performance of the ESI in the older adult population (44,147). In both, the ESI was associated with mortality, hospital admission, ED length of stay and resource consumption. Neither study reported an association of the ESI with life-saving interventions, and a similar finding was reported in a third study (148). One study found that older adults with similar chief complaints and ESI levels had higher admission and mortality rates, as well as higher resource consumption than younger adults (149).

One study reported on the performance of the MTS in older ED patients. It found that the MTS predicted mortality and hospital admission moderately, but inferiorly compared to younger adults (150). Two studies reported on the CTAS (151,152). One of these reported association of CTAS with mortality, ICU admission and resource consumption, and the other reported an association with hospital admission but not with hospital LOS. To summarize, triage instruments seem to be valid for older ED patients, but their accuracy is lowered in comparison to other adults.

Undertriage is a situation where a patient is allocated to a less urgent triage category than their "true need". It has most often been based on

retrospective expert opinion of true acuity. A small number of studies has measured undertriage based on outcomes (153). Several studies have reported a significant rate of undertriage for older adults (85,86,147,148,154–156).

Allocation to a less urgent triage category leads, by definition, to a longer time for physician assessment. In the case of undertriage this means delayed treatment. One study found that older undertriaged trauma patients had increased mortality (157), and another reported increased hospital admission and revisitation rates for older undertriaged patients (156).

The number of geriatric emergency departments (GED) has been on the rise during the past decade, especially in the United States (158). GEDs are units with specially trained staff that focus on the acute care of older adults, where the ED processes and physical environment are modified in consideration of the older patients (159). Physical environment modifications might include for example windows that allow natural light in order to decrease the risk of delirium, and the use of pressure-reducing mattresses, visual aids and cues, non-skid floors or support rails on the walls. A few studies have reported on GED triage processes. According to an American study, just 43% of GEDs utilized a modified triage process for older adults (158). The Geriatric Emergency Department Guidelines of the American College of Emergency Physicians encourages that a family member or care provider should either be present or participate in the triage process. The guidelines also recommend screening for delirium at triage (160).

Attempts to improve triage accuracy for older adults have been made. One study suggested modifying the ESI criteria for the older ED patients by altering the range for normal vital signs (161). A Delphi study recognized 17 trauma care modifiers for older adults, such as transferring all older adults with abnormal respiratory rates to a trauma centre (162). Other studies have suggested including age, mobility or a physicians first impression in the triage criteria (149,163,164). The combination of triage tools and geriatric screening tools is discussed next. Given the small number of original studies and the lack of

confirmatory studies, there is still a demand for evidence on how to improve ED triage for older adults.

2.2.5. Geriatric screening in the emergency department

Numerous geriatric screening tools and combinations of them have been described in the literature. In order to improve accuracy, attempts to combine screening tools with triage methods have been made.

Early warning scores (EWS) have been reported to predict ED outcomes in older patients, despite the age-associated changes in vital signs. High EWSs have been associated with mortality in several studies (165–168). A few studies have reported association between hospital admission (168–170) or ICU admission (165,167,169) and EWS in older ED patients. Thus, EWSs seem to be an appropriate tool in assessing older adults in the ED.

The quick Sequential Organ Failure Assessment (qSOFA) is a tool for screening sepsis in the ED (171). The qSOFA is considered positive, if at least two of the following apply:

- Respiratory rate ≥22
- Altered mentation
- Systolic blood pressure ≤100mmHg

A positive score should also prompt the evaluation of sepsis in patients who were not previously recognized as infected. Patients meeting two or more qSOFA criteria are more likely to have poor outcomes.

Two studies have reported on the accuracy of the qSOFA for older adults. Both found that the qSOFA had high sensitivity but low specificity in predicting in-hospital mortality for older patients (172,173).

The triage risk screening tool (TRST) was developed to identify older ED patients who are at risk of revisitation, hospitalization and nursing home admission (174). The original version included five items:

1. History or evidence of cognitive impairment (poor recall or not oriented)
2. Difficulty walking/transferring or recent falls
3. Five or more medications
4. ED visit in previous 30 days or hospitalization in previous 90 days
5. Nurse recommendation (concern for elder abuse/neglect, substance abuse, medication noncompliance, problems meeting instrumental activities of daily living, or other).

The commonly used cut-off value is two or more identified risk factors, i.e., patients with two or more of the five items are at risk of revisitation, hospitalization or nursing home admission. The prognostic accuracy of the TRST has been assessed in numerous reviews. One review reported that it had low sensitivity for hospital admission and revisitation (175) and another review reported modest sensitivity and poor specificity for mortality and hospital admission (176). According to a comprehensive review of geriatric screening tools by Carpenter et al., the TRST was not sufficiently accurate in predicting ED revisitation, hospital admission or any adverse outcome (9).

Idenfication of seniors at risk (ISAR) is a self-report screening tool, which was developed to identify older ED patients who are at increased risk of adverse outcomes such as death or hospital admission (177). It consists of six questions (1 point per each "yes" answer):

1. Before the illness or injury that brought you to the emergency, department, did you need someone to help you on a regular basis?
2. In the last 24 hours, have you needed more help than usual?
3. Have you been hospitalized for one or more nights during the past six months?
4. In general, is your sight good?
5. In general, do you have serious problems with your memory?
6. Do you take six or more medications every day? (107)

The commonly used cut-off value is two points. The ISAR tool was found to have moderate sensitivity for hospital admission and mortality

in one review (178) and poor to fair sensitivity for mortality in another (179). A systematic review by Carpenter et al. reported that ISAR is not sufficiently accurate in predicting ED revisitation, hospital admission or other adverse outcomes (9). However, three studies have recommended the use of ISAR at triage in the GED setting (159,180,181). Given the ambiguity of results, more evidence on ISAR in the ED is required.

The Silver Code is a prognostic tool based on administrative data. It aims to predict hospital admission, mortality and revisitation for older adults. Points are assigned to age, gender, marital status, admission to a day hospital, admission to a regular ward and polypharmacy within the past 3 to 6 months prior the ED visit (182,183). Only two studies assessed the original Silver Code; according to the review by Carpenter et al., the Silver Code lacks sufficient accuracy to predict adverse outcomes (9). Since then, the Silver Code has been expanded to utilize real-time administrative data. The new Dynamic Silver Code has been associated with adverse outcomes in two studies (182,184). More evidence is required in order to establish the accuracy of the Silver Code.

The Acutely Presenting Older Patient (APOP) tool is a new addition to the pool of geriatric screening tools (185). The screening data is similar to the previously introduced tools: age, arrival by ambulance, number of medications, help required bathing or showering, hospital admission in the past 6 months, help required at home and history of dementia. Combined with the MTS, it significantly increased the ability of the MTS to predict 30-day mortality in the mid- to high-acuity triage categories (186). Many studies have suggested using a combination of triage and geriatric screening tools but this is so far the only study to have presented combined results (9,152,161,187). Further combination studies are necessary for evidence-based recommendations.

Although several of the described tools are valid for assessing acuity for older ED patients, accuracy levels remain lower compared to younger adults. There is still a lack of evidence regarding the optimal way to triage and assess older adults in the ED. (187,188)

2.2.6. Access block for older emergency department patients

The ED LOS is defined as the time between arrival to and departure from the ED. It is often higher for older adults (72,78,84). Longer ED LOS has been shown to increase the risk of adverse events such as procedural complications and medication errors during hospital stay (189). Increased ED LOS is also associated with higher mortality (190–193), hospital LOS (194,195) and delirium (196,197). Thus, reducing ED LOS might improve patient safety. It is however not an appropriate measure to be used alone: concentrating on LOS alone might lead to a lack of in diagnostics and care.

Crowding is a loosely defined term that refers to the state of the input-output mismatch in an ED: it refers to a situation when there are insufficient resources - for example personnel or beds - to meet patient demand (198). Simply put, during crowding, the number of patients is larger than the staff can safely and efficiently look after. Not surprisingly, ED crowding has been reported to increase ED LOS. Crowding is also associated with increased hospital LOS and it might increase mortality.

Increased hospital LOS leads to fewer available hospital for new patients. This is called the access block: " a situation where patients are unable to access appropriate hospital beds within a reasonable amount of time [8 hours]" (199). In other words, patients who have been appropriately assessed and treated by the ED staff and require hospital admission stay in the ED, waiting for a place in a hospital ward. Thus, increased hospital LOS leads to increased ED LOS via the access block (200).

As stated earlier, ED visits from the older adult population, and geriatric syndromes along with it, are increasing. Triage for these patients is less accurate, leading to undertriage and therefore by definition, increased ED LOS. Thus, a vicious circle of crowding, ED LOS and hospital LOS is created (**Fig 4**).

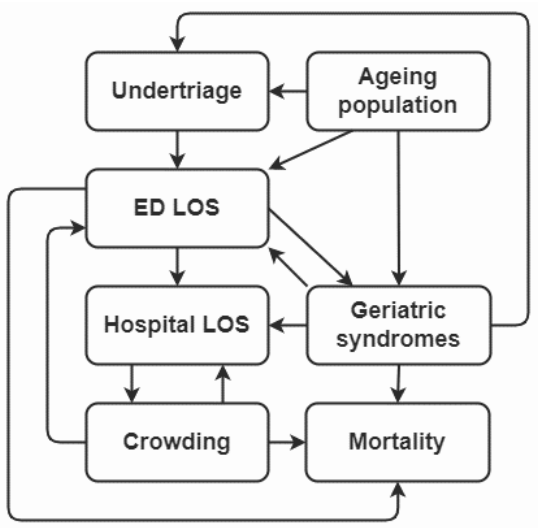

Fig 4 The vicious circle of ED crowding for older adults. Older adults are often undertriaged, which leads to longer ED length of stay. This in turn leads to increased hospital length of stay and crowding, which further increases the waiting times in the ED.

3. AIM OF THE STUDY

The aim of this thesis is to understand the use of different triage and acuity assessment methods for older adults in the ED.

The main objective is to assess the accuracy of the ESI for older adults and to see if it can be improved by age adjustment.

The secondary objectives are to explore whether ED outcomes for frail older adults can be predicted by an early warning score, and to review current knowledge on ED outcomes for older adults presenting with nonspecific complaints.

The study questions are:

I. Is the ESI triage scale accurate in the older adult population in Finland?

II. Does age adjustment improve triage accuracy?

III. Do the NEWS2 or a three-level triage scale predict negative outcomes for frail older adults in the ED?

IV. Are negative outcomes more common for patients presenting with an NSC compared to patients presenting with an SC?

The working hypothesis is that the accuracy of current acuity assessment in predicting ED outcomes for older adults is low.

4. STUDY DESIGN

This study consists of two retrospective (I-II) studies, one prospective (III) observational cohort study and one systematic review and meta-analysis (IV). The cohort studies were based at two Helsinki University Hospital (HUH) EDs - Jorvi and Peijas - and Tampere University Hospital ED. All studies were conducted in accordance with the Declaration of Helsinki statement.

4.1. SETTING

The cohort studies were conducted at three separate EDs. The Peijas ED covers two cities - Vantaa and Kerava – with a total of 250 000 inhabitants. The Jorvi ED is responsible for 320 000 inhabitants in the cities of Espoo, Kauniainen and Kirkkonummi. Both are medium sized ED's with some 60 000 visits per annum. The ED at Tampere University Hospital is large, with an annual census of 100 000 patients. All three EDs treat pediatric patients in a separate process.

The Helsinki University Hospital EDs use a local three-level triage instrument. In the Tampere University Hospital, the ESI has been in use since 2007.

4.2. STUDY POPULATIONS

Adult ED patients (I-II). We obtained data on every ED visit by an adult in the three ED's: Jorvi and Peijas hospitals of Helsinki University Hospital and Acuta at Tampere University Hospital. The visits were recorded between February 1st and 28th 2018. The month of February was selected for data collection due to the local high occurrence both trauma and infections in our climate.

We excluded pediatric patients, patients who were dead on arrival, patients who were not seen by a doctor and patients with scheduled appointments (e.g., at the fracture clinic). Nurse appointments were excluded as these were triaged on a separate track.

Frailty patients (III). This study took place at Jorvi ED of Helsinki University Hospital. The data were collected prospectively in a 6-month period between December 2018 and June 2019. Inclusion criteria for the patients were as follows: current resident in the hospital district, at least 75 years old at the time of visit, and a clinical frailty (CSF) score of at least four.

Nonspecific complaint patients (IV). This review included patient populations from eligible studies of acceptable quality. The criteria for study inclusion were as follows: published within the past 20 years (as of 2019), adult population (minimum age 18), and nonspecific complaint presentation to the ED or EMS.

4.3. OUTCOME VARIABLES

The primary outcome measure in studies I-II was 3-day mortality. The secondary outcomes were 30-day mortality, hospital and HDU/ICU admission, and ED LOS.

For study III, the primary outcome III was 30-day mortality and the secondary outcomes were hospital and HDU/ICU admission, revisits at 3 and 30 days, and ED LOS.

For the systematic review (study IV), the primary outcome measure was in-hospital mortality. The secondary outcomes were triage category, ED LOS, hospital admission, hospital length of stay, ICU admission, resource consumption, and re-visitation rates with follow-up time.

4.4. DATA COLLECTION

4.4.1. Register studies (I-II)

We performed database searches for the electronic health records (EHR) of all three included ED's. The following data were collected: date of birth, gender, time and date of arrival, time and date of departure, date of death (if within 30 days from visit), triage category, hospital, and HDU/ICU admission.

Death within three and thirty days was recorded as an event if the date of death was less than three or thirty days from the date of arrival, respectively. Hospital admission was recorded as an event if the patient was admitted to any ward. HDU and ICU admissions were pooled into one variable. The patient's age at the time of the visit was calculated as the difference between the date of arrival and the date of birth. ED LOS was calculated as the difference between time of departure and time of arrival.

For study I, we analysed the Tampere University data only. The analysis was stratified by age group: 18-64 years and ≥ 65 years.

For study II, we analysed both the Helsinki University Hospital and the Tampere University Hospital data. The analysis was run for both the standard ESI triage method and our local three-level HUH-method. Age was adjusted by moving every patient at or above a predefined cut-off age into a more urgent triage category. We used cut-off values of 65, 70, 75 and 80 years.

4.4.2. The frailty trial (III)

This study was a secondary analysis using the data originally collected for a clinical trial (201). During the study period, the ED secretary allocated an individual code to each eligible patient as part of the admittance process. For each patient, a study form with the code was delivered to the appointed nurse. The nurse then filled in the form as follows: first they assessed the patient's frailty using the clinical frailty scale (CFS) of Rockwood et al (104). If the CFS score was less than

four, the patient was excluded from the study. If the CFS score was at least four, the nurse recorded the patient's NEWS2 score, co-morbidities and social background on the study form.

We then collected additional data from the EHRs regarding the eligible patients. For each eligible patient, we recorded date of birth, gender, time and date of arrival, time and date of departure, date of death (if within 30 days from visit), triage category, hospital admission and HDU/ICU admission.

4.4.3. Systematic review (IV)

The study protocol was created as follows: we selected a twenty-years search period due to rapid development of emergency medicine in the recent past decades. We searched for publications, abstracts, and conference presentations on the topic, in English. To be included, the study population was required to include patients aged at least 18, who presented with a nonspecific complaint to the EMS and ED. The study protocol was submitted to Prospero, and it was published with the ID CRD42019123552 (202).

The first literature search was conducted on the 29th January 2019 in the following databases: Ovid, Scopus and Web of Science, including Web of Science conference proceedings. A librarian from Terkko Health Hub collaborated in the literature search (203). Records with any of the search terms presented in Table 1 in conjunction with either "emergency department" or "emergency medical services", were saved in the search results.

The first search result provided 2020 records, which were saved to the Mendeley reference manager. The records were screened by two independent researchers. At this point, further search terms were discovered, and two additional searches within the aforementioned databases were run on the 13th February and 7th July 2019. These two additional searches resulted in further 76 and 542 records, respectively. Any duplicates were removed, leaving us with 2226 records. Three studies without any abstracts or full text were included in the search results, and we requested these studies from their authors directly.

Table 1: Database search terms for nonspecific complaint review

Nonspecific complaint	Lethargy
Weakness	Failure to thrive
Decreased general condition	Home care impossible
General disability	Acopia
Off the legs	Anorexia
Not coping	Decreased mobility

Two independent authors screened the 2226 records for eligibility, resulting in 100 abstracts. There were 88 abstracts that failed to meet the inclusion criteria in the secondary assessment. The researchers assessed the twelve remaining studies for bias using the criteria of the Scottish Intercollegiate Network for cohort studies (204). A further six studies were excluded due to low methodological quality; among these there were two studies that the researchers disagreed on. These disagreements were resolved by a third assessor, resulting in exclusion.

The references and citations of the six remaining included studies were screened for their eligibility, resulting in 366 further articles. The two independent researchers judged three of these cited studies as eligible. In total, 2057 records were screened, resulting in nine eligible studies.

Data from the included studies were extracted and saved to a summary table in Excel. The extracted data consisted of study characteristics and outcomes. The recorded study characteristics were study setting, study location, median age, inclusion criteria, gender distribution, presenting complaint, and number of participants presenting with an NSC and an SC.

We used the PRISMA checklist to assess the quality of our methodology (205). The certainty of evidence was assessed by three researchers using the GRADE (206).

4.5. DATA ANALYSES

Data for the observational studies were analyzed with the Statistical Package for the Social Sciences (207) program. Personal identifying information was omitted before statistical analysis. A statistician participated in the process.

For study I, we tested binary outcomes with an AUROC analysis for both age groups. ED LOS was described using medians and IQRs. Test sensitivity was analyzed with Medcalc (208). For the test sensitivity analysis, patients were divided into high- (ESI 1-2) and medium-to-low- (ESI 3-5) acuity for 3-day mortality and HDU/ICU admission. Hospital admission and 30-day mortality were analyzed between high-to-medium (ESI 1-3) and low (ESI 4-5) acuity groups. Both admitted and discharged patients were included in the mortality analysis. Sensitivity, specificity, and positive and negative predictive values were calculated for the outcomes.

In study II, we used an AUROC analysis for all our outcomes. The analysis was run for both triage methods with and without age adjustment. Age adjustment was done by increasing triage category to more urgent by one level for all patients above a cut-off age. The cut-off values were 65, 70,75 and 80 years. We calculated the net reclassification improvement (NRI) values in order to demonstrate the effect of age adjustment. P-values were adjusted with Bonferroni correction.

In study III, parametric data was analysed with an AUROC analysis and continuous data by using the ANOVA. We tested the data for each outcome by both the NEWS2 and triage category. For clearer presentation of the data, the NEWS2s were grouped into low (0–4), moderate (5-6) and high (≥7) categories, in keeping with the Royal College of Physicians guideline (65).

In the systematic review (study IV), statistical analyses were conducted using R version 3.5.2 and the meta-analysis was carried out using the metaphor package. We performed meta-analysis using random-effects model to calculate pooled odds ratios (OR) and confidence intervals

(CI). Where data were insufficient for meta-analysis, we gave a written description of the results.

4.6. ETHICAL CONSIDERATIONS

Adult ED patients (I-II). We obtained permission from the ethical board of the Helsinki University (permission number HUS/2678/2017), Helsinki University Hospital (HUS/280/2019) and Tampere University Hospital (RI8602).

Frailty study (III). This study was registered in the context of the GAOPS trial (registration NCT03783234 at clinicaltrials.gov(209)). The study was granted permission by the ethical board of the Helsinki University and Helsinki University Hospital (statement number HUS/1171/2018) and Helsinki University Hospital (permission number HUS/278/2018).

NSC systematic review (IV). The review study only utilised previously published, de-identified data from peer-reviewed studies. An ethical board review was not required.

5. RESULTS

5.1. ACCURACY OF EMERGENCY SEVERITY INDEX IN OLDER ADULTS (I)

A total of 5901 visits were screened for inclusion to the study. After excluding 36 visits of patients who were dead on arrival and 354 visits of patients who were not assessed according to the ESI, we included 5511 visits for analysis.

The median age was 59 years (ranging from 18 to 104). There were 3141 visits by younger adults (ages between 18 and 64; median 41 years) and 2370 by older adults (at least 65 years; median age 78). Of <65-year-old patients, 1506 (47.9%) were male and of the patients aged at least 65, 1052 were male (44.4%). Distribution of patients across triage categories is presented in **Fig 5**.

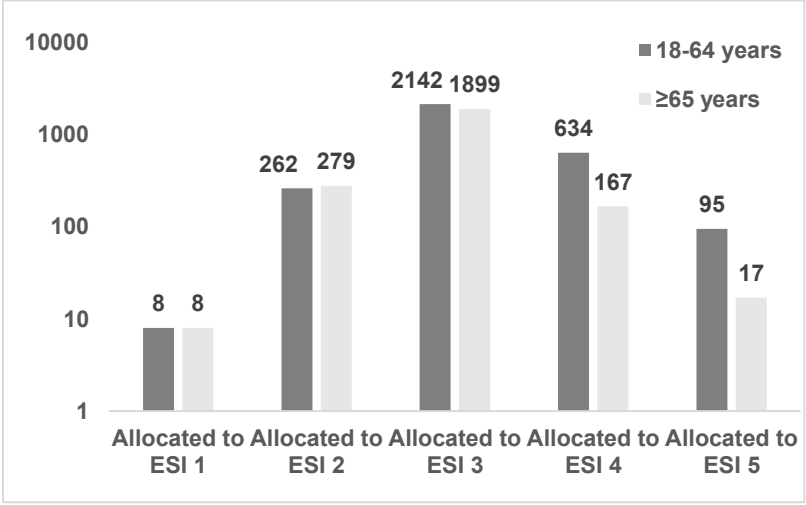

Fig 5 Number of patients allocated to ESI triage categories in study I. More patients are triaged to category 3 than to all other categories combined.

Mortality. The overall 3-day mortality was 26/5511 (0.5%) and 30-day mortality was 150/5511 (2.7%). Six patients died in the ED and were omitted from admission analysis.

In the younger adult group, there were few deaths within three days (6/3141; 0.2%), which resulted in a non-meaningful result for 3-day mortality (AUC 0.61 [95% CI 0.28-0.94]; p= 0.373) (**Fig 6**). The 30-day mortality for younger adults was 31/3141 (1.0%), and the ESI predicted this modestly (AUC 0.69 [95% CI 0.58-0.81]; (p<0.001).

With the cut-off at ESI 2, sensitivity and specificity for 3-day mortality were 65.4% (95% CI 44.3-82.8%) and 90.2% (95% CI 89.3-90.9%), respectively. For 3-day mortality, NPV and PPV were 99.8% (95% CI 99.7-99.9%) and 3.1% (95% CI 2.3-4.0%) for all adults, respectively.

For the older adults, 3- and 30-day mortality rates were 20/2370 (0.8%) and 119/2380 (5.0%), respectively. The ESI predicted 3-day mortality for the older adults well (AUC 0.82 [95% CI 0.70-0.93]; p<0.001) (**Fig 6**). The 30-day mortality prediction for older adults was modest (AUC 0.65 [95% CI 0.60-0.71]; (p<0.001).

With the cut-off set at ESI3, sensitivity and specificity for 30-day mortality for all adult patients were 97.3% [95% CI 93.3-99.3%] and 17.0% [95% CI 16.0-18.0%], respectively. NPV was 99.6% [95% CI 98.9-99.8%] and PPV 3.2% [95% CI 3.1-3.3%].

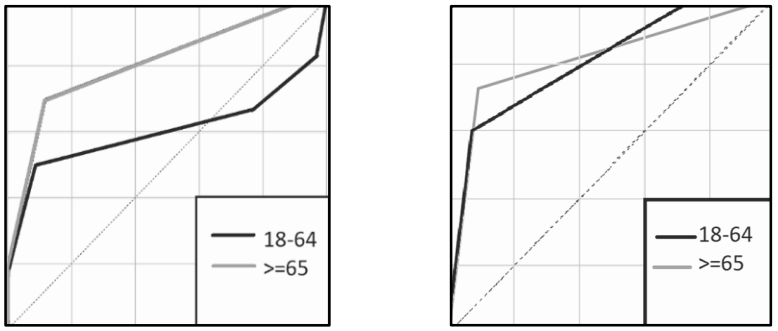

Fig 6 AUC for 3-day mortality for the older adults (left) and for HDU/ICU admission prediction (right).

Hospital admission. Of all patients, 2274/5505[2] (41.2%) were admitted to hospital. Admission rates were 89/3140 (2.8%) and 1412/2364 (59.6%) for younger and older adults, respectively.

Hospital admission prediction with the ESI was modest in both age groups. AUC for the younger adult group was 0.67 [95% CI 0.65-0.69] ($p<0.001$) and for the older adult group 0.63 [95% CI 0.61-0.65] ($p<0.001$).

With the cut-off value of ESI3, sensitivity and specificity for hospital admission for all adult patients were 95.9% [95% CI 95.1-96.7%] and 25.4% [95% CI 23.9-26.9%], respectively. NPV was 89.9% [95% CI 87.9%-91.7%] and PPV 47.5% [95% CI 46.9-48.0%].

HDU/ICU admission. Admission rate for and HDU or ICU facility for all patients was 190/5500 [3] (3.4%). HDU/ICU admission rates for the younger and older adults were 89/3140 (2.8%) and 101/2360 (4.3%), respectively.

ESI predicted HDU/ICU admissions well in both age groups (**Fig 6**). HDU/ICU admission prediction AUC was 0.82 [95% CI 0.77-0.87] ($p<0.001$) for the younger adults and 0.82 [95% CI 0.77-0.87] ($p<0.001$) for the older adults.

With the cut-off value of ESI2, sensitivity and specificity for HDU/ICU admission for all adult patients were 67.9% [95% CI 60.1-74.5%] and 92.1% [95% CI 91.3-92.8%], respectively. NPV was 98.8% [95% CI 98.5 - 99.0%] and PPV 23.5% [95% CI 21.2-26.0%].

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[2] Six patients died in the ED and were omitted from admission analysis.

[3] HDU/ICU admission data missing for one patient in the younger adult group and four patients in the older adult group

ED LOS. The median ED LOS for all adults was 240 min (IQR 156-349). In the younger adult group, the median ED LOS was 208 min (IQR 129-308) and in the older adult group, 281 min (IQR 197-395).

ED LOS varied without linearity in both groups. ED LOS was shortest in ESI categories 1 and 5 and longest in category 3 (**Fig 7**).

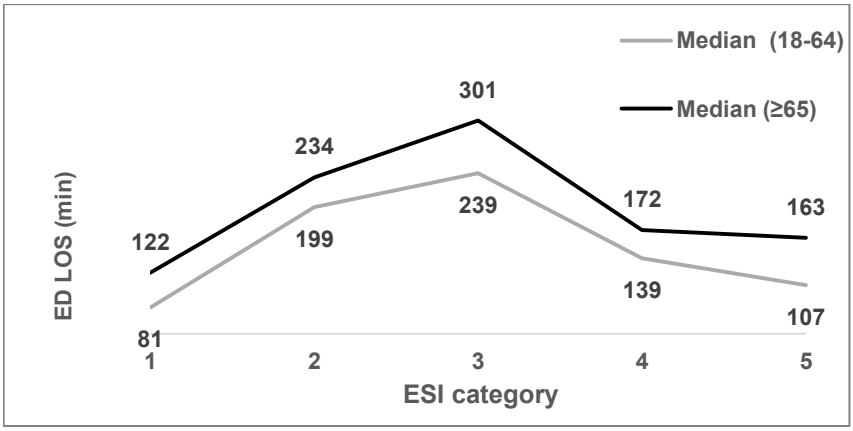

Fig 7 ED length of stay in each ESI category. ED LOS was longest in category 3 for both age groups.

5.2. EFFECT OF AGE ADJUSTMENT ON TWO TRIAGE METHODS (II)

There were 15 206 visits to the three ED's within the study period. We excluded patients who were dead on arrival, not seen by a doctor or who had a scheduled appointment for the ED outpatient fracture clinic, which left us with 13376 visits for analysis. Slightly over half of the patients were female (7120, 53.2%) and the median age was 57. Distribution of patients in our three EDs was as follows: HUH Jorvi ED 3902 (29.2%), HUH Peijas ED 3962 (29.6%) and Tays Acuta ED

5512 (41.2%). Thus, 41.2% of patients were triaged by the ESI and 58.8% were triaged by the three-level HUH method. Patient distribution across triage categories is presented in **Fig 8**.

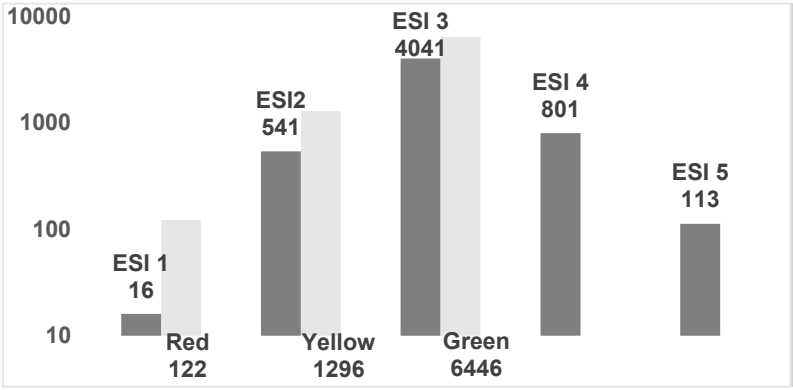

Fig 8 Number of patients in each triage category. Most patients were triaged to the standard urgency category (ESI 3 or Green).

Mortality. The overall 3-day mortality was 0.3% (40/13376). Both the standard HUH triage and ESI predicted 3-day mortality well (AUC 0.77 [95%CI 0.65-0.88]; p<0.001, and AUC 0.72 [95%CI0.57-0.87]; p<0.001, respectively). Accuracy for neither method was improved by age adjustment at any cut-off age in the ROC-curve analysis (**Fig 9** and **Fig 10**).

In the NRI -analysis, age adjustment at the cut-off age of 80 years improved the predictive value for ESI; 56% of patients who died and 19% of survivors were retriaged to a higher category, leading to an NRI of 0.37. Adjustment by any other cut-off age did not improve the NRI for either triage method (**Fig 11** and **Fig 12**).

The overall 30-day mortality was 2.2% (300/13376). Both triage methods predicted 30-day mortality modestly (AUC 0.64 [95% CI 0.59-0.69]; p<0.001 for HUH and AUC 0.69 [95%CI 0.64-0.73]; p<0.001 for the ESI). Both methods were improved with age adjustment in both ROC-curve and NRI -analyses.

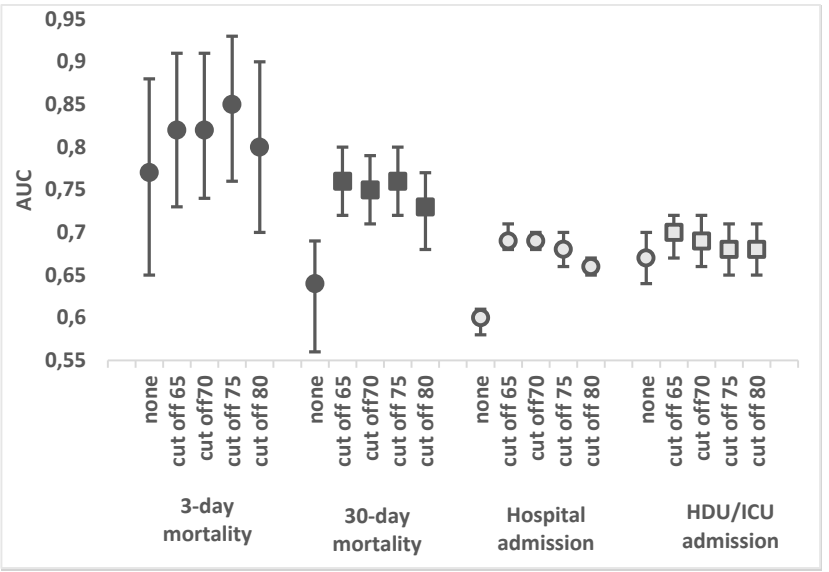

Fig 9 Effect of age adjustment for HUH triage. Age adjustment improved 30-day mortality and hospital admission prediction.

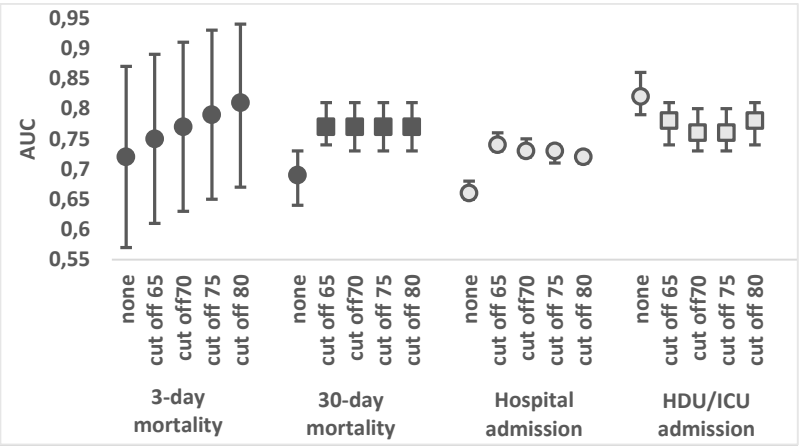

Fig 10 Effect of age adjustment on the ESI. Age adjustment improved 30-day mortality and hospital admission prediction.

In the NRI analysis, 40 to 68% of patients who died were correctly retriaged and 15 to 36% of survivors were incorrectly retriaged to a higher triage category. NRI ranged from 0.25 to 0.32 ($p<0.001$) for HUH triage. For the ESI, 49-75% of patients who died were correctly retriaged and 18-42% of survivors were incorrectly retriaged into a

higher category, leading to an NRI range of 0.31 to 0.33 (p<0.001). There was no significant difference between cut-off ages.

Hospital admission. Overall hospital admission rate was 33.5% (4487/13305). HUH triage was poor (AUC 0.60 [95%CI0.68-0.71]; p<0.001) and the ESI modest (AUC 0.66 [95% CI 0.65-0.68]; p<0.001) in predicting hospital admission (**Fig 9** and **Fig 10**). Age adjustment improved the performance of the ESI to a moderate level and HUH triage to a modest level. There was no significant difference between cut-off ages in ROC-curve or NRI-analyses.

Age adjustment improved triage accuracy for both methods in the NRI-analysis, with all cut-off ages. For the adjusted HUH method, 28 to 56% of admitted patients were correctly and 10 to 29% of discharged patients were incorrectly retriaged into a higher triage category, leading to an NRI of 0.18-0.27 (p<0.001). ESI performed similarly: 31 to 62% of admitted patients were correctly and 10 to 29% of discharged patients were incorrectly retriaged to a higher triage category (**Fig 11** and **Fig 12**).

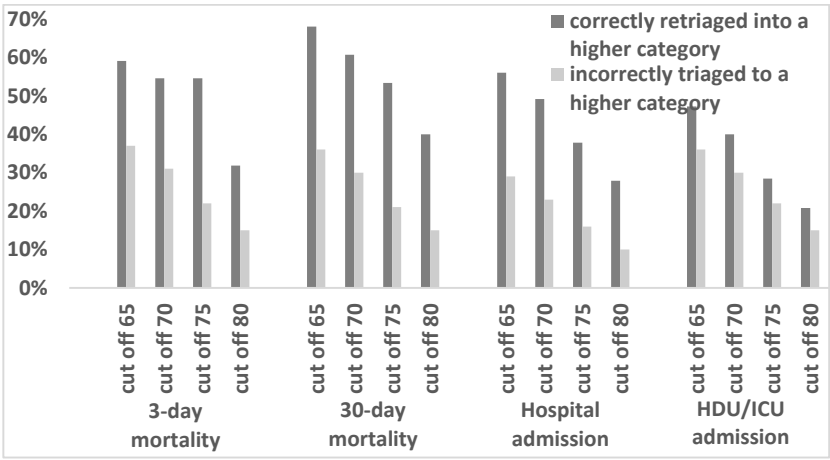

Fig 11 NRI for the age adjusted HUH triage method. Age adjustment improved 30-day mortality and hospital admission prediction.

HDU/ICU admission. The overall HDU/ICU admission rate was 5.0% (675/13361). HUH triage predicted HDU/ICU admission

modestly (AUC 0.67 [95%CI0.64-0.70]; <p.0.001) and the ESI well (AUC 0.82 [95% CI 0.79-0.86]; p<0.001) (**Fig 9** and **Fig 10**). In ROC-curve and NRI analyses age adjustment did not improve the performance of both triage methods (**Fig 11** and **Fig 12**).

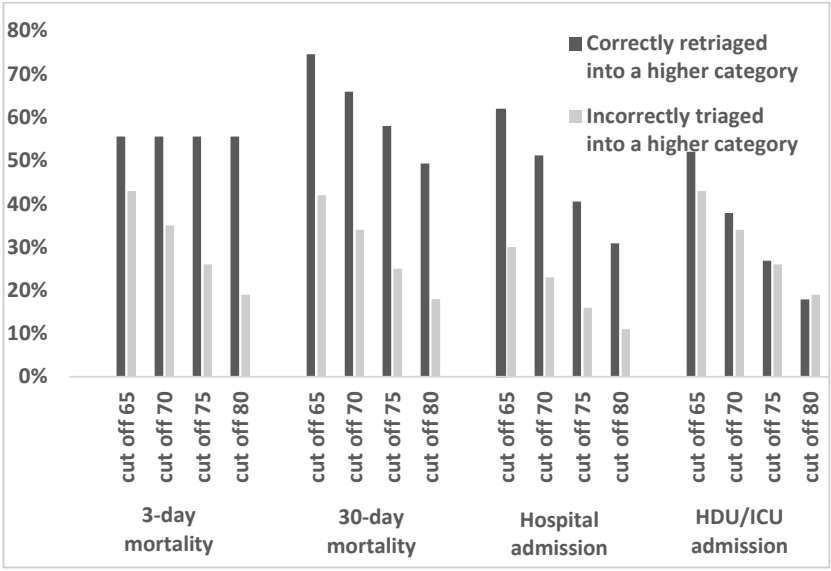

Fig 12 NRI for the age adjusted ESI. Age adjustment improved 30-day mortality and hospital admission prediction.

5.3. THE NATIONAL EARLY WARNING SCORE 2 (NEWS2) AND THREE-LEVEL TRIAGE SCALE AS RISK PREDICTORS IN FRAIL OLDER ADULTS IN THE EMERGENCY DEPARTMENT (III)

We screened 4549 patient visits, of which 4356 met our study criteria. Of these eligible patients, the nursing staff filled CFS (clinical frailty scale) assessment forms for 2388 (55%), of which nine were excluded due to being incorrectly filled. The CFS score was at least four on 1711/2379 (72%) of the forms. Follow-up data from the EHRs were available for all included visits.

Of the included patients, 664 (39%) were male. Both the mean and median age were 85 years. The median CFS score was six. The median NEWS2 was one. Regarding triage categorization, 69 (4.0%) patients were triaged as red, 356 (20.8%) as yellow and 1278 (74.7%) as green. The data were missing for eight visits.

Mortality. 30-day mortality was 96 deaths (5.6%). The NEWS2 correlated positively with 30-day mortality (AUC 0.70 [95% CI 0.64-0.76]; p<0.001) in the frail older adult population (**Fig 13**). There was a poor but statistically significant difference in mortality between triage groups (AUC 0.62 [95%CI 0.56-0.68]; p<0.001). 30-day mortality was 23.2% in the red triage group, 7.6% in the yellow group and 4.1% in the green group.

Hospital admission. Hospital admission rate was 64.4% (1103/1711). Patients who had a higher NEWS2 were more likely to be admitted (AUC 0.62 [95% CI 0.60-0.65]; p<0.001), although the accuracy was low. Almost all (97.7%) patients with a NEWS2 of at least eight were admitted to hospital. Most (80.4%) patients with a NEWS2 score between four and seven were admitted. Over half (58.3%) of patients who had a NEWS2 of three or lower were admitted.

Patients in the more urgent triage categories were more likely to be admitted to hospital (AUC 0.55 [95%CI 0.52-0.56]; p<0.001); the predictive capacity of triage category was only just significant. Admission rates were 94.2%, 68.5% and 61.8% for the red, yellow and green triage groups, respectively.

HDU/ICU admissions. HDU admission rate was 2.8%; there were no ICU admissions. Patients with a higher NEWS2 were more likely to be admitted to an HDU (AUC 0.72 [95% CI 0.61-0.83]; p<0.001) (**Fig 13**). Patients in more urgent triage categories were more likely to be admitted to an HDU bed (AUC 0.80 [95% CI 0.70-0.90]; p<0.001). HDU admission rates were 28.6%, 2.1% and 1.0% in the red, yellow, and green triage groups, respectively.

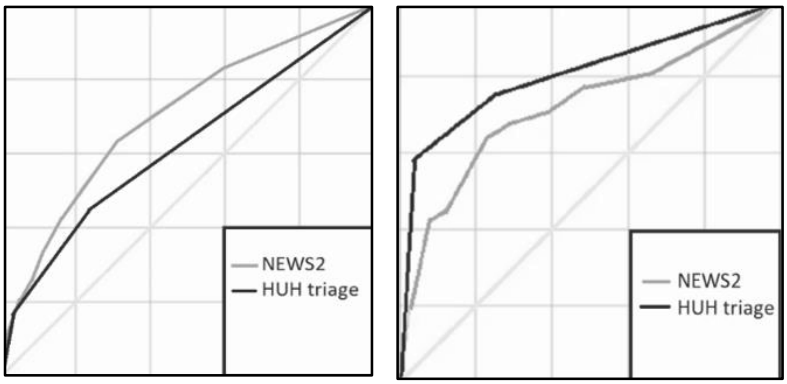

Fig 13 AUC for 30-day mortality prediction (left) and HDU/ICU admission (right) for frail older adults. The NEWS2 and HUH triage categories were predictors for HDU/ICU admission.

ED LOS. The mean and median ED LOSs were 8.6 h and 6.2 h, respectively. There was a significant difference in ED LOS between the red and yellow triage groups ($p<0.001$) but not between the yellow and green groups ($p=0.59$). Mean ED LOSs were 4.8 h, 8.45 h and 8.8 h for the red, yellow and green groups, respectively.

The grouped NEWS2 was not associated with ED LOS ($p=0.095$). Mean ED LOSs were 7.48 h, 8.61 h and 8.67 h for the high, moderate, and low groups, respectively.

Revisitation. Revisitation rate was 24%, of which 2.8% of revisits occurred within three days and 20.5% within 30 days. The NEWS2 was not associated with revisitation at either thirty or three days (AUC 0.47; [95%CI 0.44-0.51]; $p=0.13$. AUC 0.48 [95% CI 0.40-0.56]; $p=0.61$, respectively). Triage score was not associated with revisitation at thirty or three days either (AUC 0.49 [95% CI 0.46–0.52]; $p = 0.57$ and AUC 0.48 [95% CI 0.40–0.56]; $p = 0.63$, respectively).

5.4. NONSPECIFIC COMPLAINTS IN THE EMERGENCY DEPARTMENT – A SYSTEMATIC REVIEW (IV)

Screening resulted in nine eligible studies that were of acceptable quality, there were no high-quality studies. All included studies were observational: five of them retrospective and four prospective. Each of the included studies took place in an ED setting, and no prehospital studies were included. The included studies had a very low percentage of patients lost to follow-up. Blinding was not possible due to the observational nature of the studies. Characteristics of the included studies are presented in Table 2 (page 55).

The study populations were heterogenous; five studies included only older adult patients, and four included all adults. Three of the included studies included non-surgical patients only, and six included all adult patients. All included studies showed that patients presenting with nonspecific complaints were mostly older adults. The prevalence of nonspecific complaints in the older adult population ranged from 6 to 14%; in the adult population it ranged from 1 to 2%.

Mortality. Four studies reported in-hospital mortality, which ranged from 7.3 to 15.6% (124,127,210,211). A fifth study with very few admissions, reported in-hospital mortality of 36.4% (212). These five studies were significantly heterogeneous ($p < 0.001$), which is most likely due to population differences, as well as inconsistent ($I^2 = 91\%$). In-hospital mortality was significantly higher for NSC patients compared to SC patients, and the summary odds ratio was 2.50 (95% CI 1.40–4.47) (**Fig 14**). The certainty of evidence for in-hospital mortality was high according to GRADE.

In addition, one study reported increased 30-day mortality for NSC patients (20.1%) compared to SC patients (11.0%) (HR 1.7 [95% CI 1.2-2.4]) (211). Another study reported increased 10-year mortality for NSC patients (213).

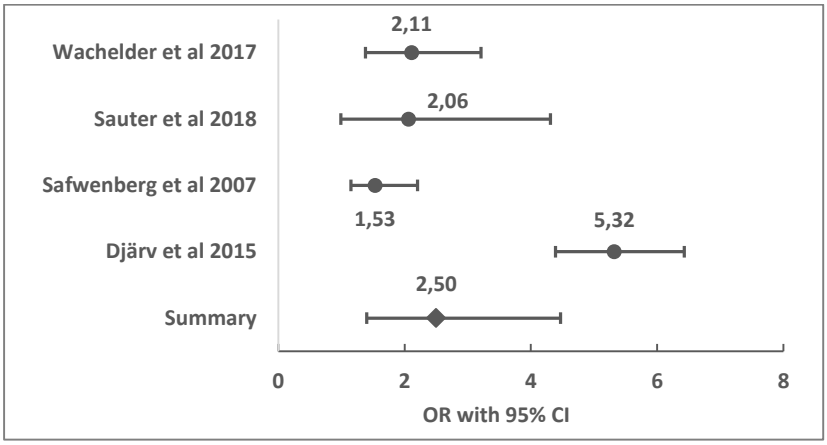

Fig 14 Comparison of in-hospital mortality between patients presenting with nonspecific complaints and specific complaints.

Hospital admission. Five studies reported high admission rates (55-84%) (124,127,130,211,214) for NSC patients and one study reported a low admission rate (2.3%)(212). Four studies included comparison groups and were included in the meta-analysis. The studies were heterogenous ($p<0.0001$) and inconsistent ($I^2 = 99\%$). Hospital admission rates were higher for NSC patients in comparison to SC patients (summary OR 3.86 [95% CI 1.76-8.47]) (**Fig 15**). The certainty of evidence for hospital admission was moderate according to GRADE.

In addition, one study reported that hospital admissions were increased for NSC patients (OR 2.00 [95%CI 1.42-2.83]), but it did not report exact figures for events and this was not included in the meta-analysis (215).

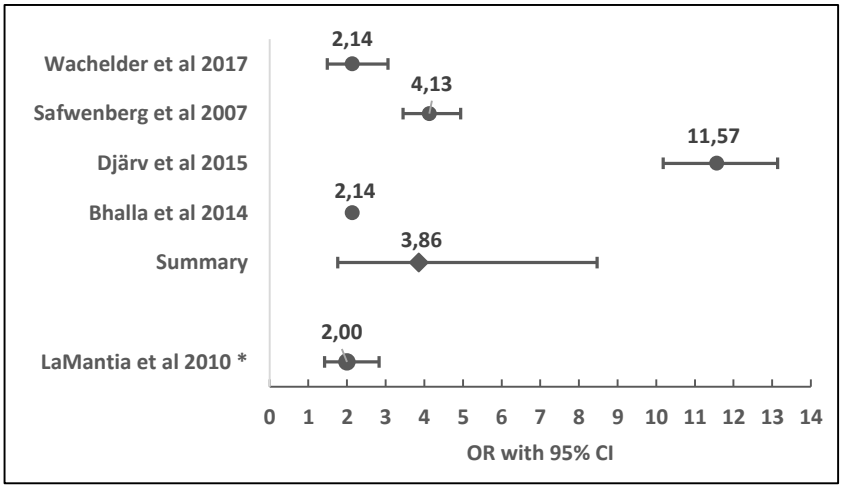

Fig 15 Comparison of hospital admission for patients presenting with nonspecific complaints and specific complaints.
*Not included in summary OR

HDU/ICU admission. Two studies reported ICU admission rates ranging from 2.5 to 3.8%. Neither reported a significant increase in ICU admission rates compared to SC patient groups (3.8% [95%CI 2.4-6.1] vs. 3.5 [95% CI 2.9-4.3] and 2.5 vs 2.9%, p=0.67). (124,130)

ED LOS. Three studies reported ED LOS. Two of these studies found a significantly increased ED LOS for NSC patients compared to SC patients(124,130). One of these reported a 50-minute increase in ED LOS (249.4 [95% CI 240.3–258.4] vs 299.6 min [95% CI 279.4–319.7]; $p < 0.0001$) and another reported a median increase of 10 minutes (178 [IQR 6–970] vs 188 minutes [IQR 23–421]; $p = 0.004$). The third study reported no difference between the groups (median ED LOS 6.27 h [IQR 3.11] vs 6.09 h [IQR 3.26]; p = 0,497) (210). The certainty of evidence for ED LOS was low according to GRADE.

Triage. Three studies reported differences in triage categories between NSC and SC patients (124,127,210). The studies were significantly heterogenous ($p<0.001$) and inconsistent (I^2 = 92%). Patients presenting with an SC were more likely to be triaged as more urgent than patients with an NSC (summary OR 2.12 [95% CI 1.08-4.16]) (**Fig 16**). According to GRADE, the certainty of evidence for triage was moderate.

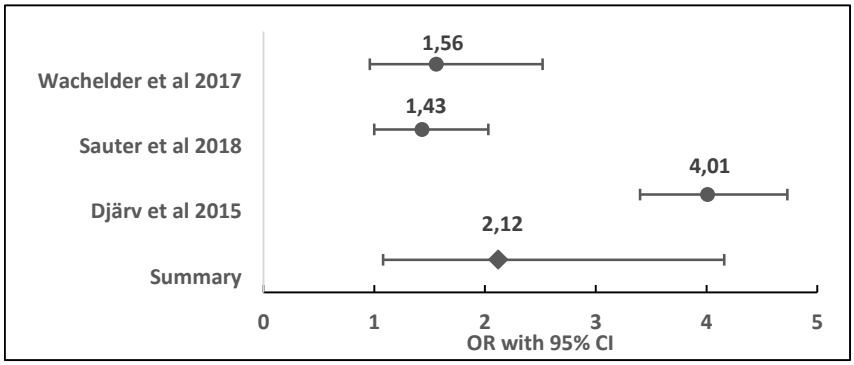

Fig 16 Patients presenting with nonspecific complaints were less often triaged as urgent in comparison to patients presenting with specific complaints.

Hospital LOS. Four studies reported hospital LOS for NSC patients ranging from five to nine days (212,213). Two of these studies reported increased median hospital LOS for NSC compared to SC patients; one reported 1.3 days (6.5 ([IQR 5.6] vs 5.2 [IQR 5.9] days; p<0.005) and another one of these reported three days (9 [IQR 4-15] vs. 6 [IQR 2-12] days) (124,210). The certainty of evidence for hospital LOS was low.

Resource consumption. Two studies reported on outcomes regarding ED resource consumption. One of these reported a significant increase in the number of diagnostic tests for NSC patients compared to SC patients (7.7 [95% CI 7.3-8.1] vs 6.0 [95% CI 5.7-6.2]; p<0.0001). The other study did not find a similar difference between the groups (mean 3.3 [SD 1.7] vs 3.1 [SD 1.8]; p=0.1). The first study reported an increased number of required procedures in NSC patients (73.3% [95% CI 69.5 -76.8] vs 63.9% [95% CI 62.7-66.1]; p<0.0001) and the other reported a decreased need for more than one consultation (19/244 [7.8%] vs 217/1540 [14.1%]; p=0.03). (124,130)

Revisitation. One study reported an increase in re-attendances for NSC patients at 30 days (OR 1.57 [95%CI 1.06-2.3]; p<0.03) and one reported a decrease at 90 days (57/244 [23.4%] vs 435/1540 [28.5%]; HR 0.8 [0.5-1.1]). (124,215)

Table 2 Characteristics of studies included in the nonspecific complaint review

Article	Study type	Presenting complaint	Population	NSC group	Control group	Total	Prevalence of NSC	Reported outcomes
Bhalla et al. 2019 (130)	Cross-sectional cohort	Generalized weakness or tiredness and exhaustion (NHAMCS)	Age ≥ 65. All ED visits	n≈5 400 000 (6.4%)	n≈ 79 000 000 (93.6%)	n=85 000 000	1% of all adults; 6.40% of older adults (age ≥65)	ED LOS; Hospital admission; ICU admissions; Resource consumption;
Djärv et al. 2015 (127)	Retrospective cohort	Decreased general condition (Adapt criteria)	Age ≥ 18. All ED visits	n=1182. 54% female. 83% ≥65 years	n=20775; 52% female; 53% ≥65 years	n=21957	1714/89554; 1.9% of all adults	In-hospital mortality; Triage category; Hospital admission;
Lamantia et al. 2010 (14)	Retrospective cohort	Generalized weakness (NHAMCS).	Age ≥ 75. All ED visits	n/a	n/a	n=3188; 60.8% female; Median age 82	n/a	Hospital admission; Revisitation;
Quinn et al. 2015 (212)	Retrospective cohort	NSC (as Nemec et al.)	Age ≥ 70. All ED visits	n=478. 54.8% female. Mean age 81.9	n/a	n/a	n/a	In-hospital mortality; Hospital admission; Hospital LOS;
Safwenberg et al. 2007 and 2008 (211,213)	Prospective cohort	General disability (as Djärv et al.)	Age ≥ 18. Non-surgical ED patients	n=719. Median age 82	n/a	n=12 995. 51.5% female. Median age 66	5.5% of adult non-surgical	In-hospital mortality; 30-day mortality; 10-year mortality; Hospital admission; Hospital LOS;
Sauter et al. 2018 (210)	Prospective observational	NSC (as Nemec et al.)	Age ≥ 18. Admitted to medical ward from ED	n=165. 47.9% female. median age 71	n=546. 44.5% female. Median age 69	n=711	n/a	Triage category; ED LOS; Hospital LOS;
Wachelder et al. 2017 (124)	Prospective observational	NSC (Definition not specific)	Age ≥ 65. Medical patients in the ED	n=244. 50.4% female. Mean age 77.6	n=1540. 54.4% female. Mean age 77.5		244/2381 (9%) of adult medical patients; 244/1883 (14%) of older medical patients	In-hospital mortality; Triage category; ED LOS; Hospital admission; Hospital LOS; ICU admissions; Revisitation; Resource consumption;
Vilpert 2018 (214)	Retrospective cohort	Home care impossible / Failure to thrive (Lausanne triage and priority scale)	Age ≥ 65. ED visits excluding nursing home residents	n≈3761 (9.6%)	n/a	39 178. 54.6% female. Mean age 78.5	9.6% of older community-dwelling adults	

6. DISCUSSION

6.1. MAIN RESULTS

According to our results the ESI is adequately accurate in predicting outcomes for the older ED patients. The local three-level triage scale predicted 3-day mortality but was otherwise inferior in predicting outcomes in comparison to the ESI. Age adjustment improved the accuracy for both triage methods. The NEWS2 was not sufficient alone in predicting ED outcomes for the frail older adults.

Patients presenting to the ED with NSCs had higher mortality and hospital admission rates in comparison to patients presenting with SCs. Yet, they were less often triaged in the more urgent categories. In other words, NSC patients were more often undertriaged.

6.2. ACCURACY OF EMERGENCY SEVERITY INDEX AND HUH TRIAGE METHODS (I-II)

The ESI predicted 3-day mortality and HDU/ICU admission well in the general adult population. It predicted hospital admission and 30-day mortality poorly. This reflects the primary purpose of triage – to recognize critically ill patients who are at risk of short-term mortality and require a high level of care.

Our results regarding HDU/ICU admissions are in keeping with previous studies (2). Two reviews from 2019 discussed the association between triage level and mortality; one found very low reported ED mortality rates and the group was unable to perform a meta-analysis. Although the outcome in our study was 3-day mortality, the finding regarding the non-elderly was similar – 3-day mortality rate was very low and led to a non-meaningful result (2). The other review reported high accuracy regarding ED mortality; however, the results regarding the ESI were from a single study (86). No studies reported on 30-day mortality for comparison.

Previous studies have reported highly variable results regarding hospitalization (2,3). It is therefore only slightly surprising that the ESI was not able to predict hospital admission well in this study. This might be due to the selected cut-off point at medium acuity – ESI 3. With a cut-off level of ESI 2, higher specificity could probably have been achieved. The reason for selecting a lower cut-off level was, however, to specifically assess level 3, which is perhaps the most difficult triage category. Patients in levels 1 and 2 are, by definition, obviously critically unwell, and there are many guidelines and algorithms to guide the diagnostics and treatment of these

patients. At the other end of the scale, patients in categories 4 and 5 are often straightforward: the patients are usually ambulatory and present with a single, non-threatening complaint. It is category 3 that requires most vigilance – due to undertriage, critically ill patients can sometimes be found waiting amongst less urgent patients. ESI 3 also by far the most common triage category; in our study 73% patients were triaged in this category. This category, therefore, warrants particular attention.

The ESI was not associated with LOS in our population. Previous findings have been ambiguous; ED LOS has been reported to be longest in category 1 (216) and 2 (30,45,217). Two studies reported similar findings to our study, showing ED LOS was longest in category 3 (19,218). Patients in the higher triage categories are seen more quickly than patients in category 3; they also require beds from a separate pool, and the availability of HDU/ICU beds does not depend on the availability of level 1 beds (ward-based care). The ED LOS shortens again in categories 4 and 5, even if they are allowed a longer time to be seen by a doctor. Admission levels in categories 4 and 5 are again lower. Thus, it can be argued, that the failure of the ESI to predict ED LOS does not reflect the time that is required to assess and treat patients. It might in fact reflect the availability of hospital beds (access block) and the resourcing of the ED, i.e., the adequate number of staff to assess each patient within the given time frame.

The HUH triage method predicted 3-day mortality well, at a similar rate to the ESI. It predicted 30-day mortality, hospital admission and HDU/ICU admission poorly and was inferior to the ESI in its predictive capacity for these outcomes. These findings are in keeping with previous studies, where the majority described superiority of five-level triage tools when compared to three-level triage methods (2).

Our results imply that the ESI performed adequately in the Finnish population. The HUH triage method, while able to predict outcomes, performed inferiorly. There is a need for national guidelines regarding acuity assessment. Based on our results, the ESI would present a reasonable, evidence-based choice. While it is imperfect, it is one of the best recognized tools for acuity assessment available. Standardization of care has been shown to improve patient safety (219–221), which might also apply to EM (222,223). Our study was, to our knowledge, the first on this topic in the Nordic countries, all of which seem to be in the early stages of developing triage standards.

6.3. ACUITY ASSESSMENT METHODS FOR OLDER ADULTS (I-III)

In our study, the ESI predicted 3-day mortality and HDU/ICU admissions well for the older adults (I). The predictive capacity of the ESI for 30-day mortality and hospital admission was poor but statistically significant. These findings concerning mortality and HDU/ICU admissions

are consistent with previous studies. Similar to the general adult population, the association between the ESI and hospital admission was weaker in our study. ED LOS was longest in category 3, which is consistent with previous studies (44,147). The predictive capacity of the HUH triage method was inferior to the ESI. This finding reflects the review by Zachariasse et al. that reported an inferior performance of three-level triage tools compared to 5-level triage tools (2).

Age adjustment for ESI improved its capacity to predict 30-day mortality and hospital admission, where the association without age adjustment was poor. It did not improve accuracy in predicting 3-day mortality or HDU/ICU admission, however, these outcomes were already associated with ESI. The optimal cut-off age was not obvious: where age adjustment improved the predictive capacity, it did so with all cut-off ages. Similarly, where age adjustment was not useful, this was true with all cut-off values. Setting the threshold for age adjustment as high as possible might be useful in order to reduce overtriage. In a study that combined the NEWS with age, a threshold age of 80 improved prediction of in-hospital mortality (146).

The NEWS2 was able to predict 30-day mortality and HDU/ICU admission well for frail older adults, which reflects previous findings (143,146,215). In our study, the NEWS2 predicted hospital admission poorly, in contrast to previous studies (143,145). The NEWS2 was not associated with ED LOS or revisitation rates. While the association of the NEWS2 with ED outcomes is modest, it is still noteworthy, as the assessment of frail older ED patients is difficult, and no robust tools have yet been developed.

Enhancing acuity assessment would improve ED outcomes for older adults. As stated earlier, reducing undertriage affects ED LOS. This has an effect in ED crowding and mortality via increased hospital LOS and hospital-induced delirium rates. While our study was not able to offer a solution to this complicated issue, it has reinforced the current view, that ESI is able to adequately differentiate critically ill older adults from those who can wait and can be used also in the older adult population.

6.4. SUMMARY OF NONSPECIFIC COMPLAINTS (IV)

The systematic review showed with high certainty that in-hospital mortality for NSC patients is increased compared to SC patients. There was a moderate level of certainty that NSC patients require hospital admission. These findings are consistent with other related studies not included in the review (7,8,133,224–226). NSC patients are undertriaged more often than patients presenting with SCs, which has also been reported in other studies (8,133,227).

ED and hospital LOS might be increased for NSC patients. These outcomes warrant further exploration; as described earlier, both seem to increase the rate of negative outcomes. There were few studies reporting HDU/ICU admission rates and resource requirements on NSC

patients. Including HDU/ICU admission rates in future studies would facilitate the assessment of triage accuracy in this patient group. The summary of all outcomes is presented in Table 3.

Table 3 Summary of outcomes for NSC patients

	Mortality	Hospital admission	HDU/ICU admission	ED LOS	Triage category	Hospital LOS	Resources
No. of studies	4	4	2	3	3	3	3
Finding	In-hospital mortality increased	Admission rate increased	No difference	ED LOS increased	Allocation to a more urgent triage class decreased	Hospital LOS increased	Diagnostic tests and procedures increased. Number of consultations decreased. 30-day revisitation increased in one study
Comments	30-day mortality increased in one study		Only two studies, no meta-analysis				1-2 studies on each outcome, no meta-analysis
Certainty	High	Moderate	-	Low	Moderate	Low	-

Our study indicates that an NSC, or generalized weakness, is a common presentation in the older ED population. It is an underestimated, under-researched, serious condition with an increased rate of negative outcomes. This study was the first time the findings of this topic were systematically reviewed and reported, and as such, this review can be used as a reference point for further studies. There is a demand for the NSC presentation to be recognized as its own entity, and for an established definition of the term (128). This was evident in a recent study that reported contradicting findings on NSCs: they defined NSC as an ED discharge diagnosis rather than a presenting complaint and received contradicting results (228). There is also a need for evidence-based guidelines for the management of this patient group in the ED, in order to improve care.

6.5. STRENGTHS AND LIMITATIONS

6.5.1. Register studies (I-II)

These were retrospective single- (I) and three-centre (II) cohort studies. The STROBE checklist was applied to assess the risk of bias (229). The number of included patients was relatively large, both age groups were well represented, and gender distribution was similar in both groups. The number of patients was small in triage categories 1 and 5, which led to a non-meaningful result

in the primary outcome for the younger adult group. A fixed continuous time period was chosen to limit the risk of selection bias; however, some bias related to seasonal variation is possible.

Very few participants (5/5511; 0.09%) were lost to follow-up regarding HDU/ICU admission and data were comprehensive for all other outcomes. Our data did not allow us to report in-hospital mortality, which is a more common outcome than 3-day mortality.

6.5.2. The frailty trial (III)

This was a prospective observational cohort study where risk of bias was assessed with the STROBE checklist (229). Although it was based in a single centre, the number of participants was relatively large. A significant number of nurse-evaluated frailty assessment data were unavailable. The lack of data collecting was presumed to be associated with periods of ED crowding, when the clinical workload was high for the nursing staff, decreasing the available time for research assessments. The lack of data could contribute to some selection bias; however, the assessments were done independently from the researchers which might reduce the effect. EHR data were missing for eight patients, no patients were lost to follow-up.

The data for this study were originally collected for an RCT concerning comprehensive geriatric assessment (CGA) in the ED. It is possible, that the CGA affected some outcomes, such as ED LOS, revisitation rates and even 30-day mortality. This study included data from both intervention (I) and control (C) groups, but the distribution of C and I patients across triage categories was not assessed as a confounder. However, the RCT study did not report a difference in the median NEWS2 between I and C groups. (201)

This study reported on a local three-level triage tool, and, as such, is not applicable to EDs using different triage methods. However, three-level instruments have previously been shown to have lower sensitivity than five-level instruments, thus any significant findings could be extrapolated to be applicable to a more sensitive triage tool as well.

6.5.3. Systematic review (IV)

This study followed international guidelines for systematic reviews and meta-analyses. It was registered at PROSPERO (202) and the study protocol and risk of bias was assessed with the PRISMA checklist (205). Quality of included studies and the overall certainty of evidence were evaluated with the SIGN checklist and GRADE (204,206). A librarian was involved in the literature search and a statistician in executing the meta-analysis.

Due to the lack of an established definition of the topic of NSC, it is possible that some relevant studies were not found. To reduce the risk of evidence selection bias, two further literature search terms were run after new potential search terms were discovered in the first search.

The topic has not been widely researched, which lead to a small number of included studies and heterogeneity in the population and outcome reporting. The funnel plot appears asymmetric, which was probably reflects the small number of included studies, rather than a significant publication bias. The included studies were estimated to have low or unclear risk of bias and the risk of bias across studies was low. No apparent limitations that would lower the confidence of the results were discovered.

Several studies from the BANC group were excluded, despite the group being one of the most cited on the topic. This was, in part, due to their different definition of NSC and thus different inclusion criteria for NSC patients. Each potentially relevant, excluded study is discussed in Appendix 3 of the original publication.

One large included study reported proportional data only; the data used for this meta-analysis were estimated based on the published figures. This study was however by far the largest study on the topic, and the quality of the study was estimated to be adequate for inclusion.

6.6. FUTURE CONSIDERATIONS

The optimal way to assess acuity for older adults in the ED remains undertermined. Our study supports the findings that the ESI is sufficiently accurate in the older adult population. However, the number of studies focusing on established five-level triage systems in the older ED patients is low; more data is required to increase the level of evidence.

It is unclear what superior means to improve accuracy for current triage methods in the older adult population would be. The two obvious paths would be to either combine an established triage tool with a geriatric screening tool, or to adjust a triage tool to accommodate older adults. There are few reports on the former, and, combining the ESI with the TRST might be a promising approach to improve accuracy in the mid-acuity categories. It is not known whether triage tools can be adjusted for older adults, as has been done for pediatric patients, without significant overtriage. If so, what the optimal modifications and age limits are remain open.

The use of the NEWS2 is becoming increasingly common in the ED setting. While it is not meant for acuity assessment, it might be useful in monitoring ED patients waiting for ward-based care. Not enough is known on the accuracy of the NEWS2 in the ED, especially regarding older adults. Further validation studies are required for evidence-based use of the NEWS2.

Regarding NSC patients, establishing a commonly accepted definition of the condition is crucial. A Delphi study would be one possible method to reach a consensus. Once a definition has been agreed on, RCTs would be required to establish guidelines and pathways to assess and treat these patients.

7. CONCLUSIONS

1. The ESI recognized severely ill patients in our population at a satisfactory level; it was associated with 3-day mortality and HDU/ICU admissions. The ESI predicted hospital admission and 30-day mortality modestly.
2. The ESI was sufficiently accurate in predicting outcomes for older ED patients; it was associated with 3-day mortality and HDU/ICU admissions. It was modest in predicting hospital admission and 30-day mortality.
3. Adjusting the local three-level and ESI triage methods by age led to improved prediction of 30-day mortality and hospital admission, without an extensive increase in overtriage. The optimal threshold age was not evident.
4. The local three-level triage method was inferior to the ESI and NEWS2 in predicting ED outcomes.
5. The NEWS2 predicted 30-day mortality and HDU admission in the frail older adult population modestly.
6. Patients presenting to the ED with a nonspecific complaint have increased mortality and hospital admission rates compared to patients presenting with a specific complaint. The NSC patients are more frequently triaged as less urgent and their length of stay in the ED and in hospital might be increased.

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