Assessing use of the South African Triage Scale in the Western Cape Government Emergency Medical Services System.

by

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Thesis presented for the degree of **DOCTOR OF PHILOSOPHY (PhD)** in **EMERGENCY MEDICINE** in the faculty of Health Sciences at the University of Cape Town.

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30 August 2021

University of Cape Town

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2. Mould-Millman NK, Dixon JM, Burkholder T, Pigoga JL, Lee M, de Vries S, Moodley K, Meier M, Colborn K, Patel C, Wallis LA. Validity and reliability of the South African Triage Scale in prehospital providers. BMC Emerg Med. 2021 Jan 15;21(1):8. doi: 10.1186/s12873-021-00406-6. PMID: 33451294.
3. Dixon J, Burkholder T, Pigoga J, Lee M, Moodley K, de Vries S, Wallis LA, Mould-Millman NK. Using the South African Triage Scale for prehospital triage: A qualitative study. International Journal of Emergency Medicine (under review).

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ACKNOWLEDGEMENTS

I would like recognize and profusely thank the following for their support and encouragement during the course of this PhD work:

- My wife, Kara, and my children, Elise and Anthony, for graciously allowing me to have the time and space to conduct these investigations.
- My research collaborators and colleagues, including Dr. Shaheem de Vries, Dr. Julia Dixon, Dr. Taylor Burkholder, Mr. Michael Lee, Dr. Adit Ginde, Dr. Smitha Bhaumik, and many others, whose support and assistance were crucial to enable this work to be completed with high rigor.
- My PhD advisor, Prof. Lee Wallis, and PhD coordinator, Dr. Willem Stassen, for their advice, feedback, and direction at all stages of this work.
- To my academic group and Department at the University of Colorado for their support and encouragement to pursue and complete this work.
- Last, and importantly, to the participants of the research study, notably the Western Cape Gov't EMS providers, who selflessly gave up their time and made themselves vulnerable in the pursuit of gaining knowledge to further help the patients they serve.

To all of you and many more who supported this work, I am thankful and indebted to you.

ABSTRACT

Introduction: A critical concept underpinning emergency medicine is triage. Triage is the systematic process of sorting patients based on acuity and/or resource need, with the goal of getting the right person to the right place at the right time to receive the right level of care. Triage influences a patient's clinical trajectory, hence impacts both patient outcomes and health system resource utilization. Therefore, the consequences of triage are arguably even more critical in two scenarios: first, early on in the patient's care, such as the prehospital setting; and second, care in resource-constrained health systems, such as in Africa. Prehospital emergency care, delivered by Emergency Medical Services (EMS) providers, represents one of the earliest opportunities for emergency triage of the undifferentiated patient. We conducted a series of projects to, first, understand the current global scientific context of prehospital triage and, next, to better understand how the South Africa Triage Scale (SATS) is used by Western Cape EMS providers for prehospital triage. Findings may help enhance the application of SATS for prehospital triage in the Western Cape. Additionally, findings could provide evidence to encourage the adoption, or rejection, of SATS triage by other EMS systems in resource-constrained settings, especially in Africa.

Methods: This project consisted of three distinct objectives which were investigated as separate, but interconnected, studies. The first objective was answered using a secondary research method (a scoping review) designed to discover and appraise existing prehospital triage tools across the world in an effort to better contextualise the specific role filled, and value added, by SATS. The second and third objectives were answered using a quantitative and qualitative approach, respectively, to assess the validity and reliability of SATS among EMS providers, and to understand EMS providers' experiences and perspectives using SATS. We converged the quantitative and qualitative data in a mixed methods analysis.

Main results: In the scoping review, we screened 1521 unique articles and completed a full review of 55 articles. We reported that the majority of publications on prehospital triage tools were focused on stroke triage (35%) and trauma triage (35%). There were 15 (27%) publications, corresponding to 11 unique tools, relevant to prehospital triage of undifferentiated patients – overall, the tools had modest triage performance characteristics in high-income settings. However, we found no publications relevant to prehospital triage with SATS in the 2009 to 2019 study period, and no triage tools were studied in low- or

middle-income countries. In the quantitative study, we conducted cognitive paper-based SATS triage assessments of 102 EMS providers of all qualifications within the Western Cape Government EMS system. We found a high rate (29.5%) of under-triage and an acceptable rate (13.1 %) of over-triage. Providers' use of the Triage Early Warning Score (TEWS) and the clinical discriminators were often incorrect in 41.4% and 41.2% of cases, respectively. In the qualitative assessment, we completed three focus group discussions with 15 diverse and representative providers from the Western Cape Government EMS system, and we achieved thematic saturation. Four major themes emerged from the discussions: Limited implementation and variable use of SATS; Prehospital effectiveness of SATS; Limitations of the discriminator; and, Special EMS considerations limiting SATS. In general, participants felt SATS was fairly easy to use and an asset in their patient care, explaining that it aided them clinically and with hospital communication. Participants, however, noted that the clinical discriminators were often challenging to apply in the prehospital setting, and the TEWS often did not reflect the patient's true or changing prehospital acuity. The qualitative findings both corroborated and helped explain some of the key quantitative results, with both suggesting that many clinical discriminators are problematic for prehospital use and manually calculating TEWS is an error-prone process for Western Cape EMS providers.

Conclusion: SATS is being successfully and innovatively used in the prehospital triage of undifferentiated patients in the Western Cape of South Africa. Researching prehospital SATS in South Africa fills a global scientific gap given we found no reports of prehospital triage tools from low- or middle-income countries. Western Cape EMS participants reported that SATS was generally helpful and relatively easy to use, but reported challenges using TEWS and the clinical discriminators. SATS had good inter-rater reliability, but poor validity. The under-triage rate of 30% was high and attributable to misuse of TEWS and clinical discriminators. The over-triage rate of 13% was acceptable and confirmed by experiences recounted by the EMS participants. Modest adaptations of SATS by expert stakeholders could improve its prehospital performance and utility in the Western Cape Province. SATS for prehospital triage likely has good applicability and utility in other resource-constrained systems, but further adaptation and testing are warranted.

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LIST OF ABBREVIATIONS

ALS: Advanced Life Support

AMPT: Air Medical Prehospital Triage

aOR: adjusted Odds Ratio

ASCOT: American College of Surgeons Committee on Trauma

BLS: Basic Life Support

CPSS: Cincinnati Prehospital Stroke Scale

CTAS: Canadian Triage and Acuity Scale

CTG: Cape Triage Group

CTS: Cape Triage Score

ECG: electrocardiogram

EMS: Emergency Medical Services

ESI: Emergency Severity Index

FAST-ED: Field Assessment for Stroke Triage for Emergency Destination

FTDS: Field Triage Decision Scheme

GCS: Glasgow Coma Scale

HITS-NS: Head Injury Transportation Straight to Neurosurgery

HREC: Human Research Ethics Committee

ICU: Intensive Care Unit

ILS: Intermediate Life Support

LAMS: Los Angeles Motor Scale

LMICs: Low- and middle-income countries

LVO: Large vessel occlusion

NEWS: National Early Warning Score

NIHSS: National Institutes of Health Stroke Scale

RACE: Rapid Arterial Occlusion Evaluation

RETTS-p: Rapid Emergency Triage and Treatment System - paediatrics

SATS: South Africa Triage Scale

SD: Standard Deviation

STEMI: ST elevation myocardial infarction

TBI: traumatic brain injury

TEWS: Triage Early Warning Score

tPA: tissue Plasminogen Activator

UCT: University of Cape Town

WCG: Western Cape Government

CHAPTER 1: INTRODUCTION

1.1 Introduction

Triage – the clinical determination of patient acuity and anticipated resource need – plays an early and important role in guiding the delivery of prehospital care and the transport of patients to the right level of care. Prehospital triage, therefore, is an indispensable function in, and of, emergency care systems which influences patient outcomes and resource utilisation.

1.1.1 The global and African burden of disease from emergency conditions.

Emergency conditions contribute a large proportion of the overall global burden of disease.(1) Approximately 24 million deaths occur each year in low- and middle-income countries (LMICs) due to emergency conditions that are amenable to prehospital and in-hospital emergency care; of these, sub-Saharan Africa is estimated to contribute 21% of the global burden of disease despite having 13% of the world's population.(1-3)

Many emergency conditions which significantly contribute to premature morbidity and mortality in LMICs are time-sensitive and include conditions such as trauma, stroke, sepsis, cardiac arrest, and obstetric emergencies.(4, 5) In time-sensitive conditions, delays in care may worsen outcomes, *ipso facto*, earlier recognition, timely management, and rapid transport to definitive care facilities can help yield better patient outcomes. In LMICs, the effective delivery of early emergency care, starting in the prehospital setting, could help avert a majority of early deaths and disability due to provision of basic care and rapid transport to a suitable destination.(1, 4, 5)

1.1.2 The need for formal prehospital care

Patients may need to be transported more than 20 km to reach a health care facility in low-income countries, with up to 80% of them walking or being carried by family members.(6) Formal systems that enable emergency care systems to reach and deliver care to patients, prior to arrival at a fixed facility, play a critical role in providing timely access to care which influences outcomes of both acute diseases and acute exacerbations of chronic

illnesses.(7-11) Existing evidence indicates that the absence of prehospital care adversely affects the outcomes of medical, obstetric, and paediatric emergencies. A meta-analysis by Henry *et al.* has indicated that delivery of prehospital care confers a 25% reduction in trauma deaths alone, and a larger cumulative effect is expected with the combination of safe transport and prompt facility-based emergency care.(3, 12)

1.1.3 The role of EMS in delivery of prehospital care

EMS systems represent the earliest formal opportunity for an emergency care system to intercept a patient, at their location outside the hospital, to identify and initiate life-saving treatment and transportation in emergency conditions.(13, 14) Further, EMS systems can aide in delivery of the patient to the right level of care, which is important in influencing the patient's on-going care and outcomes. EMS is defined as the system that organizes all aspects of medical care provided to patients in the prehospital or out-of-hospital environment.(9, 14)

The World Health Organization, via its advocacy and the Emergency Care Systems framework, emphasizes the important role played by EMS systems in the (early) delivery of prehospital care within emergency care systems, especially in resource-constrained settings globally (Figure 1).(15) Furthermore, others have shown that if appropriately used, ambulances are highly cost effective in reducing mortality from emergency conditions.(16, 17) In addition to providing care for individual patients with emergency conditions, EMS is also the foundation for effective disaster response and management of mass casualty incidents.(18-20)

Fig. 1 WHO emergency care system framework. This framework captures essential emergency care functions at the scene of injury or illness, during transport, and through to emergency unit and early inpatient care. Orange text and images represent human resources, blue represents system functions, and green represents equipment, supplies, and information technologies

Figure 1: The WHO Emergency Care System Framework

1.1.4 Triage in prehospital emergency care.

A critical task in prehospital emergency care is the accurate triage of the undifferentiated patient which helps dictate the ensuing treatment and/or transportation plan. Triage has a demonstrated mortality benefit, for example, in the setting of ST-segment elevation myocardial infarction (STEMI), stroke and trauma.(21-23) Triage is employed repeatedly and used across the spectrum of emergency care delivery: at the time of resource dispatch, upon prehospital personnel arrival at the scene of the patient, and again by staff of the receiving facility.(24)

The doctrine of timely prehospital care and rapid transport has been a mainstay of prehospital teaching since World War II when Dr. Adams Cowley identified the preponderance of mortality within an hour of traumatic injury.(25) Major trauma with massive haemorrhage is a quintessential time-sensitive emergency condition in which prehospital care is key to improving outcomes for two reasons: (i) life-saving interventions can be performed early, before the patient exsanguinates to death; and (ii) a decision can be made regarding transportation to the most appropriate facility with the necessary surgical capabilities.(26) Triage is critical to inform both the performance of life-saving interventions

(e.g., pelvic binding, intravascular volume expansion) and the decision to transport to a trauma-equipped centre.(27) Failure to appropriately perform trauma triage results in increased preventable mortality, according to studies from the USA, for example – this effect is likely further magnified in LMICs.(28, 29)

1.1.5 Mistriage and Consequences Thereof

Inaccurate triage, which occurs as either under- or over-triage, bears direct implications to emergency patient care and health resource utilization.(30, 31) Over-triage is the over-estimation of a patient's true clinical acuity or the over-estimation of perceived resource need. Under-triage is the under-estimation of a patient's true clinical state or under-appreciating the patient's need for health resources.(30) Over-triage can be medically harmful (via delivery of unnecessary interventions) and can be wasteful (by inappropriately consuming valuable health resources, especially in resource-limited settings). Under-triage can be medically harmful (because it 'misses' conditions thereby causing delays in recognition and/or under-treatment).(31)

In a few emergency conditions, such as stroke, myocardial infarction, and traumatic haemorrhage, where specific interventions need to be performed at specific hospitals in high-income countries, there are well-established over- and under-triage rates to strike a balance between avoiding missing harmful conditions and wasting health resources.(28, 29) For example, the American College of Surgeons Committee on Trauma (ASCOT) has defined (via consensus and empiric data) the acceptable levels of field under-triage (<5%) and field over-triage (25–30%). In the United States, due to policy, available resources, and health system configuration, a decision has been made to limit under-triage at the expense of over-triage to help avoid death and disability due to treatment delays, at the expenses of higher health systems costs.(29-31) Trauma triage therefore allows early determination of injury severity and anticipated resources needed to treat a critically injured patient and supports overall delivery of quality of trauma care by the entire trauma system.

In high-income settings, prehospital triage tools are constantly being scientifically assessed and modified to optimize their use. This is often achieved by striking a balance between the

triage tool's performance characteristics (e.g., over- and under-triage rates, sensitivity and sensitivity) with end-user practicality (e.g., ease of use, cost, time to use, and error rates).(29, 30) Since each health system is relatively unique – due to differing geography, different burdens of disease, differing health systems capabilities – there is no widely accepted, international 'gold standard' triage tool. Further, no universal standard or set performance characteristics exist that dictate performance thresholds or cut-offs for prehospital triage – these have to be locally determined after consideration of a myriad of factors including the disease, providers, health system, and desired outcomes.

1.2 Background

1.2.1 Development and Context of the South Africa Triage Scale

In 2004, the Cape Triage Group (CTG) convened to derive a triage system suitable for local use.(32, 33) The group included a multi-disciplinary panel of in-hospital and prehospital staff from varied backgrounds, and used best available evidence and expert opinion to arrive at a consensus triage protocol.(32) The Cape Triage Score (CTS) was developed by the group for use in emergency units across South Africa. The CTS was specifically designed for single-patient triage in hospital units, although theoretically, the Group asserted it could be used for prehospital triage. CTS comprises a physiologically based scoring system and a list of discriminators, designed to triage patients into one of five priority groups for medical attention. Three versions have been developed, for adults, children and infants.(33) The CTS was launched in hospital emergency units in the Western Cape on 01 January, 2006.

This desired attributes of the CTS were two-fold: first, an easy to use tool by all levels of prehospital providers, nursing staff and doctors - from the roadside through to the EU; second, a universally accepted and utilised objective triage system to avoid discrepancies in patient classification.(32) The following factors were considered in developing the triage system:

- **Physiologic derangement** – The CTG wrote that, *"MEWS has been used to successfully identify physiological deterioration of medical in-patients… scores of five or more were associated with increased risk of death, ICU and High Dependency Unit admission… The MEWS score is a 'simple, practical method of using routine*

physiological measurements to flag, from among the mass of admissions, patients who should not be ignored." To improve MEWS for trauma patient triage, two parameters were added: mobility status and presence of trauma. The modified MEWS score was renamed as the Triage Early Warning Score (TEWS).(32)

- **Clinically based discriminators**
    - **Mechanism of injury** – the CTG wrote, *"Mechanism of injury scores have been shown to be highly sensitive at identifying casualties with severe trauma. However, they have also been shown to have high rates of over-triage. Mechanism of injury was included but limited to high energy transfer."(32)*
    - **Presentations** – the CTG explained that, *"We deliberately avoided long lists that would lead to long algorithms or a bulky triage tool. Although there are some specific diagnoses in the triage algorithm (e.g. burn – face/inhalation), most are presentation types such as chest pain."(32)*
    - **Pain** – the CTG explained that pain is an important component of assessment of patients in the emergency unit.(32)
    - **Senior Health-Care Personnel's Opinion** – the CTG wrote that, *"There is evidence that experienced health care professional can improve the triage process by adding their opinion to other parameters."* However, no statements were offered regarding applicability to prehospital providers. *(32)*
- **Nomenclature** – the CTG selected a colour coded system because, *"… colours are more readily identifiable to both medical staff and patients (considering practical points such as colour-coded stickers on folders and even coloured zones in emergency units).*" The CTG selected a triage colour coding systems that was both intuitive and similar to existing hospital triage systems. The selected colours (and their associated definitions) included (32):
    - **Red** - resuscitation/physiologically unstable patients
    - **Orange** - serious cases with potentially unstable physiology or potentially life/limb threatening pathology
    - **Yellow** - 'physiologically stable' cases with reasonably serious medical or trauma problems

- **Green** - minor injuries/illness
- **Blue** - those who are clearly dead

There are three versions of the CTS: adult, child, and infant. The original adult version of the CTS is presented in Figure 2. The adult version was intended for patients aged >12 years, or taller than 150 cm. The infant version is for children under three years, or <95 cm, and the child version is for other children (3 to 12 years, 95-150 cm). The adult version is shown below, and the child and infant versions are available online.(32)

TEWS	3	2	1	0	1	2	3
Mobility				Walking	With help	Stretcher/ immobile	
RR		< 9		9–14	15–20	21–29	≥ 30
HR		? 40	41–50	51–100	101–110	111–129	≥ 130
Syst BP	? 70	71–80	81–100	101–199		≥ 200	
Temp		< 35		35–38.4		≥ 38.5	
AVPU				Alert	Voice	Pain	Unresponsive

	RED	ORANGE	YELLOW	GREEN	BLUE
TEWS	**> 7**	**6 to 7**	**3 to 5**	**0 to 2**	**Dead**
MOI	Entrapment	Impact – high	Impact – low		
SYMPTOM					
Respiratory	Asthma – status	Asthma			
Cardiac		Chest pain			
Vascular		Haemorrhage – arterial			
AVPU	Unresponsive	Responds to Pain	Responds to Voice	Alert	
Neuro	Seizure – current	Seizure – post-ictal			
Psych		Psychosis/Aggression			
Ortho		Limb – threatened			
		Dislocation – major joint	Dislocation – minor joint		
		Fracture – open	Fracture – closed		
Burn	Burn – face/ inhalation	Burn > 20%	Burn – minor		
Medical	Hypoglycaemia < 2.2	Overdose/Poisoning	Abdominal pain		
GIT		Haemetemesis – fresh blood			
Obs and gynae		Pregnancy – trauma	Pregnancy – PV bleed		
ANATOMY	Trauma – airway	Trauma – head/neck torso Evisceration	Trauma – limb		
PAIN		Severe	Moderate	Mild	
	~~~~~~~~Senior health-care professional's discretion~~~~~~~~				
'trauma' = penetrating/blunt 'torso' = chest/abdo/back					

Figure 2: Original Cape Triage Score (32)

1.2.2 Principles Underlying Use of the CTS

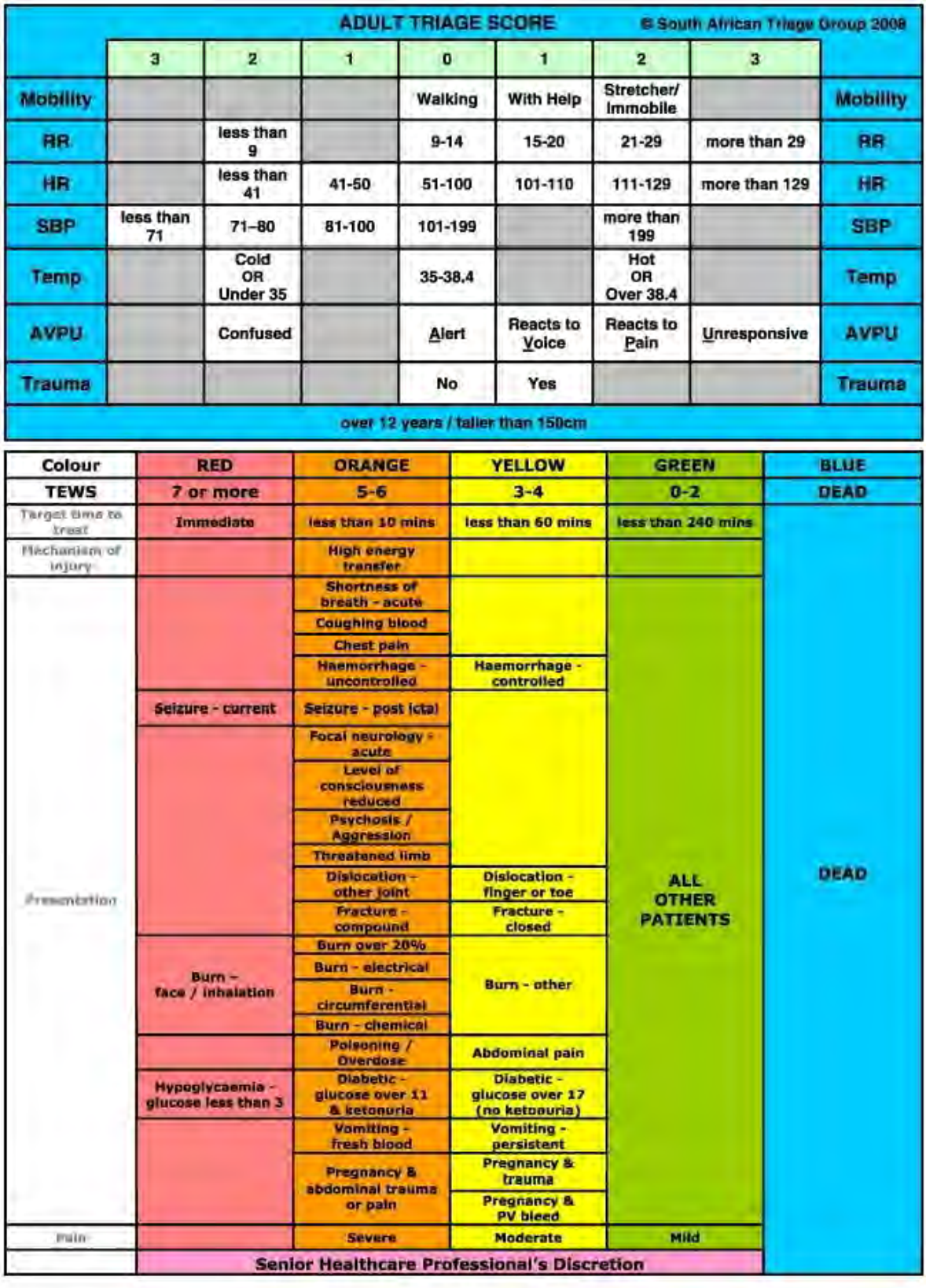
The first step in triage is calculating the TEWS score which requires measuring vital signs and awarding points from the TEWS sheet. The TEWS score is designed to encourage the triaging healthcare professional to actually measure physiological parameters (e.g., systolic blood pressure, pulse rate), which is clinically valuable for purposes beyond triage. Points from the TEWS sheet are totalled and the resulting value is read off from the first line of the triage coding chart.(32)

The CTG emphasized that it was not necessary to "tick all the boxes" for triage of individual patients – if a patient's TEWS score resulted in an 'orange' triage classification, then the patient was 'orange', unless there is an obvious other problem that would make them 'red'. A current seizure, for example, will result in the triage of the patient as 'red' regardless of his/her TEWS score.(32)

1.2.3 Assessments of Cape Triage Score and Evolution into SATS

One of the earliest assessments of CTS was performed by Wallis et al in 2007.(34) Hospital emergency unit data were prospectively collected over a 4-month period. Authors found that of 798 patients who were triaged and analysed, CTS under-triaged 24% and over-triaged 25% of patients who required admission. The authors explained that by altering the colour code parameters, amending the discriminator list as well as the addition of a trauma factor, they were able to reduce (harmful) under-triage to 12% with 45% over-triage, which was felt safer and more clinically acceptable.(34)

In 2008, the South African Triage Group (SATG), formerly the Cape Triage Group, convened to modify the CTG into its present form: the South Africa Triage Scale (SATS), including a training manual released in 2012.(35) The current adult version of SATS is shown in Figure 3.



ADULT TRIAGE SCORE								© South African Triage Group 2008
	3	2	1	0	1	2	3	
Mobility				Walking	With Help	Stretcher/ Immobile		Mobility
RR		less than 9		9-14	15-20	21-29	more than 29	RR
HR		less than 41	41-50	51-100	101-110	111-129	more than 129	HR
SBP	less than 71	71–80	81-100	101-199		more than 199		SBP
Temp		Cold OR Under 35		35-38.4		Hot OR Over 38.4		Temp
AVPU		Confused		Alert	Reacts to Voice	Reacts to Pain	Unresponsive	AVPU
Trauma				No	Yes			Trauma
over 12 years / taller than 150cm								

Colour	RED	ORANGE	YELLOW	GREEN	BLUE
TEWS	7 or more	5-6	3-4	0-2	DEAD
Target time to treat	Immediate	less than 10 mins	less than 60 mins	less than 240 mins	DEAD
Mechanism of injury		High energy transfer			
Presentation		Shortness of breath - acute		ALL OTHER PATIENTS	
		Coughing blood			
		Chest pain			
		Haemorrhage - uncontrolled	Haemorrhage - controlled		
	Seizure - current	Seizure - post ictal			
		Focal neurology - acute			
		Level of consciousness reduced			
		Psychosis / Aggression			
		Threatened limb			
		Dislocation - other joint	Dislocation - finger or toe		
		Fracture - compound	Fracture - closed		
	Burn - face / inhalation	Burn over 20%	Burn - other		
		Burn - electrical			
		Burn - circumferential			
		Burn - chemical			
		Poisoning / Overdose	Abdominal pain		
	Hypoglycaemia - glucose less than 3	Diabetic - glucose over 11 & ketonuria	Diabetic - glucose over 17 (no ketonuria)		
		Vomiting - fresh blood	Vomiting - persistent		
		Pregnancy & abdominal trauma or pain	Pregnancy & trauma		
			Pregnancy & PV bleed		
Pain		Severe	Moderate	Mild	
	Senior Healthcare Professional's Discretion				

Figure 3: SATS Adult Reference Table (South African Triage Group, 2008)

In 2012, Twomey *et al.* conducted a cross-sectional reliability study of hospital emergency unit doctors and nurses using a series of hospital clinical vignettes that were prospectively

collected.(36) Following a 1-day training, authors found acceptable inter- and intra-rater reliability for emergency physicians and nurses which indicated that SATS provided reliable triage acuity ratings.[same ref] The inter-rater agreement among nurses (0.66) and physicians (0.76) was substantial, and the average intra-rater agreement within each individual nurse (86%) and physician (80%) was almost perfect.(36)

As SATS was adopted across South Africa, in rural and urban settings, it also diffused outside of South Africa (e.g., Pakistan, Malawi, Haiti, and Ghana).(37-40) Several studies reported modest to good in-hospital performance characteristics, including reliability, accuracy, sensitivity and specificity.(37-40) However, no prehospital or EMS provider assessments were conducted.

1.2.4 Western Cape EMS System Incorporation of SATS

Around 2012, SATS was incorporated into routine prehospital emergency care use by the Western Cape Government (WCG) EMS system. The WCG EMS system is a public EMS system that provides 24/7 ambulance services to a catchment population of over six million in the Western Cape Province of South Africa.(41) In 2017, WCG EMS employed approximately 2000 operational EMS providers in across three cadres: basic, intermediate, and advance life support (BLS, ILS, and ALS, respectively); they executed approximately 450,000 ambulance responses, and providers are expected to use SATS in all clinical cases.(42)

Although, theoretically, all cadres of EMS providers have the skills and tools to derive the SATS triage score in an ambulance, SATS had never been primarily intended for, nor tested in, the prehospital emergency care environment.(36) To date, the prehospital triage performance characteristics of SATS, and prehospital providers' perspectives of SATS, remain unstudied.

1.3 Extended Problem Statement

As explained earlier in this chapter, research of prehospital SATS in the Western Cape is important to improving our understanding of how SATS is used as an instrument for

conducting prehospital triage of individual patients. In general, and beyond the focused questions posed by this specific PhD thesis (in section 1.4), there are many layers of consequential questions that need to be ultimately answered by the scientific and EMS communities about prehospital SATS. While only a narrow subset of the following questions will be answered from this research, here are several unanswered broad questions (organized via the following perspectives):

1) Patient/clinical – e.g. is prehospital triage accurately performed? How reliable and valid is prehospital SATS? How does SATS perform on various patient sub-populations or compliant types? The reason to answer these types of question is because findings may be used to help improve the accuracy and performance of prehospital SATS triage which may help to ensure and safeguard quality prehospital patient care. Further, patient-level data may help EMS medical directors and practitioners in other EMS contexts (outside the Western Cape) decide whether SATS may be a worthwhile tool to help augment patient triage and care;
2) Health system – e.g., what are the health system implications from yielding a prehospital SATS triage colour designation? How does prehospital SATS triage facilitate the patient's access and trajectory in the health system? Are there situations in which a prehospital SATS colour does not yield the desired consequences for the health system? The importance of answering these sorts of questions is that, ideally, accurate prehospital triage facilitates patient access to relevant destinations and levels of care, and helps to dictate healthcare resource allocation and consumption;
3) Prehospital context and environment – e.g., is SATS a practical tool for prehospital providers to apply? Are there prehospital situations in which SATS may not be useful or practical? How does the prehospital setting (i.e., changing time, distance, and geography) affect the use and interpretation of SATS? Questions of this nature are valuable to answer to provide more contextually-relevant information about how SATS works in ambulances and the out-of-hospital setting, especially considering the preponderance of prior implementations and studies of SATS have been in hospital emergency units;
4) EMS providers – e.g., how do EMS providers feel about using SATS? Do EMS providers perceive SATS to be valuable? How do their feelings and perceptions

impact their use of the tool in the field? What changes may they suggest to help improve SATS for prehospital care? Improving our understanding of the prehospital end-user experiences and perspectives of SATS could theoretically help to improve the fit and ease of use in the prehospital context.

To reiterate, only a subset of the litany of questions above can practically be answered within the constraints of this PhD thesis (explained in section 1.4). Further, since this PhD thesis represents the first formal scientific study of prehospital SATS, we will attempt to gain a broad, yet informative, understanding of prehospital SATS to purposefully help direct and guide future studies.

It is also important to mention that there are implications of conducting research on prehospital SATS beyond the Western Cape and outside of South Africa. Considering that EMS systems are emerging and growing in many LMICs, including across Africa,(1, 43) our findings may catalyse use of SATS in other resource-limited prehospital settings globally. As the first formal study of prehospital SATS, our research findings may provide evidence to international resource-constrained EMS systems that may be helpful in informing their decision on if and how to adopt and/or adapt SATS to their prehospital system, based on the experiences and findings from the Western Cape.

1.4 Research questions, aim, and objectives

1.4.1 Research Questions

Considering the myriad of unanswered questions about prehospital SATS in the Western Cape (from Section 1.3), this PhD thesis focused on answering the following questions:

- Across the world, what prehospital triage tools are reported in the peer-reviewed scientific literature? Why are they being studied? What are their general performance characteristics as triage tools?
- What are the quantitative triage performance characteristics of prehospital SATS when used by WCG EMS providers? Specifically, what is the reliability and validity of SATS when used by a prehospital provider for prehospital scenarios?

- What are the experiences and perspectives of the end-users of prehospital SATS? Specifically, what are the positive, and challenging, aspects of using SATS for prehospital triage? Do WCG EMS providers perceive value from prehospital SATS?

1.4.2 Research Aim

The overall aim of this research project was, first, to provide a worldwide perspective and context for SATS as a prehospital triage tool, and second, to gain an in-depth understanding of performance and use of SATS by WCG EMS practitioners.

1.4.3. Research Objectives

1) To identify publications that report prehospital triage tools being used across the world to understand why they are being studied and to describe their performance characteristics (Scoping Review).
2) To assess the validity and reliability of SATS used for prehospital triage by WCG EMS providers (Quantitative Assessment).
3) To understand EMS providers' perspectives and experiences of using SATS as a prehospital triage tool in the Western Cape Province (Qualitative Study).
4) To understand how the subjective experiences and opinions of EMS practitioners aligns or diverges with the objective data collected in the quantitative assessment.

Answering Objective #1 provided us with a practical approach to achieve a better understanding of the global scientific landscape and context of prehospital triage within which SATS exists. It helped us better understand the gaps and roles that SATS can fill across the world as a prehospital triage tool.

Answering Objective #2 provided us with the first pieces of scientific evidence regarding the objective performance characteristics of SATS in the prehospital context. Acceptable validity and reliability are essential performance characteristics of any triage tool, including SATS. Further, initial data on reliability and validity are critical to informing next research steps e.g., refining SATS, conducting additional studies, and/or continuing to use SATS as-is.

Answering Objective #3 provided critical insights about how SATS is being used on a day-to-day 'real-life' basis. Information learned from this objective better allowed us to understand strong and weak points of prehospital SATS from the operational and subjective clinical perspective that may not be quantifiable.

Answering Objective #4 enabled a crucial 'triangulation' and 'mixing' of the findings, such that part of the qualitative data helped to explain the quantitative data, and *vice versa*, wherein some of the quantitative data supported the subjective experiences and opinions. Objective #4 provided a deeper understanding of the entirety of findings from Objectives #2 and #3.

These four distinct, but highly inter-related, objectives and studies seek to provide the global and scientific context for SATS as a prehospital triage tool (Objective #1), and then to advance our understanding of the performance and end-user perspective of prehospital SATS (Objectives #2, #3, and #4). To the best of our knowledge, the quantitative and qualitative studies of prehospital SATS were the first reports of a prehospital triage tool in a low- and middle-income country. Our vision was that findings from this PhD research would be locally useful (to advance prehospital triage in the Western Cape and in South Africa) and internationally relevant (for other resource-constrained prehospital systems).

1.5 Ethical Clearance and Permissions

The entire study was approved by University of Cape Town Human Research Ethics Committee (Ref. # 705/2016 – Appendix 1) and by the Colorado Multiple Institutional Review Board (Appendix 2). Organisational permission was granted by the Western Cape Government (WCG) Emergency Medical Services (EMS) – see Appendix 3. All approvals were provided prior to commencement of data collection. Findings from this study will be disseminated to the relevant stakeholders, namely WCG EMS, Division of Emergency Medicine at UCT, Division of Emergency Medicine at Stellenbosch University and the relevant WCG emergency care directorate.

1.6 Report Format

Each of the four research objectives were investigated as individual, but interconnected, studies and are presented as individual chapters (2, 3, 4, 5). In chapter 5, findings from chapters 3 and 4 were converged and discussed, using a mixed methods approach that allowed the qualitative findings to help explain the quantitative, and for the quantitative findings to support the qualitative, where applicable. The final chapter (6) pulled together conclusions and recommendations from the entire body of work, and several recommendations are offered for further work.

CHAPTER 2: PREHOSPITAL TRIAGE TOOLS ACROSS THE WORLD: A SCOPING REVIEW OF THE PUBLISHED LITERATURE.

2.1 Declaration from author and co-authors

The following co-authors contributed to the publication: Dr. Smitha Bhaumik (SB), Dr. Merhej Hannun (MH), Dr. Chelsea Dymond (CD), Ms. Kristen DeSanto (FD), Dr. Whitney Barrett (WB), and Prof. Lee A Wallis (LAW).

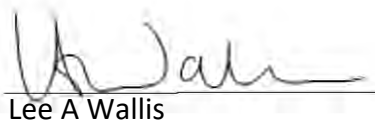
Contributions of the authors were as follows: Nee-Kofi Mould-Millman (NMM) conceived of the study with input from LAW. NMM developed the objectives and designed the study methodology, including the inclusion/exclusion criteria. SB, MH and KD helped to refine and develop the search criteria. CD was the medical librarian who performed the literature search. SB and MH were primary article reviewers, and NMM was the senior reviewer. NMM outlined and drafted the first version of the paper. All other authors contributed to interpretation of findings and provided critical revisions to the manuscript. All authors approved the final version and agreed to be accountable for the final version. The extent of contributions from each person are as follows:

- NMM: 50%
- SB: 20%
- MH: 15%
- KD: 5%
- CD: 2.5%
- WB: 2.5%
- LAW: 5%

Given the large number of co-authors, the principal investigator and the supervisor hereby sign for approval on behalf of the group, in accordance with the UCT Doctoral Degrees Board guideline titled, “GUIDELINES FOR THE INCLUSION OF PUBLICATIONS IN A DOCTORAL THESIS.”

22-June-2021

Nee-Kofi Mould-Millman — Date



30 August 2021

Lee A Wallis — Date

2.2 Synopsis

2.2.1. Rationale for conducting the scoping review

It was important for us to gain a better understanding of the global context of prehospital triage tools. Understanding the global scientific landscape of prehospital triage would enable us to better contextualize the role, value, and contributions that SATS offered as a prehospital tool. We were keen to understand what other types of prehospital tools existed, clinical conditions they were used for, their performance characteristics and why they were being reported in the scientific literature. Further, we were interested in discovering which other prehospital triage tools, if any, were studied from other low- and middle-income countries or African settings. Answers to these questions would help improve our understanding of whether SATS was novel and/or if SATS filled any clinical gaps in the field. Additionally, understanding the breadth of existing literature on this topic would help us better triangulate and appraise the relevance of our SATS research findings. A scoping review, instead of systematic review, was used because the purpose of the review was to identify knowledge gaps, scope a body of literature, and to clarify concepts.

2.2.2 Aims

The primary aim was to identify published prehospital triage tools in use across the world and to understand reasons why these studies were performed. Secondarily, we sought to describe the performance characteristics of these tools. To help improve the appeal and relevance of our scoping review to audiences from lower income settings, we also aimed to provide recommendations on which tools may be suitable for adoption in new and developing EMS systems.

The purpose and aims of this scoping review are very closely tied to the overall aim of this thesis. Understanding the breadth of existing prehospital triage tools, and their characteristics, would enable us to become better attuned to the body of scientific literature on prehospital triage tools and the value added to the field by further scientific studies of prehospital SATS.

2.2.3 Main results

- After a thorough and extensive search, we reviewed one and one-half thousand articles, with 55 (3.6%) satisfying all our criteria.
- Interestingly, we found that prehospital trauma triage tools and prehospital stroke triage tools dominated the published literature, accounting for 70% of all peer reviewed published reports on this topic. Tools used for the prehospital triage of general "undifferentiated" patients comprised 27% of the published literature.
- We found no single universally accepted 'standard' prehospital triage tool.
- We found no prior articles studying prehospital SATS.
- We found no articles from low- or middle-income countries, including South Africa – most articles were from North America and Europe and did not consider triage in resource-constrained health systems.
- A consistent overarching purpose for publication of the tools was to assess validity and accuracy, or often to study performance of simplified versions of existing tools. Specifically, we found that:
    - Tools for prehospital triage of undifferentiated patients commonly assessed how well these tools predicted emergency unit triage (i.e., their accuracy), need for hospitalization (i.e., their validity), and short-term mortality (also a measure of their outcomes validity).
    - Tools for prehospital stroke triage often assessed how well the tools diagnostically predicted in-hospital strokes (i.e., accuracy) and the need for in-hospital tissue plasminogen activator or other definitive care (i.e., validity).
    - Tools for prehospital trauma care were mostly to assess rates of over- and under-triage to trauma centres (i.e., accuracy) and survival to discharge (i.e., validity). Several studies assessed whether simplifications of the tool would yield performance characteristics similar to the main prehospital triage tool.

Below (in section 2.3) is the content of the verbatim manuscript, immediately followed by the references of the manuscript. The context and meaning of the manuscript are described in detail at the end of this chapter (sections 2.4 – 2.5).

2.3 Manuscript

(the manuscript is under review at BMC Emergency Medicine; it is presented verbatim from pages 25-42)

Prehospital Triage Tools across the World: A Scoping Review of the Published Literature

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Abstract

Background: Accurate triage of the undifferentiated patient is a critical task in prehospital emergency care. This scoping review aims to identify published tools used for prehospital triage across the world and describe their performance characteristics.

Methods: A comprehensive search was performed of primary literature in English-language journals from 2009 to 2019. Papers included focused on emergency medical services (EMS) triage of single patients. Two blinded reviewers and a third adjudicator performed independent title and abstract screening and subsequent full-text reviews.

Results: Of 1521 unique articles, 55 (3.6%) were included in the final synthesis. The majority of prehospital triage tools focused on stroke (n=19; 35%), trauma (19; 35%), and general undifferentiated patients (15; 27%). All studies, and resulting articles, were performed in high income countries, with the majority in North America (23, 42%) and Europe (22, 40%). 4 (7%) articles focused on the paediatric population. The general triage tools aggregated prehospital vital signs, mental status assessments, and sometimes, features of the history, exam, and anticipated resource need, to categorize patients into numerical or colour categories to represent level of acuity. The studies assessed the tools' ability to accurately predict emergency department triage assignment, hospitalization and short-term mortality. The stroke triage tools were designed to promote rapid identification of patients with acute large vessel occlusion ischemic stroke to trigger timely transport to diagnostically- and therapeutically-capable hospitals. Stroke triage literature evaluates tools' diagnostic performance, impact on tissue plasminogen activator administration rates, and correlation with in-hospital stroke scales. Trauma triage tools sought to identify patients that require immediate transport to trauma centres with emergency surgery capability. The studies on trauma triage evaluate prediction of trauma centre need, under-triage and over-triage rates for major trauma, and survival to discharge.

Conclusions: The published literature on prehospital triage tools predominantly derive from high-income health systems and mostly focus on adult stroke and trauma populations. Most studies sought to further simplify existing triage tools, without sacrificing triage

accuracy, or assessed the predictive capability of the triage tool. There was no clear 'gold-standard' singular prehospital triage tool for acute undifferentiated patients.

Keywords: prehospital; EMS; emergency medical services; triage; scoping review; global health; international; trauma; stroke.

Background

Emergency medical services (EMS) systems deliver prehospital care and transport to victims of sudden illness or injury [1]. A critical task in prehospital emergency care is the accurate triage of the undifferentiated patient which helps dictate the ensuing treatment and/or transportation plan. Triage has a demonstrated mortality benefit, for example, in the setting of ST-segment elevation myocardial infarction (STEMI), stroke and trauma [2, 3, 4]. Triage is employed repeatedly and used across the spectrum of emergency care delivery: at the time of resource dispatch, upon prehospital personnel arrival at the scene of the patient, and again by staff of the receiving facility [5].

In low- and middle-income countries (LMICs) in particular, prehospital triage may play an even more critical role. It is estimated that more than half of deaths in LMICs are caused by conditions that benefit from prehospital and emergency care. Examples include infectious diseases, complications of pregnancy, cardiovascular disease, road traffic accidents and interpersonal violence [6]. Many LMICs have nascent EMS systems that would benefit from effective triage tools [7, 8, 9].

Regardless of country or setting, there is a general paucity of review literature appraising prehospital triage tools currently in use across the world. The only comprehensive search of prehospital triage tools to date is a 2013 systematic review which assessed patient-level outcomes attributable to validated prehospital triage systems [10]. Despite screening over 11,000 unique titles and abstracts, and performing 120 full text reviews, the authors found no studies that met their inclusion criteria, which required the triage tool to undergo direct comparison to an alternate tool or to a no triage arm. Hence, more studies are needed to better understand the state of prehospital triage across the globe in an effort to inform future EMS research and development.

The primary aim of this scoping review was to identify the breadth and diversity of published prehospital triage tools in use across the world and to understand reasons why these studies were performed. Secondarily, we sought to describe the performance characteristics of these tools to provide recommendations on which tools, if any, may be suitable for adoption in new and developing EMS systems.

Methods

We used a scoping review methodology. A scoping review is "a way of mapping key concepts that underpin a research area" [11]. It is carried out to determine the extent of research available regarding a topic and is particularly useful in disciplines with emerging evidence [11].

We reviewed scientifically peer-reviewed published literature. We focused this review on triage tools used by EMS providers at the time of single patient care in the prehospital setting. Considering our focus on triage in routine EMS care, we did not include mass casualty triage tools given their unique mode of application to sorting patients in the specific circumstance of multi-casualty events. We defined prehospital triage as the algorithmic process undertaken by an EMS provider to sort the undifferentiated patient into an appropriate category based on suspected pathology and level of acuity. Clinical treatment protocols (e.g., step-by-step prehospital asthma treatment), clinical guidelines, and singular technology-dependent triage tools (e.g., electrocardiogram (EKG) for prehospital STEMI triage) are excluded from our definition of triage.

A medical librarian performed a comprehensive literature search in December 2019. Relevant publications were identified by searching a combination of index terms and keywords for the concepts of triage and pre-hospital care in the following databases: MEDLINE (via Ovid MEDLINE® and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions®, 1946 to present), Embase (via Elsevier, Embase.com, 1947 to present), and Web of Science Core Collection (via Clarivate Analytics, including Science

Citation Index Expanded 1974 to present, and Social Sciences Citation Index 1974 to present).

Results were limited to English language articles published between 2009 and 2019 to include more contemporaneous papers that are more likely to study tools in current use. Publication types were limited to the primary literature, including observational cohort and interventional studies. Since we sought to perform a direct review of the most robust primary literature studying these tools, we excluded case reports, reviews, systematic reviews, meta-analyses, comments, editorials, letters, and conference proceedings. All results were exported to, and deduplicated in, EndNote X9 (Clarivate Analytics, Philadelphia, PA). Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) was used for screening and full text review. See Appendix 4 for a list of all database search strategies.

Retrieved articles were independently screened by two trained reviewers (A1, A2), blinded to each other's reviews. During screening, each reviewer read article titles and abstracts to determine if they satisfied inclusion criteria, and to ensure they did not meet any exclusion criteria (see Table 1). Articles were scored as 'yes', 'no', or 'maybe'. Discrepant reviews, or any reviews marked as 'maybe', were adjudicated by a third reviewer (A3).

Table 1. Article inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Prehospital/EMS focused*	In-hospital focus only
In-depth description of triage tool included[#]	Hypothetical triage tool[@]
Triage tool/process must be a main focus[$]	Systematic review/meta-analysis
Traditional ground and aeromedical EMS system	Atypical EMS systems
Observational studies with n ≥50	Observational study with n <50
Interventional studies	Triage by EMS dispatch/communications centre
	Mass casualty triage tool
	Termination of resuscitation tool
	Prehospital clinical algorithm or protocol[^]

** The study had to specifically include patient-level prehospital data.*

[#] The triage tool must be fully described within the article or through a provided reference. The tool should help the provider arrive at a specific, often binary, triage decision (e.g., Transport patient to trauma centre or not; label patient as low or high acuity).

[$] Assessment of triage outcomes or process must be a stated primary or secondary objective of the study.

[@] The triage tool is not actively used in prehospital clinical practice, is used for research purposes only, or is in development.

^ *Excludes EMS agency prehospital algorithms or protocols used for clinical management en route (e.g., "asthma protocol") or those that rely on a single diagnostic tool such as a fingerstick glucose or EKG to make a triage decision (e.g., "chest pain protocol")*

The final list of included ('yes') articles was divided between the two reviewers (A1, A2) for a full text review and critical synthesis. The full manuscript of each article was reviewed in detail, and if an article was deemed to meet one or more exclusion criteria, then it was excluded with reason(s) provided. Full text review articles were summarized in prose in a paragraph format (see Appendix 5) which note findings of most relevance to the research objectives. Data from articles were also coded in a summary table (see Appendix 6). The investigators independently appraised, then collectively discussed, all findings to reach consensus regarding key conclusions and recommendations.

The studies included in the final synthesis were assigned a four-tier quality rating (very low, low, moderate, or high) assessed by a customized scale based off the GRADE criteria, which included the study design, number of centers, and sample size (small <300, moderate 300-1000, or large >1000) [12]. For example, very low quality rating was assigned to retrospective observational studies that were single center or with small sample size, and a high quality rating was reserved for interventional, controlled, multi-center studies with large sample sizes.

Results

One thousand five hundred and twenty one unique articles were retrieved from database query (Fig. 4). After title and abstract screening, 72 (4.7%) met inclusion criteria, and 1449 (95.3%) were excluded. Out of 72 articles which had full-text reviews performed, 55 (3.6% of 1521 unique articles) were deemed relevant and included in the full-text qualitative synthesis. Seventeen articles were excluded during full-text review with reasons cited in Fig. 4. The prose format synopsis of all 55 articles can be found in Appendix 5, and a summary table of each study can be found in Appendix 6.

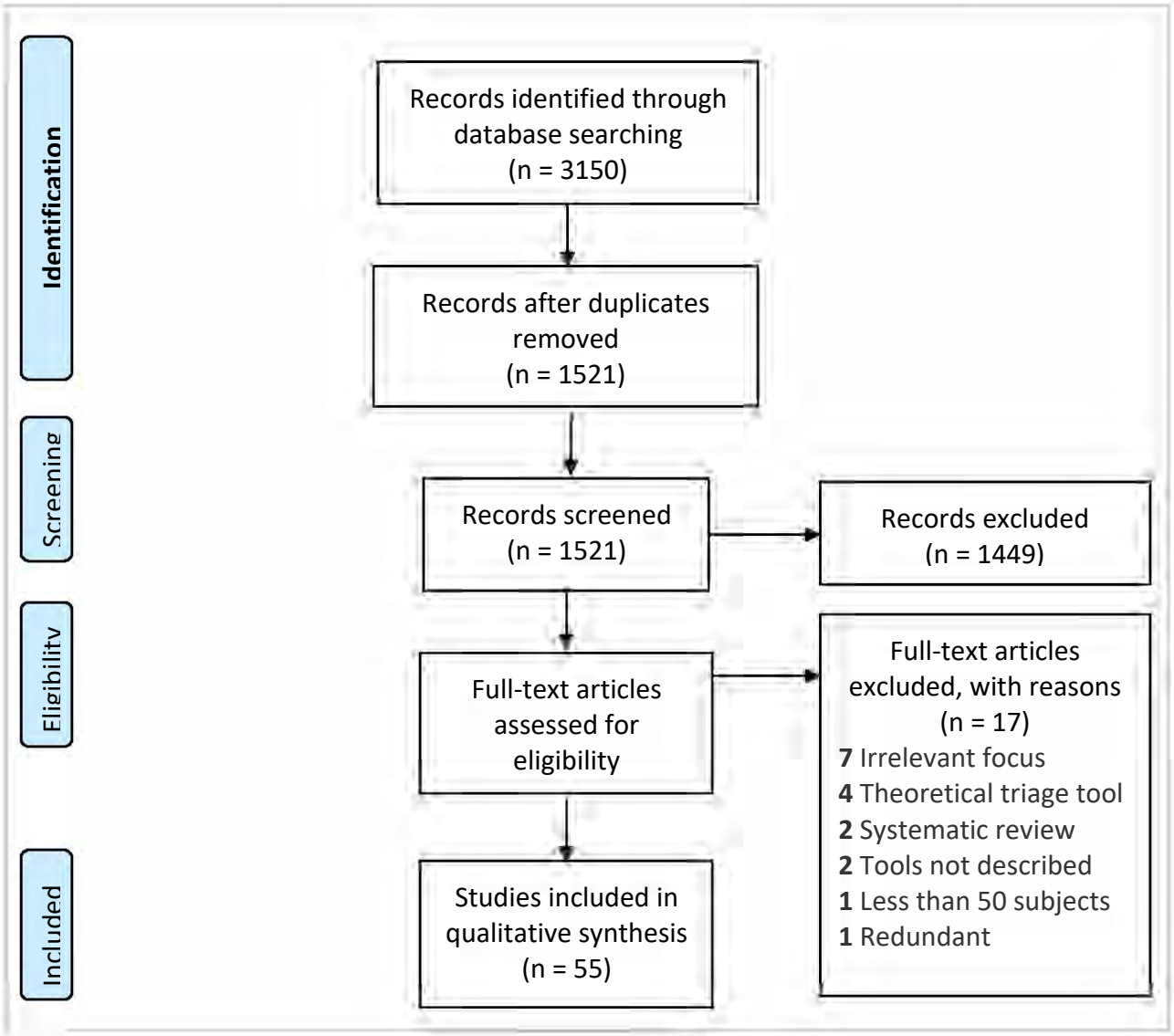

Fig. 4 PRISMA flow diagram of articles

Medical Conditions

Of the 55 studies included in our final analysis, 19 (35%) focused on stroke triage, 19 (35%) on trauma triage, and 15 (27%) on triage of general undifferentiated patients. Of the remaining 2 (3%) studies, one addressed infectious disease triage [13] and the other addressed triage of patients with only non-traumatic chief complaints [14].

Location and Design of Studies

All studies were performed in World Bank designated high income countries, with 23 (42%) in North America, 22 (40%) in Europe, 6 (11%) in East Asia and 4 (7%) in Australia. All studies were prospective or retrospective observational cohort studies with the exception of one small randomized controlled clinical trial on stroke triage [15].

Paediatric Populations

Twelve studies within the general undifferentiated triage and trauma triage categories included the paediatric population, and four (7%) focused on paediatric patients exclusively. These four studies examined the Rapid Emergency Triage and Treatment System-paediatrics (RETTS-p) tool used for general undifferentiated paediatric triage in Sweden [16, 17], the Centres for Disease Control and American College of Surgeons Committee on Trauma National Trauma Triage Protocol/Field Triage Decision Scheme (FTDS) for paediatric trauma in the United States [18], and regional paediatric trauma tools employed in England [19].

General Undifferentiated Triage Tools

The tools for general undifferentiated triage focused on standardized communication of level of acuity assignments between prehospital and emergency department providers. Frequently studied examples include the United Kingdom National Early Warning Score (NEWS), the Canadian Triage and Acuity Scale (CTAS) and the American Emergency Severity Index (ESI) [20, 21, 22]. Such tools incorporate prehospital vital signs and level of consciousness assessments [23, 24]; some also include chief complaint, exam findings, and anticipated resource needs as part of the algorithm [25, 26]. A wide variety of clinical end points were studied, including short-term, in-hospital and 30-day mortality, inter-rater reliability while using a singular scoring system (e.g., between dispatch, EMS provider, and emergency room triagist), correlation between differing prehospital and in-hospital scoring systems, need for lifesaving interventions within hours of ED arrival, and need for intensive care unit (ICU) admission. There is significant heterogeneity of clinical end points in the articles reporting all-comer triage tools. Consequently, a single triage tool in this group with the best performance metrics could not be identified.

Stroke Triage

From 19 (35%) articles, we found 18 different stroke prehospital triage tools designed to aid with the recognition of acute stroke. The most commonly studied stroke triage tools were the Rapid Arterial Occlusion Evaluation (RACE, n =5 studies, 26%), Cincinnati Prehospital Stroke Scale (CPSS; n =4, 21%), Field Assessment for Stroke Triage for Emergency Destination (FAST-ED, n =4, 21%), and Los Angeles Motor Scale (LAMS, n =3, 16%). The

authors stated the ultimate aim of prehospital stroke triage is to ensure timely transport of patients with acute ischemic stroke to designated stroke centres that have capabilities for neuroimaging, administration of thrombolytic agents and/or endovascular intervention. According to the authors, these tools also aim to channel patients presenting with stroke mimics, such as hypoglycaemia or seizure, away from the major stroke centres to optimize health system resource utilization. Finally, several articles argued that stroke triage tools aim to be easy to use and efficient to administer in the prehospital setting, and to correlate well with the gold standard tools used by in-hospital providers, such as the National Institutes of Health stroke scale (NIHSS) [27]. Of the 19 articles assessed, 10 (53%) used the NIHSS as the referential standard of comparison, or as a model from which scales were derived. Clinical end points for the stroke triage studies were diverse and included: detection of large vessel occlusion (LVO), diagnosis of stroke/transient ischemic attack, tissue plasminogen activator (tPA) administration rate, stroke team activation, accurate destination triage decision, and inter-rater reliability.

The highest quality studies for stroke triage evaluated the RACE scale. RACE evaluates five items: facial palsy, upper extremity paresis, lower extremity paresis, head and gaze deviation, and aphasia/agnosia, with a total score of 0 to 9. For example, in a large prospective study in Spain, Carrera et al. validated RACE among a cohort of 1822 patients and found a sensitivity of 84% and specificity of 60% for detecting large vessel occlusion (LVO) for RACE score ≥5. 35% of the patients with a RACE ≥5 had LVO, compared with 6% LVOs with a RACE < 5 ($p<0.001$) [28]. Jumaa et al. found that RACE ≥5 had a sensitivity of 77% and specificity of 75% for LVO eligible for mechanical thrombectomy among a cohort of 1147 patients in the United States [29]. Additional scales that have undergone head-to-head comparisons with RACE with comparable performance include the FAST-ED and the CPSS tools [30, 31]. The performance characteristics of FAST-ED and CPSS were assessed in 5 (26%) of articles. Overall, both have comparable sensitivity (56-83%) and specificity (60-89%) for LVO prediction [30, 31].

Trauma Triage – Ground EMS

A common objective of included trauma triage articles was to accurately identify injured patients that require emergent transport to designated trauma centres. The studies on

trauma triage more consistently used similar end points, including trauma centre need, under-triage and over-triage rates, and survival to discharge. Trauma centre need was uniformly defined as Injury Severity Score (ISS) > 15, need for urgent surgical intervention, or need for intensive care unit level care.

The majority of trauma triage tools identified are based off of the FTDS [32] which appears to be the de facto standard in studies originating from the USA. Since its initial publication in 1986, the FTDS has been revised five times: in 1990, 1993, 1999, 2006 and 2011. According to the articles, the FTDS uses stepwise identification of four aspects of clinical presentation involving physiologic criteria, anatomic criteria, mechanism of injury criteria, and special considerations criteria to identify patients requiring transport to a trauma centre. Physiologic criteria focus on vital signs and Glasgow Coma Scale (GCS); anatomic criteria include specific severe injury patterns such as penetrating trauma, flail chest and crush injury; mechanism of injury criteria focuses on high energy mechanisms such as falls from specific height, high speed vehicular crash, and motorcycle accidents; and special considerations include extremes of age, high risk comorbidities, burns, pregnancy, and anticoagulated status [32].

The highest quality study of FTDS performance within this scoping review was conducted by Newgard et al. in 2011; it evaluated the performance characteristics of the 2006 version of FTDS, with a cohort of 122,345 injured patients evaluated and transported by EMS over a 3-year period [33]. Major trauma was defined as ISS > 15, and the overall sensitivity and specificity of the FTDS criteria for identifying major trauma patients were 86% (95% CI 85% to 87%) and 69% (95% CI 68% to 69%), respectively. Triage sensitivity and specificity, respectively, differed by age: 84% and 66% (0 to 17 years); 90% and 64% (18 to 54 years); and 80% and 75% (≥55 years). Overall, FTDS appears to have comparatively reduced sensitivity and increased specificity in detection of trauma in elderly patients.

Other frequently studied ground EMS tools included the Vittel criteria (France) [34, 35], Dutch Field Triage Protocol (Netherlands) [36,37], and Prehospital Index (Canada) [37, 38].

Trauma Triage – Aeromedical EMS

Three studies focused on the use of trauma triage tools to decide on the utility of helicopter transport [39, 40, 41]. Brown et al. conducted a US retrospective cohort study of 258,387 trauma patients (16% transported by helicopter, remainder by ground) and found odds of increased survival to discharge for patients transported by helicopter in the following FTDS conditions: GCS <14 (adjusted Odds Ratio 1.22); respiratory rate <10 or >29 (aOR 1.32), penetrating injury (aOR 1.40), or age> 55 (aoR 1.15) [40]. In 2017, Brown et al. investigated the Air Medical Prehospital Triage (AMPT) score, which awards points for low GCS, abnormal respiratory rate, unstable chest wall injury patterns, paralysis, multisystem trauma, or fulfilment of any physiologic plus anatomic criterion from FTDS. The authors found that helicopter EMS increases odds of in-hospital survival by 6.7% for patients with AMPT score ≥ 2 (Absolute Risk Reduction 1.067; 95% CI 1.040—1.083, p<0.001, n=222,827) [41].

Trauma Triage – Traumatic Brain Injury

Two studies by Fuller et al. focused on predictive tools for triaging severe traumatic brain injury (TBI) in the field [42, 43]. The authors studied the Head Injury Transportation Straight to Neurosurgery study (HITS-NS) triage tool and London Ambulance Service major trauma triage tool and found that both had poor sensitivity (<45%) for detection of severe TBI which was concerning for EMS providers missing TBIs [42,43].

Simplifying Triage Tools

While most trauma triage studies investigated performance characteristics of established tools, a subset attempted to identify ways to further simplify tools for EMS providers [34,44]. These studies emphasized the challenges of designing the ideal triage tool: the design must optimize over and under-triage rates while remaining streamlined and user friendly to promote widespread adoption.

Discussion

Our scoping review found 55 studies on prehospital triage tools published within the past decade. These tools focused on general undifferentiated, trauma, and stroke populations and all included studies originated from high-income countries. Studies predominantly sought to assess predictive accuracy of the triage tools compared to in-hospital clinical

outcomes, and many studied accuracy in simplified versions of existing tools. These published triage tools are generally designed to help prehospital providers determine destination of transport, means of transport and level of acuity. These tools also appear to provide a shared language for prehospital personnel to communicate with other emergency personnel, and assist in identifying vital sign derangements and exam findings across a spectrum of age ranges to differentiate 'acute' and 'non-acute' patients.

Trauma and stroke tools comprised over two-thirds of the included articles, perhaps because of their clinical and health systems significance. Outcomes for trauma and stroke depend on timely field recognition and are influenced by highly time sensitive interventions that are destination-dependent [45, 46]. Further, trauma and stroke care are regionalized in many high-income countries, therefore right patient destination are important to study for trauma and stroke system optimization. Last, both stroke and trauma outcomes are used to drive 'benchmarking' for health system accreditation and funding, which may also drive their importance as a research topic [47, 48, 49].

In trauma, the US FTDS appears to be the "industry standard" triage tool used, likely reflecting that the majority of our studies were from North America, specifically, the USA. As the majority of tools within the trauma triage literature derive from the FTDS, this well-researched tool is a promising starting point for further simplified trauma triage tool development, such as identifying individual components that may predict clinically relevant trauma outcomes. The trauma literature was relatively cohesive in that most studies used common clinical end points, which facilitates comparisons across studies.

In stroke care, while no single tool emerged as the prehospital triage 'gold' standard, the RACE, FAST-ED and Cincinnati Prehospital Stroke scales appear to have the highest quality data supporting their use. The National Institutes of Health Stroke Scale was presented in multiple studies as the gold standard in-hospital tool which was used for comparison.

The all-comer triage literature includes a myriad of tools with varying complexity, from those that incorporate vital signs alone (e.g., NEWS), to those with complex diagnostic algorithms incorporating history and exam findings to arrive at a level of acuity designation

(e.g., CTAS). No one tool emerged as a clear gold standard, and authors' use of a wide variety of clinical end points which make cross comparisons challenging.

Research themes common to these studies include simplifying existing tools such that they are efficient and accurate for the EMS provider to derive an accurate triage decision, and to identify the most accurate tool out of a large cadre of tools currently available. Standardized reporting of clinical end points would facilitate this endeavour in future research. Additionally, we noted a paucity of articles researching implementation or assessing end user perspectives [28, 50, 51], and no studies examined costs associated with triage decisions. Qualitative studies, cost analyses, and implementation studies would be helpful to further our understanding of the value provided by prehospital triage tools.

Lastly, all the studies included in this scoping review were performed in a few high-income settings, and the tools may not translate well to other high-income settings or LMICs with a different healthcare configuration, infrastructure and cadres of prehospital providers. Destination decision making would need to be locally-determined, especially in LMICs where specialty diagnostic (e.g., computed tomography scanners) and therapeutic resources (e.g., tPA) may be even more scarce. Further, triage tools may need to be tailored based upon regional injury and illness patterns. For example, prehospital triage of obstetric emergencies was notably missing from our review. Jenson et al. performed a systematic review of emergency department (i.e. in hospital) triage tools in LMICs and identified the South Africa Triage Scale (SATS), modified Early Warning Score and the Australasian Triage Scale as promising tools that had been validated across multiple studies in LMIC settings [8]. SATS has been implemented in the prehospital setting in South Africa and studies analysing performance characteristics, while on-going, are yet to be published [52].

In recent years, prehospital care has received increased recognition in international health policy. Data extrapolated from the Global Burden of Disease study show that 24 million lives are lost each year in LMICs due to conditions sensitive to prehospital and emergency care. Ischemic heart disease, cerebrovascular accidents, and unintentional injuries are the largest contributors to morbidity and mortality in these settings [6, 53]. In 2019, delegates to the 72nd World Health Assembly adopted a resolution to strengthen emergency and trauma

care systems and prehospital care was highlighted as an essential component [54]. Prehospital triage tools are a key building block for quality and safety assurance in the development of novel EMS systems [55]. It is our hope that this scoping review has provided a valuable framework for what is known thus far, and that further research will be done to advance the field.

Limitations

The authors acknowledge the following limitations of this scoping review. First, the review was limited to English language publications. This may have excluded triage tools published in non-English journals. Secondly, the review was limited to only peer-reviewed published literature; it is likely that white papers and other non-peer-reviewed papers discuss additional triage tools currently in use. Lastly, inherent to this study's design as a scoping review, the authors were unable to draw quantitative conclusions about the performance characteristics of the tools presented.

Conclusions

This scoping review found that the majority of literature on prehospital triage focused on trauma and stroke specifically, with a few reports on triage tools for general undifferentiated patients. Much of this body of work originates from high income countries. The Field Triage Decision Scheme for trauma, and the Rapid Arterial Occlusion Evaluation for stroke, are especially well studied tools which may serve as tools for emerging EMS systems or as good starting points for simplified adaptations for established EMS systems. We found no single universally accepted or 'standard' prehospital triage tool. Future research should focus on implementation analysis and real-world application of these tools. Additionally, research efforts could focus on the development a valid and reliable prehospital triage tool for the undifferentiated patient that is suitable (with light adaptation) to a variety of contexts, especially EMS systems in low- and-middle income countries.

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2.4 Chapter Discussion

The findings from this worldwide scoping review were useful to provide necessary global relevance and context for SATS as a prehospital triage tool. First, the fact that we found no studies on prehospital triage or tools from low- and middle-income countries was profound, although this was not surprising given the relative maturity of EMS systems in high-income countries compared with lower income and African countries.(5, 43, 44) Second, we found that the predominance of scientifically published work on prehospital triage focused on trauma and stroke, with relatively few focused on tools for triage of the undifferentiated patient. Together, the first and second points were compelling arguments for the need for further research on the topic of prehospital triage of the undifferentiated patient, especially in lower-income settings. Next, we concluded that there was no clear "universally accepted" prehospital triage tool – although not surprising, this finding specifically heightened the relevance of SATS and underscored the need for further research of tools capable of triaging all-comer prehospital patients. Last, the research focus of these tools indicated that published triage tools were commonly scrutinized to assess their accuracy and reliability, including ways their use could be simplified for prehospital practitioners, which was reaffirming considering the similar focus of the quantitative questions posed by this thesis.

2.5 Chapter Conclusion

In conclusion, the findings from this scoping review made for a highly compelling case for the scientific study of SATS as a prehospital triage tool, thereby justifying the research presented herein. This was primarily due to the following attributes of SATS, based on our prior experiences and knowledge before conducting this PhD thesis work: (i) that SATS was being used for prehospital triage of undifferentiated populations; (ii) that prehospital SATS was being used in a resource-constrained health system; (iii) that no prior scientific studies of prehospital SATS existed. Hence, we expected that findings from this prehospital SATS

research would help to address a discrete scientific gap and advance the field of prehospital triage, specifically in lower income settings, and generally across the world. Locally, findings could help support the innovative use of SATS and/or inform changes to SATS that could improve its impact to the Western Cape health system.

CHAPTER 3: VALIDITY AND RELIABILITY OF SATS IN PREHOSPITAL PROVIDERS.

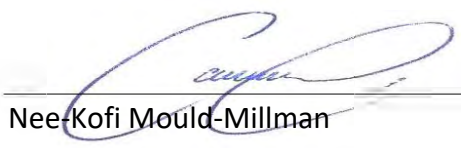
3.1 Declaration from author and co-authors

The following co-authors contributed to the publication: Dr. Julia M. Dixon, Dr. Taylor Burkholder, Ms. Jennifer L. Pigoga, Mr. Michael Lee, Dr. Shaheem de Vries, Mr. Kubendhren Moodley, Ms. Maxene Meier, Dr. Kathryn Colborn, Ms. Chandni Patel, Prof. Lee A. Wallis.

Contributions of the authors were as follows: Nee-Kofi Mould-Millman (NMM) conceived of the study with input from LAW and JD. NMM developed the objectives and designed the study methodology. JD and TB helped to refine the study approach. NMM adapted the hospital vignettes for use in this study. NMM designed and pilot tested the data collection instruments. NM, JD, TB and JP collected the data. NMM and JD cleaned the data. KC and MM performed the analysis. NMM interpreted the findings with assistance from KC and MM. NMM outlined and drafted the first version of the paper. All other authors contributed to interpretation of findings and provided critical revisions to the manuscript. All authors approved the final version and agreed to be accountable for the final version. The extent of contributions from each person are as follows:

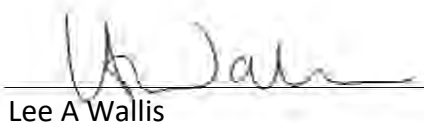
- NMM: 45%
- JD: 15%
- TB: 15%
- JP: 5%
- KM: 5%
- ML: 2.5%
- SdV: 2.5%
- MM: 5%
- CP: 2%
- LAW: 3%

Given the large number of co-authors, the principal investigator and the supervisor hereby sign for approval on behalf of the group, in accordance with the UCT Doctoral Degrees Board guideline titled, “GUIDELINES FOR THE INCLUSION OF PUBLICATIONS IN A DOCTORAL THESIS.”



22-June-2021

Nee-Kofi Mould-Millman — Date



30 August 2021

Lee A Wallis — Date

3.2 Synopsis

3.2.1. Rationale for conducting the study

Western Cape Government EMS innovatively began using SATS as a prehospital triage tool in 2012. Until this research was conducted, SATS had only been studied and validated for in-hospital triage of the undifferentiated patient, in South Africa and in a few low-resource settings outside South Africa. One scientific question that is important to answer during the development or application of triage tools is how the instrument quantitatively performs. While there are many measures of 'performance', we chose to focus on those most reported in the scientific literature: validity (i.e., how it correlates with the true triage accuracy) and reliability (i.e., does it repeatedly generate the same results across users).(28, 36-38) Since this was the first formal assessment of prehospital SATS, we chose to stay methodologically aligned with earlier in-hospital SATS validation studies, and we performed this research using case-based vignettes in a written examination format.(36-38) This was advantageous for several reasons, including practicality, case standardization, data completion, and clinical representativeness.

3.2.2. Aim and objectives

The aim of this work was to conduct the first appraisal of prehospital SATS performance by WCG EMS practitioners.

The objectives of this study were to assess the inter-rater reliability (i.e., consistency among raters) and validity (i.e., triage accuracy) of the SATS when used by WCG EMS prehospital providers for single-patient triage. Triage accuracy was measured as over- and under-triage rates, a common outcome measure for triage tools.(28, 36-38)

3.2.3. Main results

- We completed assessments of 102 WCG EMS providers with diverse ranks. Overall, SATS had modest inter-rater reliability but poor validity.
- SATS attained a reasonable over-triage rate (13.1%). This implied that a reasonable rate of patient transports occurred to unnecessarily higher levels of care (13.1% over-triage was not felt to be overly wasteful of resources).

- SATS had a very high under-triage rate (29.5%). We inferred this could frequently result in missing dangerous conditions and/or inappropriate transport to lower levels of care, culminating in the potential for patient harm.
- TEWS was very often (57%) incorrectly computed, with most errors being due to under-calculation of the TEWS compared to the actual score.
- The clinical discriminators were incorrect in about 40% of cases, and discriminators demonstrated poor inter-rater reliability.

Below (in section 3.3) is the verbatim content of the published manuscript, immediately followed by the references from the manuscript. The context and meaning of the published paper are described in detail in the rest of the chapter (i.e., sections 3.4 – 3.5).

3.3 Published article

(The article is published in BMC Emergency Medicine; it is presented verbatim on pages 49-65)

Validity and reliability of the South African Triage Scale in prehospital providers.

(BMC Emerg Med. 2021 Jan 15;21(1):8. doi: 10.1186/s12873-021-00406-6.)

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Abstract

Background. The South African Triage Scale (SATS) is a validated in-hospital triage tool that has been innovatively adopted for use in the prehospital setting by Western Cape Government (WCG) Emergency Medical Services (EMS) in South Africa. The performance of SATS by EMS providers has not been formally assessed. The study sought to assess the validity and reliability of SATS when used by WCG EMS prehospital providers for single-patient triage.

Methods. This is a prospective, assessment-based validation study among WCG EMS providers from March to September 2017 in Cape Town, South Africa. Participants completed an assessment containing 50 clinical vignettes by calculating the three components — triage early warning score (TEWS), discriminators (pre-defined clinical conditions), and a final SATS triage color. Responses were scored against gold standard answers. Validity was assessed by calculating over- and under-triage rates compared to gold standard. Inter-rater reliability was assessed by calculating agreement among EMS providers' responses.

Results. A total of 102 EMS providers completed the assessment. The final SATS triage color was accurately determined in 56.5%, under-triaged in 29.5%, and over-triaged in 13.1% of vignette responses. TEWS was calculated correctly in 42.6% of vignettes, under-calculated in 45.0% and over-calculated in 10.9%. Discriminators were correctly identified in only 58.8% of vignettes. There was substantial inter-rater and gold standard agreement for both the TEWS component and final SATS color, but there was lower (moderate) inter-rater agreement for clinical discriminators.

Conclusion. This is the first assessment of SATS as used by EMS providers for prehospital triage. We found that SATS generally under-performed as a triage tool, mainly due to the clinical discriminators. We found moderate inter-rater reliability, but poor validity. The under-triage rate of 30% was higher than previous reports from the in-hospital setting. The over-triage rate of 13% was acceptable. Further clinically-based and qualitative studies are needed.

Keywords: EMS; SATS; South Africa Triage Scale; Triage; Prehospital

Background

Medical triage is the process of systematically sorting patients based on acuity and anticipated resource need.[1,2] Triage facilitates delivery of timely, quality care by mobilizing the right type of care for the right patient at the right time.[3] In a patient experiencing an acute stroke or myocardial infarction, for example, triage performed by emergency medical services (EMS) providers may allow earlier prehospital recognition of the acute condition thereby triggering faster delivery of appropriate pre- and in-hospital care to help minimize morbidity and mortality.[1-3]

Several in-hospital triage tools exist that are commonly used to triage undifferentiated patients on arrival to emergency departments, many with demonstrated clinical and operational benefits. In the prehospital setting, a singular, internationally-accepted tool or system for the initial triage of undifferentiated emergent patients in the field by EMS providers does not exist.[1-3]

A 2018 systematic review of in-hospital adult emergency care triage tools used in low-and-middle income countries concluded that the South African Triage Scale (SATS) had the highest quality of evidence with sensitivity and specificity of 70-75% and 91-97%, respectively.[4] Additionally, a prior South African emergency center study found SATS had an over-triage rate of 15% and under-triage rate of 10%.[2] SATS was originally developed in 2006, created for and validated amongst in-hospital emergency care physicians and nurses in South Africa.[5-8] To use SATS, a numerically-based Triage Early Warning Score (TEWS) is first calculated from the total of a numerical score to each of five vital signs, mobility and trauma and can range from 0-17. A Score of 0, 1, or 2 is assigned green; 3 or 4 is yellow, 5 or 6 is orange and 7 or greater is red. If a “discriminator” (i.e., a high-risk clinical condition such as chest pain or current seizure) is present the patient’s triage color is upgraded to match the category assigned to each clinical discriminator in the SATS reference table (see Figure 3 and 7). The final SATS colors used to denote triage acuity and priority, from highest to lowest acuity, are: Red, Orange, Yellow, and Green; Blue is dead).[2,6,9,10]

In 2012, SATS was incorporated into routine prehospital emergency care use by the Western Cape Government (WCG) EMS system. The WCG EMS system is a public EMS system that provides 24/7 ambulance services to a catchment population of over six million in the Western Cape Province of South Africa.[11] In 2017, WCG EMS employed approximately 2000 operational EMS providers in across three cadres: basic, intermediate, and advance life support (BLS, ILS, and ALS, respectively); they executed approximately 450,000 ambulance responses, and providers are expected to use SATS in all clinical cases.[11,12]

Although all cadres of EMS providers have the skills and tools to derive the SATS triage score in an ambulance, SATS was not intended for, nor formally adapted to, prehospital emergency care.[9] To date, the prehospital triage performance characteristics of SATS remain unstudied. Accurate prehospital triage is necessary to minimize under-triage which can lead to inadequate intervention or transport to lesser-equipped facilities, and over-triage which can result in wasteful and harmful unnecessary interventions or transport to over-burdened tertiary facilities.[13]

Methods

Aim

The objective of this study is to assess the inter-rater reliability (i.e., consistency among raters) and validity (i.e., triage accuracy) of the SATS when used by WCG EMS prehospital providers for single-patient triage.

Design

The study was designed as a prospective, assessment-based validation study among WCG EMS providers from March to September, 2017 in Cape Town, South Africa.

Setting and Participants

At the time of this study, foundational education for WCG EMS providers from across the Western Cape Province included a 6-week certificate courses for BLS (recently discontinued), a 12-week course for ILS (soon to be replaced with a 1-year certificate), and a 2-year (diploma) and 4-year (degree-earning) training for ALS providers.[14] WCG EMS

providers responded to over 500,000 calls per year, of which approximately 40% are trauma cases.[11,12] Providers often staff ambulances as a mixed-tier crew (e.g., BLS with ILS, or BLS with ALS). BLS providers' scope of practice is limited and best described as advanced first aid (e.g., airway suctioning, splints and wound care) plus cardiopulmonary resuscitation with general access to a relatively narrow selection of medications (e.g., oxygen, oral glucose and oral non-opioid analgesics). ALS providers, however, can deliver a wide variety of drugs and may perform advanced cardiac, trauma, and critical care life support and procedures, including endotracheal intubation and ventilator management. ILS providers' scope of practice lies between BLS and ALS, and ILS providers can perform several invasive interventions and deliver a narrow selection of intravenous drugs.[12]

Initial training on the use of SATS occurred "on the job" by educators within the EMS system – however, all cadres of providers received the same SATS training. WCG EMS providers intermittently may participate in various refresher trainings, short courses, and advancement courses which are offered at the Western Cape Province College of Emergency Care several times per year. Topics at the College cover a variety of clinical and non-clinical content (e.g., leadership training). All providers enrolled in courses at the College during the study period were eligible to participate in this study. One BLS, one ILS, and one ALS cohort each at the College was chosen from which study participants would be enrolled.

Recruitment

From March to September 2017, study investigators recruited a convenience sample of 102 participants from the College. Sample size calculations were based on an intraclass correlation coefficient (ICC; a descriptive statistic used when quantitative measurements are made on units that are organized into groups) of 0.2, power of 0.9, and alpha set of 0.05. None of the participants were actively enrolled in courses at the College that pertained to triage nor use of SATS.[15] Participants from classroom cohorts of BLS, ILS and ALS providers were approached for consent. Staff at the College of Emergency Care delivered advanced advertisement of the study to eligible classes. A study staff member verbally reviewed informed consent with all potential participants, and written consent was obtained from each willing participant.

Assessment

Participants were briefed on the assessment procedures by a study investigator (JP, TB). Participants were individually administered the written SATS assessment under supervision of one study investigator. Participants were each given an examination booklet and a standard SATS adult color reference table (routinely available in their clinical practice). Each assessment was administered in an examination booklet, comprised of 50 clinical vignettes of adult prehospital emergency cases typical for the Western Cape Province (see sample vignette in Figure 1).

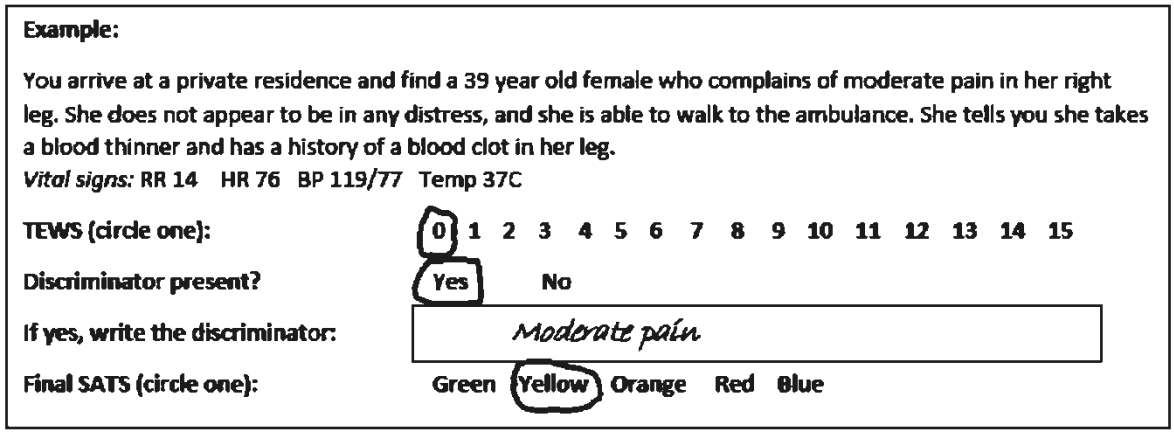

Figure 1: Sample vignette from the SATS written assessment

The 50 vignettes were retrieved from a larger set of 100 validated vignettes previously used for hospital staff assessment of SATS.[2] Vignettes were purposefully selected to represent a mixture and balance of case types and SATS distributions that are representative of those seen by WCG EMS. The case context in the original hospital-based vignettes were lightly edited by study investigators (NM, TB, JD) to reflect the prehospital context, but the core clinical scenario and gold standard TEWS, discriminator, and final SATS were unchanged.[10-14] Twomey and co-investigators from the hospital-based study re-scored all 50 vignettes by re-providing gold standard TEWS, discriminators, and SATS answers for each vignette. There were 19 trauma and 31 medical vignettes. Selected vignettes had the following gold standard SATS color (i.e., final triage color): 5 green, 15 yellow, 23 orange, 6 red and 1 blue. By SATS convention, blue is dead on arrival, red denotes the highest triage acuity, followed

by orange, yellow and green corresponds to the lowest acute). The correct TEWS responses in vignettes ranged from 0 to 13. See Appendix 7 for all vignettes.

Data Collection

Each participant provided demographic information (age, sex, qualification, years of experience, and current district). For each clinical vignette, participants provided a TEWS value (between 0-17), a clinical discriminator (if applicable), and the final SATS color. Responses were manually entered into a password-protected Microsoft Excel spreadsheet Version 15.0 (Microsoft Corporation, Redmond, Washington, USA) by a study staff member. A second research team member manually verified accurate data entry from a random selection of 10% of assessments.

Analysis

Reliability was assessed by inter-rater reliability, defined as level of agreement in vignette item (i.e., TEWS, discriminators, and SATS) responses among EMS providers. Validity (i.e., triage accuracy) was assessed using mistriage rates, defined as rates of over- or under-triage when comparing EMS raters to gold standard vignette responses.

Cleaned data were exported from the Microsoft Excel spreadsheet into a statistical software program R, version 3.4.0 (R Core Team, Vienna, Austria). Demographic data were descriptively analyzed. Vignette responses were scored in comparison to the gold standard answers to calculate the proportions of TEWS or SATS that were under, over or accurately determined (e.g., a score of Orange is considered under triage if the gold standard score is Red), and the proportion of discriminators that were missing, correct or incorrect.

A novel statistical measure of agreement, Sklar's Omega, was used. Sklar's Omega is a Gaussian copula-based framework that permits estimation of the degree of agreement between the EMS providers' scores and the gold standard physicians' scores.[16] Confidence intervals were estimated using bootstrapping methods with 1,000 iterations. Traditional interpretations of agreement were used: less than 0.2 represented slight agreement, between 0.2 and 0.4 fair agreement, between 0.4 and 0.6 moderate agreement, between 0.6 and 0.8 substantial agreement, 0.8 or greater was considered near-perfect agreement.[17]

The absolute difference between the overall expected agreement with gold standard and inter-rater was averaged to find an overall average difference for each vignette.

Ethics approval and consent to participate

Ethical approval was received from the University of Cape Town Human Research Ethics Committee (HREC ref no: 705/2016) and the Colorado Multiple Institution Review Board (protocol no: 16-2271). Written institutional approval was obtained from WCG EMS. Informed written consent was obtained from all participants of the study (see informed consent form in Appendix 8).

Results

The assessment was completed by 102 WCG EMS providers with mean age of 35-years (SD 7.7) and mean field experience of 6.3-years (SD 5.5) (Table 2). A total of 5100 vignette responses (i.e., 50 vignettes x 102 EMS provider respondents) were available for analysis.

Table 2: Western Cape Government EMS provider characteristics (N=102)

Characteristics	**Participants, n (%)**
Sex	
Male	50 (49)
Female	41 (40)
Missing	11 (11)
Qualification	
BLS	59 (58)
ILS	37 (36)
ALS	6 (6)
Location of Practice	
Rural	42 (41)
Metropole	52 (51)
Missing	8 (8)
Mean age (SD; range)	35 years (7.8; 21-55)
Mean Field Experience (SD; range)	6.3 years (5.5; 0.9-30.2)

Legend: ALS: advanced life support. BLS: basic life support. ILS: intermediate life support. SD: standard deviation.

Overall, the final SATS triage color was accurately determined in 2883 (56.5%) vignette responses. The under-triage rate was 29.5%, and the over-triage rate was 13.1% (Table 3). The highest proportion of under-triage occurred in vignettes with gold standard SATS of red (300, 49%), and over-triage most often occurred in vignettes with a gold-standard SATS of green (213, 41.8%). There were similar proportions of under-triage in trauma (559, 28.8%) and medical vignettes (947, 30.0%) (Table 3). The over-triage rate was also similar in medical (400, 12.7%) and trauma (266, 13.7%) cases.

Table 3: Comparison of participant and gold standard vignette TEWS, discriminator, and SATS responses.

	SATS Color vignette responses*				
	Correct (%)	**Under-Triaged (%)**	**Over-Triaged (%)**	**Missing (%)**	**Total (%)**
Overall	2883 (56.5)	1506 (29.5)	666 (13.1)	45 (0.9)	5100 (100)
Gold Standard					
Red	307 (50.1)	300 (49.0)	n/a	5 (0.8)	612 (100)
Orange	1268 (54.0)	867 (37.0)	189 (8.1)	22 (0.9)	2346 (100)
Yellow	918 (60.0)	334 (21.8)	264 (17.2)	14 (0.9)	1530 (100)
Green@	294 (57.7)	n/a	213 (41.8)	3 (0.6)	510 (100)
Blue^	96 (94.1)	5 (4.9)	n/a	1 (1.0)	102 (100)
Trauma	1098 (56.7)	559 (28.8)	266 (13.7)	15 (0.8)	1938 (100)
Medical	1785 (56.4)	947 (30.0)	400 (12.6)	30 (1.0)	3162 (100)
	TEWS vignette responses*				
	Correct (%)	**Under-Calculated (%)**	**Over-Calculated (%)**	**Missing (%)**	**Total (%)**
Overall	2173 (42.6)	2296 (45.0)	555 (10.9)	76 (1.5)	5100 (100)
Gold Standard					
Red	107 (17.5)	482 (78.8)	21 (3.4)	3 (0.3)	612 (100)
Orange	1103 (47.0)	915 (39.0)	299 (12.8)	29 (1.2)	2346 (100)
Yellow	653 (42.7)	670 (43.8)	189 (12.4)	18 (1.2)	1530 (100)
Green	306 (60.0)	158 (31.0)	41 (8.0)	5 (1.0)	510 (100)
Blue	4 (3.9)	48 (47.1)#	28 (27.5)	22 (21.6)	102 (100)
Trauma	569 (39.4)	1141 (58.9)	184 (9.5)	44 (2.3)	1938 (100)
Medical	1604 (50.7)	1155 (36.5)	371 (11.7)	32 (1.0)	3162 (100)

** 102 respondents each completing a 50-vignette assessment = 5100 vignette responses in total.*

@ Green patients are lowest acuity, so under-triage is not possible

^ Blue patients are dead, so over-triage is not possible

 # Includes 43 vignette responses in which TEWS was scored as 0

Compared to the gold standard, the TEWS score was correctly calculated in 2173 (42.6%), under-calculated in 2296 (45.0%), and over-calculated in 555 (10.9%) of all vignette responses (n=5100) (Table 3). TEWS was most often incorrect in trauma cases (1325, 68.4%), mostly attributable to under calculating the score in 1141 (58.9%) of trauma vignette responses.

TEWS was most often under-calculated in vignettes with a final SATS of red (482, 78.8%) and over-calculated in cases with gold standard SATS of orange (299, 12.8%), yellow (189, 12.4%), and green (41, 8.0%), but least-often over-calculated in cases with gold standard SATS of red (21, 3.4%).

Out of 50 vignettes, 42 (84%) had at least one discriminator which was correctly identified (yes/no) in 3570 (70.0%) of all 5100 vignette responses (Table 4). Further, the specific discriminator was correctly listed in 2521 (58.8%) of applicable vignette responses (Table 4). Of the 1506 vignette responses that were under-triaged, the selected clinical discriminator was seldom correct (392, 26.0%) and very often incorrect (1114, 74.0%). The discriminator was incorrect or missing in 1017 (52.5%) of trauma and in 1526 (48.3%) of medical vignette responses. The clinical discriminator was correctly identified for 183 (29.9%) of red, 1231 (52.5%) of orange, 826 (54.0%) of yellow and 242 (47.5%) of green SATS gold-standard cases. The most frequent error regarding use of discriminators occurred in cases where no discriminator was expected (per gold standard) of which participants selected that a discriminator was indicated in 360 (44.1%). High energy transfer, burn circumferential and reduced level of consciousness had the lowest percentages of correct discriminator use, with 31 (15.2%), 18 (17.6%) and 54 (17.6) of relevant vignette responses, respectively (Figure 2).

Table 4: Use of discriminator in vignettes.

Respondents' answer correctly indicated that:	**Vignettes in which final SATS was:**				**All Cases (%)**
	Correct (%) N=2883	**Under-Triaged (%) N=1506**	**Over-Triaged (%) N=666**	**Missing (%)***	

A discriminator was, or was not, needed	2309 (80.1)	851 (56.9)	379 (56.9)	31 (0.9)	3570 (70.0)[#]
Discriminator was correctly explained	1912 (66.3)	392 (26.0)	202 (30.3)	15 (0.6)^	2521 (58.8)^

Note: row percentages do not add to 100% because multiple vignettes had more than 1 discriminator.

** Missing % = n from missing / n from row total.*

[#] N=5100 total vignette responses (i.e., 50 vignettes each with 102 respondents)

^ N=4284 total eligible vignette responses (i.e., 42 vignettes each with 102 respondents)

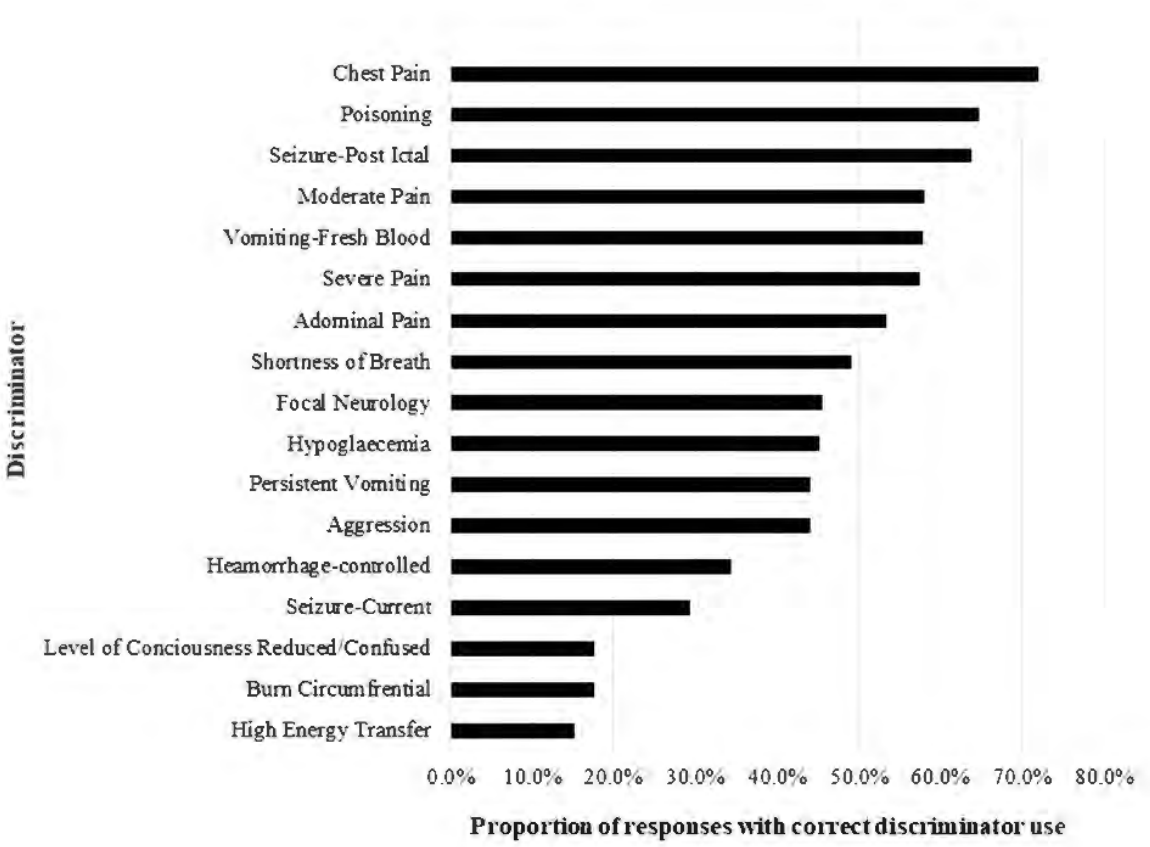

Figure 2: Accuracy of discriminators used in vignettes.

Table 5 summarizes the results of the agreement calculations. Inter-rater agreement among prehospital providers was consistently stronger than agreement between providers and gold standard when assessing SATS, TEWS, and the discriminator. Overall, there was substantial inter-rater and gold standard agreement for TEWS that ranged from moderate to substantial. SATS performed similarly with substantial agreement for both inter-rater and providers' agreement with gold standard. Discriminator agreement was moderate for inter-rater and gold standard comparisons.

Table 5: Agreement among providers, and agreement between providers and gold standard.

	Inter-Rater Agreement Mean (95% CI)	Agreement with Gold Standard Mean (95% CI)
TEWS	0.690 (0.552, 0.781)	0.677 (0.557, 0.783)
SATS	0.710 (0.577, 0.804)	0.695 (0.588, 0.791)
Discriminator	0.589 (0.440, 0.712)	0.491 (0.371, 0.592)

Legend: TEWS: Triage Early Warning Score. SATS: South African Triage Scale.

Table 6 summarizes the top 5 most influential vignettes on the total inter-rater agreement and agreement between providers and gold standard with regard to the final triage score (i.e., SATS color). The left-most column is the number of the vignette being left out during that calculation of agreement. The middle column describes the case in the vignette. The right-most column is the average difference in Sklar's Omega when that vignette was left out of the estimation. From this table, vignette #17 has the most influence on final SATS agreement, followed by vignettes 37, 47, 6, and 20. Four are medical cases, and one is a trauma case. All are low acuity cases (i.e., gold standard SATS of green).

Table 6: Influential Vignettes.

Vignette	Brief description of Vignette	Averaged Difference*
17	Medical case – low acuity, psychiatric illness with agitation	0.049
37	Trauma case – low acuity, ground level fall with arm pain	0.048
47	Medical case – low acuity, severe pain from buttock abscess	0.048
6	Medical case – low acuity, severe pain from abdominal complaint	0.047
20	Medical case – low acuity, asthma exacerbation	0.047

** average difference in Sklar's Omega when the vignette was left out of the estimation.*

3.4.5 Discussion

SATS is a well-established in-hospital emergency care triage tool used in South Africa and multiple other low- and middle-income countries. This study is the first formal assessment of SATS among a cohort of EMS providers with prehospital experience using SATS. We found that SATS had poor validity, evidenced by high rates of under-triage, and moderate inter-rater reliability, evidenced by consistent mis-triage among EMS providers.

Overall, SATS underperformed as a prehospital triage tool - the final SATS triage color was only correct in about one-half (57%) of cases and there was a high (30%) rate of under-triage. However, the over-triage rate was 13% which we considered acceptable, but not excellent. We based this conclusion from a report by Twomey *et al.* who reported that an under-triage rate of 10% and an over-triage rate of 15% were adequate when SATS was tested among South Africa in-hospital emergency physicians and nurses.[2] In their report from 2012, Twomey *et al.* compared those rates to the only existing and accepted international pre- and in-hospital triage rates from the American College of Surgeons Committee on Trauma which recommends an under-triage rate of 5-10% and an over-triage rate below 50% for prehospital trauma triage in the USA.[19] Considering that SATS triages conditions beyond trauma, and considering the resource-limitations of the South African health system, Twomey *et al.* concluded that 15% and 10% SATS over- and under-triage rates, respectively, were acceptable.[2] The very high under-triage rate in this prehospital study appears to be due to under-calculation of TEWS and incorrect use of clinical discriminators by EMS providers. The medical implication is that the acute patients may be often under-triaged, which may be medically harmful as patients may be transported to hospitals with lower levels of care, may not receive the requisite level of ambulance care or may experience delays in care.

TEWS was often under-calculated. TEWS is an accurate predictor of need for emergency treatment, prognosis of emergency patients and identifying patients at risk for adverse outcomes. Calculation of TEWS requires two steps: first, assigning points to five physiologic parameters (respiratory rate, heart rate, systolic blood pressure, temperature, and mental status), mobility status, and trauma status; and second, adding all points to yield the total TEWS.[18] TEWS was very often under-calculated in trauma cases and high-acuity ("red") cases. Higher acuity patients, by definition, have more deranged vital signs which theoretically increases the complexity of calculating a TEWS, thereby increasing the likelihood of a computational error in the two-step process. Since these paper-based vignettes were administered in a relaxed classroom setting with a reference sheet, the component of provider stress that could further exacerbate computational errors in real life clinical care was likely significantly minimized, implying that under-computations of TEWS

could likely be worse in real life application during critical cases. Explanations for why TEWS was often incorrect in trauma cases may be due to errors of commission (e.g., providers' incorrectly assigned points for injury and/or the mobility statuses) or omission (e.g., providers forgot that trauma and/or mobility statuses require the addition of points) – the specific reason requires further investigation.

The clinical discriminators were frequently incorrectly selected, or very often missing when one was indicated, which occurred uniformly across medical and trauma case types, and more frequently incorrect in red cases. This contributed to the overall high under-triage rate. The clinical discriminators were originally developed by the Cape Triage Group in 2006 to help identify high-risk emergency conditions that present to in-hospital front-line clinicians (emergency doctors and nurses) in South Africa.[5,18] Many of these clinical conditions may be difficult for EMS providers to consistently apply as many discriminators are subjective (e.g., 'moderate pain' or 'high energy transfer'), require diagnostic information (e.g., 'hypoglycemia' or 'dislocation') or may be challenging to accurately establish in the field (e.g., 'burn over 20%' or 'poisoning/overdose'). Since the clinical discriminators can over-ride the triage color determined by the TEWS score, the discriminator alone can dictate the final SATS color independent of TEWS. The study found that several trauma-relevant discriminators e.g., 'high energy transfer', 'burn circumferential' and 'haemorrhage controlled', and neurologic discriminators (e.g., 'level of consciousness reduced/confused' and 'focal neurologic' issue) were among the most frequently incorrectly applied discriminators. Improving accurate use of trauma- and neurologic-relevant discriminators may require supplemental EMS provider training and/or modification of those discriminators so they are more EMS provider appropriate. However, overall, the clinical discriminators – as originally designed – did not perform well in this cohort of EMS providers.

It was interesting to find that SATS was used reliably. Specifically, we found substantial inter-rater agreement in determination of the final SATS triage color (k=0.71), which indicates consistency in application among EMS providers. A prior reliability study of South African in-hospital providers found comparable overall SATS kappa scores indicating substantial agreement among nurses (k=0.66) and among physicians (k=0.76).[9] Of note, use

of clinical discriminators had relatively worse agreement, both within EMS providers (k=0.59) and when EMS providers were compared to gold standard (k=0.49). These findings suggest that EMS providers, as a cohort, use this triage tool fairly inconsistently compared to in-hospital providers, but use it consistently within themselves – however, we should note that the EMS providers generated incorrect triage scores 43% of the time, as a cohort, due to incorrect calculation of TEWS and/or misapplication of the clinical discriminators. This suggests there are consistent errors (resulting in poor accuracy) in how these EMS providers use SATS, often attributable to the discriminators.

Recommendations

Based on our findings, there are several key recommendations. First, there exists an opportunity for focused re-training of prehospital providers on clinical discriminators, with emphasis on trauma and neurologic complaints and several other frequently misused discriminators. Second, EMS providers may also benefit from re-training and reminders to help them consider the patient's trauma and ambulatory status during calculation of the TEWS; however, this may be qualification dependent. Third, EMS providers may need computational assistance with calculation of the TEWS, and/or a re-formulation of the TEWS table to minimize the likelihood of a computational error, especially in critical ('red') cases. Last, the clinical discriminators may need re-formulation to be more compatible with prehospital providers' clinical knowledge, 'diagnostic' capabilities and clinical context.

Limitations

This study utilized a written assessment rather than simulated cases or chart analysis and therefore may not reflect the true performance of SATS in the 'live' clinical environment. However, the artificiality of the testing environment should not affect inter-rater reliability, as the effect of the testing setting will be distributed between the group of subjects and within individual subjects. Additionally, the vignettes tested some, but not all, of the clinical discriminators or combinations of TEWS values, so findings are limited to only those tested. Analysis of results according to level of training ALS, ILS or BLS was not done due to the relatively small sample size.

Conclusions

This study was the first assessment of validity and inter-rater reliability of prehospital SATS triage among a cohort of South African EMS providers. Overall, SATS under-performed as a prehospital triage tool. The study found good reliability, but poor validity, among EMS providers using SATS for prehospital triage in clinical vignettes. The final SATS triage color was correctly determined in only about one-half of cases. The under-triage rate of 30% was higher than previous reports from the in-hospital setting. The over-triage rate of 13% was acceptable. The high under-triage rate of SATS is attributable to under-calculation of TEWS and incorrect use of clinical discriminators. Discriminators could be better tailored to prehospital medicine. Additional clinical and qualitative studies of EMS providers are needed to fully understand the performance and use of SATS.

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3.4 Chapter Discussion

This was the first assessment of reliability and validity of prehospital SATS. We adapted clinical vignettes previously used by the Cape Triage Group for in-hospital provider validation studies. Using adapted hospital cases allowed us to compare our validity and reliability statistics to that previous body of work. This comparison proved important because no other standards or recommendations exist about thresholds of over- and under-triage for prehospital triage in resource-limited settings.

Via comparison to other existing triage instruments, the 30% SATS under-triage rate appears very high.(28, 29) This was predominantly due to under-calculation of TEWS and frequent incorrect use of clinical discriminators by EMS providers, especially in trauma cases. The medical concerns herein are that: sicker patients may be under-triaged, thereby potentially causing medical harm as patients may be transported to inappropriate destinations; and, sicker patients may be undertreated in the ambulance, or may experience delays in receiving important care. The TEWS relies on computation of multiple clinical parameters (e.g., vital signs, mobility, trauma) and we suspect that since higher acuity patients tend to have more deranged or abnormal clinical parameters, there is higher chance that a provider may incorrectly compute the TEWS. However, further studies of end-users could help ascertain specific reasons.

Notably, SATS overall had substantial inter-rater reliability demonstrating that WCG EMS providers tend to use it similarly as a group. Unfortunately, the inter-rater reliability for clinical discriminators was poor, again demonstrating that the discriminator list is problematic for prehospital providers to consistently use. This is likely because the discriminators are more tailored towards in-hospital provider use, considering that the

discriminators often require clinical diagnoses (e.g., 'dislocation', 'seizure – post ictal') or simple lab findings (specifically, 'diabetic – glucose >11 and ketonuria' and diabetic related discriminators). However, EMS providers have limited ability and training to make clinical diagnoses, and most ambulances do not have point-of-care diagnostic capabilities, except the occasional point-of-care glucose tests for hypo- and hyper-glycaemia (but certainly no urine dip sticks that are required to diagnose ketonuria which is relevant to two discriminators). Further, dislocations and fractures are pertinent to four discriminators – however, it is plausible that EMS providers do not feel comfortable ascribing these discriminators to the patients' injuries given their diagnostic uncertainty. Further studies among EMS providers are needed to better understand which discriminators are challenging and why.

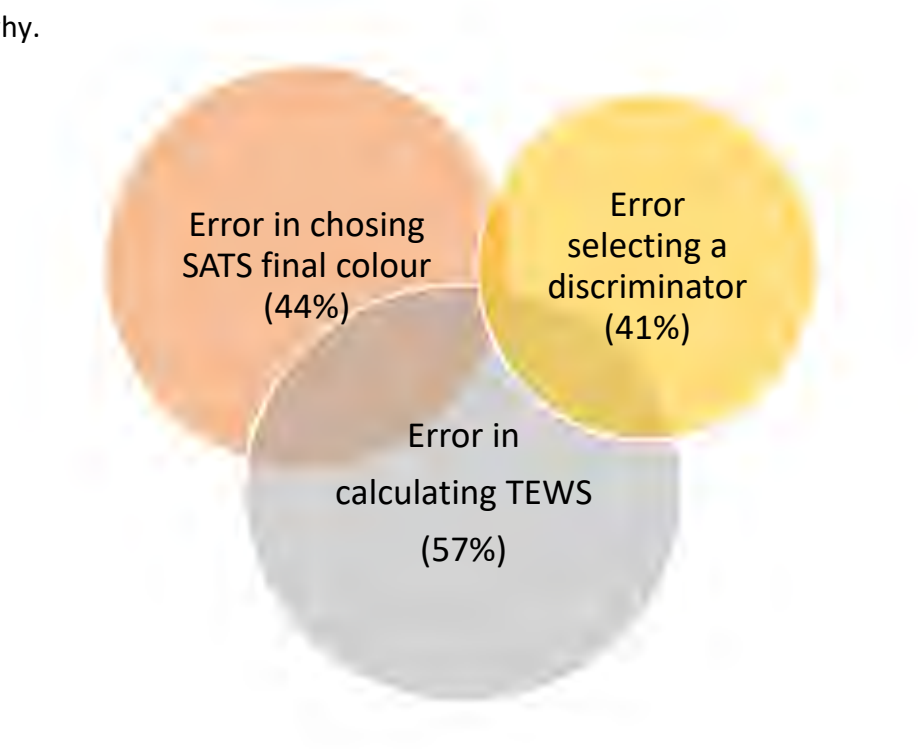


Figure 3: Summary of sources of error culminating in poor SATS validity and reliability.

We used Sklar's Omega for the analysis. Slar's Omega is a Gaussian copula-based framework that permits estimation of the degree of agreement between the EMS providers' scores and the gold standard physicians' scores.16 The framework is advantageous over other analytic tools because it can accommodate any number of units, any number of coders, and missingness; and can be used to measure agreement with a gold standard, intra-coder agreement, and/or inter-coder agreement.

3.5 Chapter Conclusions

SATS had poor validity, evidenced by high rates of under-triage, and moderate inter-rater reliability, evidenced by consistent mis-triage among EMS providers. The aetiology of the poor validity of SATS is largely due to difficulty of prehospital practitioners applying the discriminators and incorrect use of TEWS in more complex patients. Validity of SATS could be improved by prehospital adaptation (simplification) of the clinical discriminator list, with changes potentially focused on those discriminators that are both common in clinical practice and frequently misapplied by EMS providers. Additionally, SATS validity could be improved via more accurate computation of TEWS, which could be achieved by computational aides (e.g., quick reference tables) and/or focused re-training of EMS providers. The SATS colour coding system, however, could be preserved despite the recommended changes above. The qualitative study performed in the following chapter helps provide some clarity on these issues, but further clinically-based studies may also be helpful.

CHAPTER 4: USING THE SOUTH AFRICAN TRIAGE SCALE FOR PREHOSPITAL TRIAGE – A QUALITATIVE STUDY.

4.1 Declaration from author and co-authors

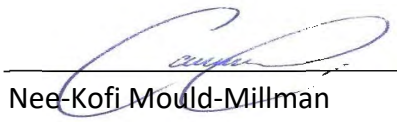
The following co-authors contributed to the publication: Dr. Julia M. Dixon, Dr. Taylor Burkholder, Ms. Jennifer L. Pigoga, Mr. Michael Lee, Mr. Kubendhren Moodley, Dr. Shaheem de Vries, and Prof. Lee A. Wallis.

Contributions of the authors were as follows: Nee-Kofi Mould-Millman (NMM) conceived of the study with input from LAW. NMM developed the objectives, designed the study methodology, and secured IRB and facility approvals. NMM wrote the interview guides, with assistance from JD and TB. NM, JD and TB collected the data. JD and JP transcribed the audio recordings. NMM, JD and TB reviewed and coded the transcripts and completed the qualitative analysis. NMM and JD interpreted the findings with assistance from TB, ML and LAW. NMM and JD drafted the first version of the paper. All other authors contributed to interpretation of findings and provided critical revisions. All authors approved the final version and agreed to be accountable for the final version. The extent of contributions from each person are as follows:

- NMM: 45%
- JD: 20%
- TB: 15%
- JP: 5%
- ML: 5%
- SdV: 2.5%
- KM: 2.5%
- LAW: 5%

Although NMM contributed the majority of effort to the entirety of this study (especially the conception, formulation of research questions, scientific design, approvals, interpretation of findings), JD contributed heavily to the interpretation and drafting of the paper, and as a trainee and mentee of NMM, JD was given the opportunity for first authorship while NMM maintained senior authorship, which is academically customary in the United States. This was approved by the UCT Doctoral Degrees Board.

Given the large number of co-authors, the principal investigator and the supervisor hereby sign for approval on behalf of the group, in accordance with the UCT Doctoral Degrees Board guideline titled, “GUIDELINES FOR THE INCLUSION OF PUBLICATIONS IN A DOCTORAL THESIS.”



Nee-Kofi Mould-Millman	22-June-2021 Date

Lee A Wallis	30 August 2021 Date

4.2 Synopsis

4.2.1. Rationale for conducting the study

In the previous chapter, we completed a quantitative assessment of validity and reliability of prehospital SATS. The purpose of the investigation in this chapter is to understand the end-users – specifically, the EMS providers' – perspectives and personal experiences using SATS as a prehospital triage tool. This topic was previously unstudied. In the next Chapter (5), we will bring together the quantitative and qualitative findings as a distinct objective.

A qualitative study of SATS (this Chapter) would help to yield rich information about the prehospital environment, population and relevant factors that could influence the EMS practitioners' ability to optimally use SATS in the field – such factors are often not discovered in quantitative assessments. Therefore, conducting this qualitative assessment provides contextual richness and depth to this topic, which complements the quantitative findings of the validity and reliability studies.

A-priori, we had intended to triangulate our quantitative and qualitative findings such that they could support and help explain each other. In chapter 5, we converge our findings to accomplish this. In this chapter, we simply present the qualitative findings resulting from our focus group discussions. Our rationale for conducting focus groups is that the sharing of experiences and perspectives would be amplified via group discourse within EMS provider peer cohorts, which would yield richer responses as compared to individual interviews.

Several key aspects of the design of the qualitative work were not explained in the manuscript, which will be briefly discussed here. These include the selected methodology and key aspects of the methods (specifically, bracketing, reflexivity, and trustworthiness). These will be briefly discussed here.

First, the general approach selected was a phenomenological study. Phenomenological studies examine the lived human experience through descriptions of the actors or people involved.(45) The goal of phenomenological studies is to describe the meaning that experiences hold for each subject. This type of research is used to study areas in which there is little knowledge. In this SATS research, we sought to describe the lived experience of

Western Cape EMS providers in using SATS, including an understanding of the meaning of their clinical experiences relevant to SATS. In group discussions, we asked respondents to describe their experiences as they perceive them, which is characteristic of phenomenological studies.(45)

In phenomenological research, the researcher must first identify any biases and take into account what he or she expects to discovered, then deliberately put aside these ideas in a process called bracketing. This process enables the researcher to more clearly and objectively see the experience from the perspective of the person who had the lived experience. Prior to focus group discussions, focus group discussion leaders specifically performed a series of reflexive exercises – both individually and as a group – to identify preconceived notions, possible biases, and expectations of the research.(45) An exercise in reflexivity was again repeated prior to, and after, the conduct of each focus group discussion. This required the researchers to develop an awareness of our preconceptions, to reflect on actions taken, our roles and emerging understandings, while we remained engaged in the research process.(46) Reflexivity and bracketing are considered best practices in robust qualitative methodology.

Trustworthiness or rigor of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of a study.(47) While most experts agree trustworthiness is important, there is no consensus as to what constitutes trustworthiness in qualitative research. Generally accepted criteria include: credibility ("the confidence in the truth of the study and therefore the findings"), dependability "(the stability of the data over time and over the conditions of the study"), and transferability ("the extent to which findings are useful to persons in other settings").(47) Given the phenomenological paradigm used, we sought to discover the lived experience of our EMS provider subjects, as told from their perspectives and in their words, with nothing material to gain nor lose from their participation in the study. Hence, we had no reason to suspect that there were any threats to the credibility of our participants and their recounted experiences and perspectives. The fact that we heard similar stories and experiences and perspectives, regardless of the focus group or the respondents' backgrounds, was affirming and minimized any concerns about dependability. In our focus groups, we deliberately

cohorted EMS providers by similar rank to prevent intimidation and to promote honest and reliable information to help maximize the dependability of our findings. Last, we intentionally selected a diverse group of EMS providers who represented all geographic areas (urban and rural), demographics (including age, gender, years of experience), and across all cadres (basic to advanced). Our rationale was that selecting such a diverse group of respondents would help to maximize the likelihood that our findings from the focus group discussions could be transferred or extrapolated to the larger EMS population.

4.2.2 Aim and objectives

The overarching aim of this study was to provide a more in-depth experiential understanding of prehospital SATS from the perspective of WCG EMS providers.

Our objective was to qualitatively describe EMS providers' perspectives, experiences and impressions of using SATS as a prehospital triage tool in the Western Cape.

4.2.3 Main results

- Overall, participants felt positively about SATS as a prehospital triage tool. Respondents indicated that it served as a useful indicator of medical acuity and helped to guide destination decision selection.
- Respondents noted that on occasion, SATS enabled them to identify patients who appeared sicker than the practitioner thought, which was useful. However, many respondents noted that SATS often generated a higher triage score than they thought was true, which they often attributed to the clinical discriminator.
- The clinical discriminators were a common cause of dissatisfaction in all focus groups. Many respondents indicated that they struggled to use many of the existing discriminators (because they seemed EMS-irrelevant or were too subjective), and often made up their own discriminators to help reflect the patient's acuity (as they perceived) and to help justify the EMS practitioner to transport the patient to a specific facility.

- Another strong point of frustration across the respondents was that SATS did not reflect the evolving nature of their patient care, especially patients who were improving upon arrival to the facility and subsequently had a lower SATS score. Respondents indicated that this would often cause friction between them and the hospital providers, which respondents attributed to the final SATS score. Respondents indicated that SATS was a useful communication tool, but the hospital providers needed to be better sensitised and understanding of the evolving nature of SATS in the field.

4.3 Published article

(This article has been under review at BMC Emergency Medicine since 19-Jul-2021; the manuscript is presented verbatim on pages 72-89)

Using the South African Triage Scale for prehospital triage: A qualitative study.

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4.4.1 Abstract

Background: Triage is a critical component of prehospital emergency care. Effective triage of patients allows patients to receive appropriate care and to judiciously use personnel and hospital resources. In many low-resource settings prehospital triage serves an additional role of determining the level of destination facility. In South Africa, the Western Cape Government innovatively implemented the South African Triage Scale (SATS) in the public Emergency Medical Services (EMS) service in 2012. The prehospital provider perspectives and experiences of using SATS in the field have not been previously studied.

Methods: In this qualitative study, focus group discussions with cohorts of basic, intermediate and advanced life support prehospital providers were conducted and transcribed. A content analysis using an inductive approach was used to code transcripts and identify themes.

Results: 15 EMS providers participated in three focus group discussions. Four major themes emerged from the qualitative analysis: Implementation and use of SATS; Effectiveness of SATS; Limitations of the discriminator; and Special EMS considerations. Participants overall felt that SATS was easy to use and allowed improved communication with hospital providers during patient handover. Participants, however, described many clinical cases when their clinical gestalt triaged the patient to a different clinical acuity than generated by SATS. Additionally, they stated many clinical discriminators were too subjective to effectively apply or covered too broad a range of clinical severity (e.g., ingestions). Participants provided examples of how the prehospital environment presents additional challenges to using SATS such as changing patient clinical conditions, transport times and social needs of patients.

Conclusions: Overall, participants felt that SATS was an effective tool in prehospital emergency care. However, they described many clinical scenarios where SATS was in conflict with their own assessment, the clinical care needs of the patient or the available prehospital and hospital resources. Many of the identified challenges to using SATS in the

prehospital environment could be improved with small changes to SATS and provider re-training.

Background

The South African Triage Scale (SATS) was developed to triage undifferentiated acute care patients presenting to facilities in low-resourced African settings.(1) SATS was created for, and first validated amongst, in-hospital emergency care providers (physicians and nurses) in South Africa.(2–6) To determine the final SATS triage acuity, a Triage Early Warning Score (TEWS), consisting of the variables mobility, heart rate, respiratory rate, systolic blood pressure, temperature, mental status and presence of trauma is calculated. Each score is associated with a SATS colour, green, yellow, orange, red and blue from lowest to highest acuity respectively. Additionally, the SATS colour can be upgraded to a higher acuity using a list of 32 high risk clinical discriminators (Figure 1).(1) In validation studies, SATS had an over triage rate of 15% and under triage rate of 10% when tested among South African in-hospital emergency centre providers.(2,3)

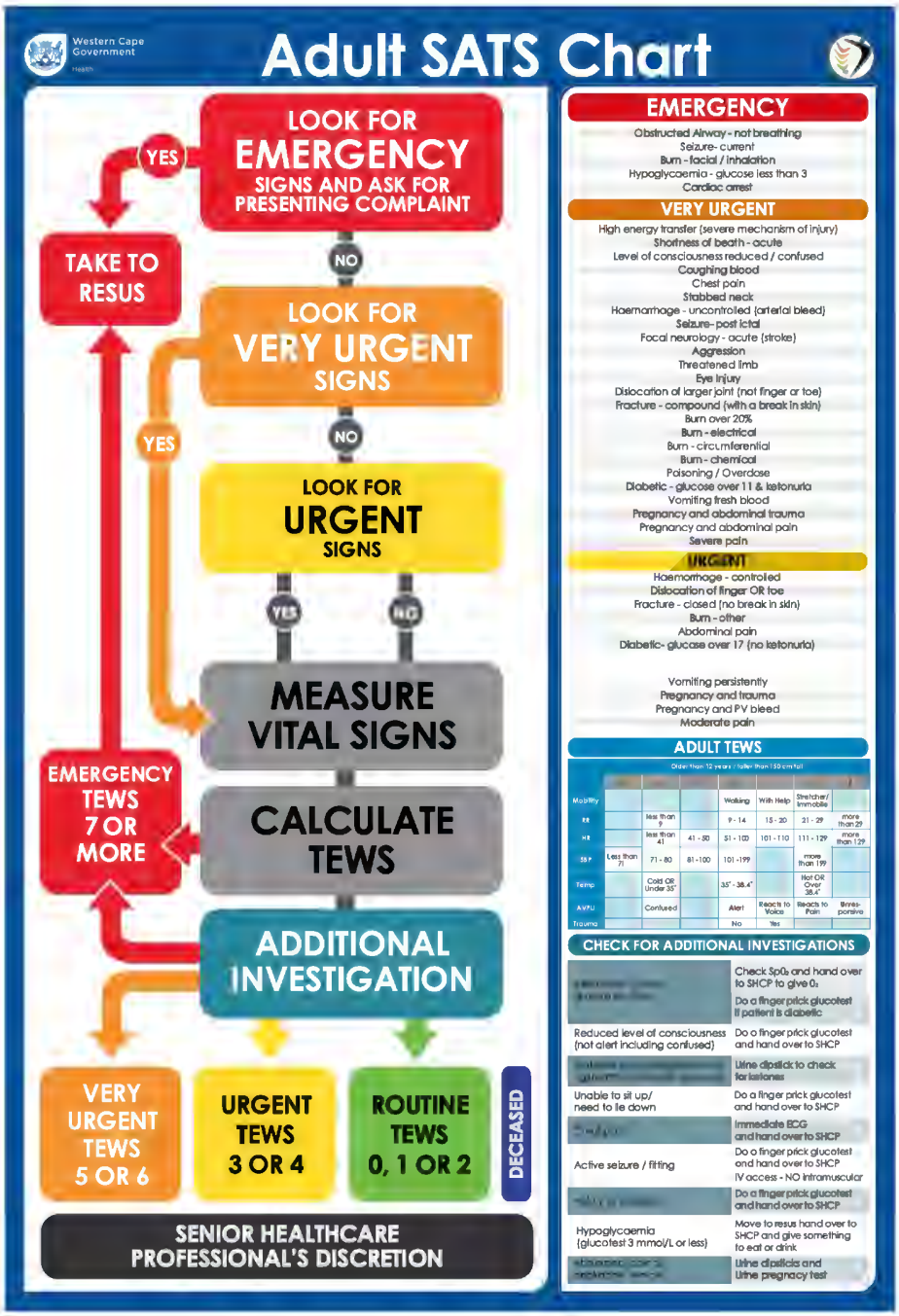

Figure 1: South Africa Triage Scale chart for adult patients. (1)

The Western Cape Government (WCG) Emergency Medical Services (EMS) system is a government-operated EMS system responsible for providing ambulance services in Western Cape Province of South Africa. In 2017, WCG EMS executed approximately 450,000 ambulance responses, which includes primary responses (i.e. to the scene) and inter-hospital transfers.(7) In 2012, SATS was formally and innovatively incorporated into prehospital emergency care by the WCG EMS system as a tool to guide both patient triage

and destination decision making.(8) Lower acuity (SATS green and yellow) patients are usually triaged to district hospitals and higher acuity patients (SATS orange and red) are triaged to regional and tertiary facilities. Although prehospital providers have the resources and skills to derive the SATS triage acuity, it was never intended for use in, nor formally adapted for, prehospital care.

In the prehospital setting, ideally an effective triage instrument can objectively and accurately determine clinical acuity, standardize handover communication, and guide the selection of an appropriate destination facility.(9) Consequences of incorrect application of a triage tool include under-triage (i.e., under-estimating true acuity), which can be harmful to patients or over-triage (i.e., over-estimating true acuity), which may result in wasted resources.(9–11) The only prior study of prehospital SATS, conducted in WCG EMS, reported an acceptable (13%) over-triage rate and a high (30%) under-triage rate, the latter largely attributed to misuse of the clinical discriminators.(8) However, the providers' perspectives and personal experiences using SATS as a prehospital triage tool remain unstudied. A strong and practical need exists to assess the prehospital provider perspectives and experience of using SATS use in the WCG EMS system. Findings from this study may also have application and implications to prehospital systems in other resource-limited settings and help facilitate the provision of high-quality emergency care and optimize utilization of limited health resources.

Objective:

We sought to qualitatively describe EMS providers' perspectives and experiences of using SATS as a prehospital triage tool in the Western Cape.

Methods

Focus group discussions with WCG EMS providers were conducted in March and April, 2017. Participants for the focus groups were deliberately cohorted according to the three training tiers (basic, intermediate and advanced) of EMS providers, to allow participants to share and discuss perspectives that may be unique to their level of training and to prevent perceived hierarchy from limiting participation of less experienced providers. Focus group participants were recruited from WCG EMS personnel attending continuing education

courses at the WCG EMS College of Emergency Care. None of the focus group participants were actively enrolled in courses at the College of Emergency Care that involved triage nor use of SATS [Personal communication, Michele Kings, Western Cape College of Emergency Care].

An interview guide was developed by the study investigators, and interview questions were confidentially reviewed and revised by a small group of WCG EMS staff (not participating in the study) to ensure focus group questions were phrased in a contextually, grammatically and culturally appropriate fashion. The interview guide was organized according to questions with similar topics e.g., initial SATS training, components of SATS, challenges and facilitators of using SATS in the field and suggestions for improvement. (Appendix 9) The focus group discussions were conducted in a private room at the College of Emergency Care and led jointly by a US study investigator (initials redacted for peer review) and a trained WCG EMS staff member (initials redacted for peer review). Focus group discussions were designed to last approximately 90 minutes and were conducted in English, and terms in other languages (Afrikaans, Xhosa) were clarified by the WCG EMS staff member in real-time. Participants were provided with the SATS poster which serves as visual aid summarizing the SATS process and routinely available on WCS EMS ambulances. All focus group sessions were audio recorded, and supplementary field notes were taken by the interviewer. Focus groups were transcribed verbatim in English by a study investigator into Microsoft Word and verified for accuracy by a second investigator.

Qualitative Analysis:

Content analysis with an inductive approach was selected due to investigators previous exposure to, and observations of, prehospital SATS used by WCG EMS providers. Three study investigators (*initials redacted for peer review*) developed a code book using content analysis methodology.(12) In traditional content analysis, the transcripts provide the framework for the code book, and keywords from the transcript are frequently used as initial codes.(12) Each transcript was iteratively coded by at least two reviewers independently (*initials redacted for peer review*), and differences were resolved by study

team consensus and more precise definitions of codes were developed. Coded transcripts were entered into Atlas.Ti (ATLAS.ti Scientific Software Development GmbH, Version 8.4.4) and analyzed for themes, and categories within themes, as they related to the primary research question of the EMS experience of using SATS.

Ethical Approvals

Full research and ethical clearance was obtained from the University of Cape Town (HREC# 705/2015) and Colorado Multiple Institutional Review Board (COMIRB Protocol 16-2271). Written institutional approval was also obtained from WCG EMS. Written informed consent was obtained from all participants (see informed consent form in Appendix 8).

Results:

A total of three focus groups were conducted, each consisting of five WCG EMS providers. All participants had prior experience using SATS in the prehospital setting. Eleven participants were male; 8 participants were from rural and 7 from urban EMS bases (ILS group: 4 male 1 female, 3 rural, 2 urban; BLS group: 2 female, 3 male, 4 rural and 1 urban; ALS group: 4 male 1 female, 4 urban, 1 rural). Prehospital providers' perspectives and experiences of using SATS emerged according to the following themes: implementation of SATS, perceived effectiveness of SATS, use and limitations of the clinical discriminator, and special EMS considerations.

Implementation and use of SATS

Participants described either receiving formal training or no formal training. Formal training occurred with a booklet and a brief instructional overview when SATS was implemented into use by WCG EMS followed by experiential learning on the road. Others describe no formal training at all and learning how to use the tool from their peers or on their own. Participants stated they often refer to the SATS reference card, or poster on the ambulance wall, to help determine the triage acuity of their patients. Participants from all focus groups described how SATS is used as both a triage and destination decision making tool: the triage acuity often helps to determine the level of destination facility. Participants noted that, specifically for trauma, there are WCG protocols that determine destination facility instead of SATS, however many also noted that they rarely use the trauma protocol and instead use SATS.

BLS E: "I actually had a [*continuing medical education*] workshops where all of the people we had to go sit in a classroom for an hour or day, and they gave us a little book where you, it actually explains the entire process of TEWS and SATS."

ILS E: It was nothing formal. Just basically learning it on the ambulance. Well, TEWS we were explained. But SATS worked was actually filling it out on our report forms. So it was more learn by doing.

ILS B: Also there is a lot of information to remember so I always defer, I have one on my clip board that I refer back.

Perceived effectiveness of SATS

When SATS works well

Overall, participants stated that SATS was a useful prehospital triage tool that performed positively in a large portion of cases. Participants reported that TEWS was the easiest part of the tool to use because it utilized objective vital sign data. Respondents explained that SATS provides them with a consistent language and objective tool that promotes communication and patient handover with facility providers. Participants also felt that SATS helped identify patients who initially appeared 'not sick' but may have abnormal vital signs – this situation results in providers upgrading the TEWS score and/or triage acuity.

ALS C: It's actually nice, the TEWS… your patient is actually green, but now has got severe abdominal pain, which makes him now…you upgrade him to a yellow. Which means he doesn't go to a day hospital now, but he goes to a tertiary hospital. When the doctor say, "Why are you bringing this patient here?," you say "According to the discriminator, he's yellow/orange…he's supposed to be here."

BLS D: I mean especially your patients that seem green especially when you arrive on scene and they are walking and talking, let's say an abdominal complaint or something like that, and sometimes when you actually sort of go through TEWS you pick up with a heart rate or respiratory rate or something like that, that they are actually to be triaged more toward yellow or orange, sometimes even red. Those are the times when I really have felt it's made an effect on how I change my sheet.

ILS: When it comes to give over, for the doctors, for them accepting or not accepting a patient. I think it helps.

ALS B: Very rarely do you find it's like 100% completely off kilter. It's more than, like, close to what you need or the patient needs in the end.

When SATS does not work

Participants also described patient scenarios when SATS was not a helpful tool, particularly for the care of trauma patients. Multiple participants gave examples of trauma patients with a SATS triage of green or yellow but who were clearly going to need surgical care at a higher level of facility. In both trauma and medical cases, when the provider gestalt of the patient's acuity did not match the SATS final triage acuity, participants in all focus groups described how they adjusted the TEWS score by one or two points, such as marking the patient as not mobile because they were on the stretcher, to justify taking the patients to the facility they felt was most appropriate. Several participants also stated that SATS was limited because it did not represent an accurate clinical picture of the patient in front of them which they felt was the most important factor for triage and destination decision making.

> BLS D: I think TEWS personally, is more for my medical patients. I use trauma patients, I basically, I triage them by myself as they present and how I see it. After I've done my own assessment and things like that, because, once again, it's a piece of paper, it can't say what the mechanism of injury was.
>
> ALS D: The thing is, it's also the alertness as well. The AVPU can also be a little subjective at times.
>
> ILS E: I have had red patients on TEWS and they looked perfect. I've had patients that are yellow to green on TEWS and they need a hospital immediately. So the thing with a red patient to me, is that is my interpretation of it. How important is it to have this patient in the hospital? Is there anything I can do?

Experiences with the SATS discriminator

Using the discriminator

Participants had the broadest range of experiences when it came to using the clinical discriminators. Some reported they rarely used discriminators while others described always writing in some type of discriminator, even if none of the SATS discriminators applied to the clinical scenario they wished to describe. The self-created discriminator was discussed in focus groups with all levels of providers. Participants explained that they often used a novel free text discriminator to help justify their choice of destination facility. For rural participants, this was important when they could identify a patient's resource need (e.g., x-

ray) and match the patient's need to the resource-available facility in their community, regardless of the SATS acuity.

> ILS E: I will say if you've got a round hole and you try to plug it, [SATS] is a square peg. It fits it. But it's not right. I can understand somehow in a hospital setting it works really well. You've got various departments and those discriminators are at the discretion of a doctor or the physician attending. But we don't have that, that discretion. So we are given these discriminators to kind of fill in.

> BLS B: As the TEWS was scoring green or a yellow, we going to score maybe a red because we see this is maybe a life-threatening thing. That is how we discriminate. This is life-threatening and then we see the patient need the help as soon as possible, so then we discriminate to the red.

> BLS D: I've noticed that sometimes you don't get what you're looking for in the discriminators. You put in your own discriminator because you feel, once again, the patient doesn't present what, the patient might triage green, you actually can see by the presentation, because I mean, this is a piece of paper, it can't see the patient.

Challenging Discriminators

Participants stated one of the most subjective and difficult components of SATS was the discriminator. One reason given by participants for difficulty in using the discriminator is unavailability of point-of-care testing, which is available for in-hospital triage, such as ketones in the urine, and rapid pregnancy tests- hence, they cannot apply discriminators appropriately in the prehospital setting. Participants also explained that other discriminators are often very subjective and hard to apply to patients consistently; examples include 'severe pain', 'chest pain' and 'abdominal pain'. Participants also described how the trauma discriminators (e.g., 'high energy transfer' and 'fracture - closed') were difficult to use due to their highly subjective interpretation and for fear that trauma patients can rapidly decline during transport.

> ALS B: Very rarely will people use severe pain, using it as a discriminator for taking a patient to a particular facility. I don't think. I think people, either they've used it and it hasn't worked for them because the doctors don't like it or they just don't consider it as a discriminator.

> ILS B: But there is also times when there are ambulances that are not enough…There is diabetic glucose of 11. What do you do? We don't have a test like that for the urine.

> ILS C: There are some calls that don't have applications and what you fill in and guess because the discriminator is a major player factor with regards to your TEWS. Because I find just look at the presentation of the patient and the patient does not look well.

Field versus hospital acuity

Participants also mentioned that the acuity level associated with discriminators did not seem to be a good fit for the acuity of certain clinical conditions the prehospital environment. For example, 'seizures-post ictal', in the hospital yields an orange SATS final triage score, however, in the back of the ambulance, the limited clinical scope of providers and chances of the patient having another seizure led some prehospital providers to believe these patients should be classified with higher acuity (e.g., red). Participants mentioned that other clinical discriminators which proved difficult to use are burns and ingestions due to the broad range of clinical presentations and severity associated with each. Participants explained that discriminators should allow providers to differentiate within a discriminator category severe cases from less severe cases based on their clinical assessment.

> ALS C: I've never used burns, I guess you know, you end up doing vital signs on them anyways and they tend to score in the 7's [for TEWS] anyways a lot of the times I've had them, you know. So, I've never really had to use discriminator. I never find myself needing to look at the list with those sorts of patients because it's usually quite obvious that they're critical we've got to go somewhere.

> BLS E: I think most of the times it's helpful in our situation to upgrade the colour, because there is only so much you can do for a patient in a certain situation, so if they are scored higher, they can either upgrade our vehicle to the paramedic vehicle or to a higher qualification vehicle, or the hospital knows what's coming, and they can prepare.

> BLS D: Or the whole score, I think should be more humanized. You know, because now it's paper. For me it feels like a piece of paper that tells you this is where patient should be. Where I feel that any score should be more human and that actual piece of paper is. Nobody presents the same.

Special EMS considerations

Participants identified challenges of using SATS due to the unique prehospital environment. These challenges were often nuanced and due to a combination of the providers' expertise, resources available, patient circumstances and the relationship with the facility. BLS, ILS and ALS providers have different scopes of practice and all provide care with a limited amount of

resources that impacts their field decision making. Providers from all cohorts described using SATS in an adjusted way that justified and facilitated faster access to a facility or additional resources when needed.

Dynamic clinical care in the field

Participants also gave multiple examples of decompensating patients in the field often further complicated by long transport times and challenged by limited in-ambulance resources. Participants reported an awareness of how rapidly a patient's condition can change and that providing care is more difficult in the back of an ambulance compared to within a facility. Additionally, participants described a lack of understanding by the facility personnel about their EMS scope of practice, often resulting in facility personnel questioning why an intervention was not delivered or why the patient was brought to their facility and not another.

> BLS E: You can control bleeding or whatever, but trauma is a continuous thing. You can fix one thing and something else can go wrong. So it's a continuous process.
>
> ILS C: I think the other thing is you are sitting with two environments. One is the unstable environment where we are working So you take this red patient, according to you. You come in and take the patient to a doctor, which is highly qualified and a sister. They look at you and say "Why is the patient red? they are stable. So the same red for me is not the same red for them. I think that is a big difference between hospital and myself. The stability of the environment.
>
> ALS A: The expectation is that we are supposed to diagnoses the patient and that's the also a little unreasonable cause we're not supposed to diagnose. We're not qualified to diagnoses people. It's not our job. We triage them. That's essentially what we do. We go and triage and take them somewhere. That's it!

Communication with facilities

Participants described a broad range of experiences with SATS when communicating with receiving facilities. Participants stated that the hospital staff often challenged their SATS assessment and some reported the hospital re-calculated the triage acuity and sent them to another facility. Others reported a more positive relationship with the facilities and facility providers' willingness to collaborate and help the patient. The experience of using SATS to determine the destination facility was different for rural and urban providers. Several rural

participants described being told by one level of facility to take the patient to a different level of facility which can be more than an hour away.

> ILS D: Problem is that he's stable now, but after the 1.5h drive to the hospital, one will not take me. Another 1.5h away from the hospital for a secondary call. Then the patient is going to be three hours in the ambulance when they could have spent half their time in the hospital already.
>
> ALS B: But you know, and then you go face the barrage of attacks but it's not just all about SATS, it's about the patient sometimes.
>
> BLS B: It seems like they don't know, they don't actually have an idea of how do I do it on the road. They just sometimes think of us as drivers. They don't have a better idea of what we actually do to the patient.

SATS conflicts with socio-cultural factors

Participants described many scenarios in which the socio-cultural patient factors were in direct conflict with the SATS driven destination. Multiple participants described examples of patients from rural communities or with chronic illness who either refused to go to a high level facility or needed a higher level facility but who were scored as green or yellow.

> ALS B: You know it can be kind of lame if you spend all of your time following a chart to make a decision. And having the freedom to go, "Ok, maybe this patient could use something different and maybe there is space to decide. Maybe it's more inclined to be a yellow-type abdominal pain kind of thing even though abdominal pain is always yellow.' Someone suffering from abdominal pain for the last six months and no one has helped them with it, maybe it's time they go somewhere a little better than the CHC to get the help they need.
>
> ALS B: Social problems are a lot of the reason why we end up where we are or why the end up going to the places they need to go to or why they're sick in the first place.

Discussion:

To our knowledge, this study is the first to investigate the perspectives and experiences of prehospital providers as end-users of SATS in the out-of-hospital setting. Our study findings advance our understanding about the introduction and use of SATS in a clinical environment for which it was not initially designed. Overall, participants spoke positively about many aspects of their experience with SATS, but they also elucidated multiple issues regarding the prehospital clinical challenges of SATS and the health systems consequences of using SATS in

the prehospital setting. The identified thematic areas — implementation and use of SATS, perceived effectiveness of SATS, use and limitations of the clinical discriminator, and special EMS considerations — are important to understanding which improvements to prehospital SATS are necessary while preserving those components that currently work well. The themes identified are also useful for triangulating the findings of previous quantitative assessments of the validity of pre-hospital providers' use of SATS in WCG EMS.

Implementation and use of SATS. SATS was implemented into WCG EMS with only brief formal training for those employed by the agency at the time of implementation and largely informal peer-to-peer training on the job for those who subsequently joined. A previous study of 102 WCG EMS providers found an unacceptable under-triage rate of 29.5%, much higher than similar studies of doctors and nurses in-hospital.(8) While EMS provider qualification levels and difference in scope of practice may contribute to the poorer prehospital SATS performance, we posit that on-going formal training, including SATS competency assessments, are important for optimal use of SATS by prehospital providers in the long-term. It is important to note that previous in-hospital validation studies of SATS relied on doctors, nurses, and nursing assistants who had undergone formal training sessions prior to validation assessments. (3,5,6)

Participants practicing in urban areas with many potential destination facilities discussed the beneficial use of SATS to help select the most appropriate destination. Inappropriate selection of the destination facility has been found to be a major issue in other prehospital systems in Africa.(13) Participants indicated that being able to use the tool to select an appropriate destination was valuable, although issues arose with certain types of patients (e.g., traumatic injuries). SATS did not help providers advocate for their choice of destination when facilities declined to accept the patient—either due to a mismatch of understanding of which SATS levels were appropriate to transfer to their facility or to a re-calculation of SATS upon arrival to the facility. The latter could be addressed by issuing or clarifying guidance to WCG EMS providers and hospital personnel as the SATS-based destination decision-making. Issues with trauma patients are already addressed through a WCG EMS protocol for transporting injured patients. The integration of SATS triage acuity

with other protocols may help prehospital providers determine best destinations and better optimize health system resource utilization, with unique considerations for rural settings.

Perceived effectiveness of SATS. Most providers describe being able to use SATS effectively and feel SATS helps them identify high-acuity patients and communicate in shared terminology with the hospital providers who also use SATS for triage. In contrast to this perceived ease of TEWS, it was recently noted that it is often under-calculated by WCG EMS personnel, particularly for trauma and high-acuity patients.(8) We did not identify a potential reason for this in the focus groups, although simple computational errors while multi-tasking under stress have been proposed as one potential cause – additional clinical studies may be warranted to better understand this, and an audit and feedback program may potentially help improve accuracy.

Use and limitations of the SATS discriminator. The list of clinical discriminators was originally developed for use by frontline in-hospital clinicians (doctors and nurses). Clinical discriminators are intended to identify high-risk clinical conditions that are otherwise not captured by TEWS and require higher medical priority or more resources.(14) During previous validation of the use of SATS by WCG EMS providers, it was found that clinical discriminators were often missing or incorrectly applied. Several trauma-related discriminators (e.g., 'high energy transfer', 'burn circumferential' and 'haemorrhage controlled') were among the least frequent to be correctly applied.(8) In our study, participants echoed difficulties with applying the discriminators due to subjectivity (e.g. 'severe pain') and the requirement of advanced diagnostic studies (e.g., 'diabetic – glucose over 17 (no ketonuria)'). A modified list of clinical discriminators for the use of prehospital providers that are less subjective, require no diagnostics and fall within the scope and training of prehospital providers has the potential for improving prehospital triage in systems like WCG EMS.

Participants also reported situations in which their clinical gestalt or level of concern for a patient was discordant with the final SATS acuity. BLS and ILS providers discussed using free text discriminators to request additional field resources, such as an ALS ambulance "upgrade", in situations where they feared the patient could decompensate (e.g., patients

with significant injuries). All types of providers suggested they create their own discriminator and then manually upgrade their assessed SATS to match their level of concern and destination facility choice. The use of SATS as a decision tool for destination facility will inherently have mismatches due to the conflict between the original hospital-oriented intent and prehospital application. Perhaps, allowing for EMS senior ALS or ILS provider discretion to upgrade the SATS acuity may better allow them to match patients with their prehospital-determined acuity.

Special EMS Considerations. Prehospital providers are faced with the challenges of being advocates for their patients, safeguarding health system resource utilization and applying their own clinical assessment. Not infrequently, these priorities come into conflict. Participants noted pressure from patients to modify their triage or destination due to social concerns and healthcare resource needs. While SATS or the EMS provider's clinical judgement might dictate that a patient from a rural area be transported to a distant referral centre, some patients may lack the resources to return from such long distances and plead to be taken to a closer day hospital. Rural respondents stated this was challenging, but it is unclear if future iterations of prehospital SATS could help with this aspect of patient advocacy.

The potential for a change in clinical status of a patient during prolonged transportations also became apparent in focus groups. On the one hand, the fear of decompensation of their patient may drive providers to try to upgrade the SATS to request further resources (e.g. ALS providers) on scene or transport to a closer (under-resourced) facility, while improvements in a patient's clinical status during transport (e.g. a hypoglycaemic patient that responds to glucose) may provoke a receiving facility to suggest the patient's acuity no longer warrants that level of care and suggest they transport to another facility. This creates inefficiencies for the EMS system and frustrations among EMS providers. Integrating SATS into EMS operational policies, and aligning prehospital SATS with local destination guidelines, may help improve this issue.

Limitations:

This single-system study of WCG EMS may not be generalizable to other prehospital systems. While the sample size and convenience sampling method inherently limit the data, we were able to recruit a diverse collection of providers with varying experience in rural vs urban setting, level of training, and duration of employment with WCG EMS. Despite having only three focus groups, we reached thematic saturation. The qualitative design and analysis was focused to assess the prehospital providers' experience with SATS in their setting. As such, we did not investigate the perception of prehospital SATS from in-hospital personnel or dispatchers, both of which interact routinely with the study group as they use SATS.

Conclusion:

This study was the first to evaluate prehospital providers' perspectives and experience with the use of the SATS. WCG EMS providers of all levels of training generally expressed positive attitudes regarding SATS, including objectivity of TEWS and benefits of having a common triage tool with hospital providers. However, respondents identified significant gaps and limitations to effectively using SATS in the prehospital setting, including poor applicability of many clinical discriminators, aligning prehospital providers' perceived severity with SATS triage acuity, non-integration of SATS into destination guidelines, and challenges using SATS in rural areas or with long-distance transports. Together, these findings suggest that prehospital SATS use may be improved by on-going training, prehospital modifications of the discriminator list and better integration of SATS with local destination guidelines.

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4.4 Chapter Discussion

The findings from these focus group discussions are highly informative and enrich our understanding of WCG EMS providers' experiences and perspectives using prehospital SATS in a resource-constrained setting. Overall, the respondents were cautiously complementary and thankful for SATS, but respondents offered a multitude of challenges, pains and frustrations regarding their experiences with prehospital SATS.

Respondents were most satisfied with SATS because it provided them an objective measure of acuity (mostly due to the TEWS) and provided them with a tool for shared communication with facilities and to help justify their transportation and care decisions. This strongly suggests that SATS should remain as a WCG prehospital triage tool, partly for its objectivity and partly because it generally serves as a valuable communication aide between EMS practitioners and facility personnel.

However, there were many issues that challenged EMS providers during their day-to-day use of prehospital SATS. The two most significant issues were that the SATS triage colour occasionally did not reflect the true acuity of their patient (SATS often over-triaged patients due to the clinical discriminators, in the respondents' experiences), and that evolving patient conditions during prehospital transport often created challenges especially at hospital handover. Regarding the former issue, respondents were clear that the discriminator list is a cause of dissatisfaction to them and is inappropriate for the EMS users (which is not surprising, considering the original creation of SATS was from a group dominated by hospital emergency medicine trained clinicians).(32, 33) To avoid EMS providers misusing discriminators, further EMS adaptation of the discriminator list may be required. Regarding the latter issue of changing prehospital SATS scores, this suggests that the mode of use and communication of prehospital SATS values necessitates some reconsideration – it is a dynamic reality of prehospital care (especially during prolonged

transports) that patient conditions will evolve during transportation, but respondents suggest that facility providers view SATS more statically. The manner in which facility providers and EMS practitioners communicate using SATS may need to be re-worked to better align both parties.

4.5 Chapter Conclusion

Overall, WCG EMS providers appear to generally have a favourable impression about the value of SATS, suggesting it could have a long-term role in the Western Cape emergency care system. However, several EMS-specific adaptations are necessary to ensure it is valid and contextually relevant to prehospital care. Suggested changes include revising the clinical discriminator list and enabling SATS to conform to prehospital patient, providers, and geographic contexts.

CHAPTER 5: CONVERGENCE AND DISCUSSION OF QUANTITATIVE AND QUALITATIVE FINDINGS

5.1 Approach

In this chapter, I bring together the quantitative (Chapter 3) and qualitative (Chapter 4) data using a parallel, convergent, mixed methods design. Mixed methods refers to the planned mixing or integrating of both quantitative and qualitative data, rather than keeping the strands of data separate.(48-51) The latter approach, i.e., keeping the qualitative and quantities findings separate, is termed multi-methods research.(48)

Experts assert that mixed methods is a "methodology" and consider the collection, analysis, and integration of quantitative and qualitative data as a clear and concrete approach.(48) Others view the integration, or "blending" more generally as combining the qualitative and qualitative approaches methodologically, extending from the philosophical assumptions to the interpretation of the results.(49, 50)

From a methodological perspective, mixed methods research has several core characteristics. First, it requires the collection and analysis of both quantitative and qualitative data. Second, the quantitative and qualitative data must each be collected and analysed in a rigorous manner and follow procedures for good research designs. Third, and arguably the most critical point, is that there must be integration or "mixing" of quantitative and qualitative data.(48)

The mixing can occur in three conceptual ways: merging, connecting, or embedding (48):

- Merging means that the distinctiveness of each dataset dissolves. Also called a side-by-side comparison, quantitative findings may be presented first, then qualitative findings presented to support the quantitative, then the unique forms of both sets of data dissolve or meld into a discussion section such that the distinctiveness of each dataset disappears. This is commonly referred to as a "parallel convergent" design, in recognition of the parallel procedures of quantitative and qualitative data collection, and the combination (convergence) of findings from both in the merging process.(48)

- Connecting means that results from one dataset are used to help inform the data collection procedures of a second dataset. For example, a researcher may first conduct a survey on randomly selected individuals, analyse results, and use the findings to conduct a qualitative study. This is also described as "sequential", in recognition of the fact that one step occurs before the next.(48)
- Embedding means that a researcher nests a supportive (secondary) dataset within a major (primary) dataset for augmenting the major dataset. For example, a researcher embeds a small qualitative dataset (e.g., from focus group interviews) within a clinical trial prior to the experiment so that detailed information about the participants can be used to design an intervention.(48)

In this thesis, the mixed methods approach I selected was merging. Merging was accomplished via a parallel convergent design. This design was advantageous because it was both logistically practical and scientifically beneficial. The parallel approach was necessary to overcome logistic and practical challenges of recruitment. Specifically, in this study, we recruited cohorts of EMS provider participants who were enrolled in various courses at the Western Cape College of Emergency Care (the "College"). The arrangement between the research team and the administrators at the College only allowed us to approach one class at a time, and during the contact period, to collect written informed consent and, on the same day, conduct the quantitative assessment from consenting participants. Further, we had to quickly arrange follow-up focus group discussions with consenting participants while they were still enrolled at the College. Consequently, for logistic reasons, we could not collect, enter, clean, analyse, and interpret findings from the quantitative phase before proceeding with the qualitative phase, or *vice versa*. Hence, the parallel mixed methods approach logistically enabled us to collect, analyse, and interpret quantitative data (Chapter 3) in parallel with conducting the qualitative (Chapter 4) work.

Post-data collection, the convergent aspect of this approach (Chapter 5) allowed me to later "blend" or "mix" or "converge" the findings so as to yield a final set of findings that were greater than the sum of the qualitative and quantitative findings, had they been considered separately.(48, 49)

5.2 Explained findings

To help organize the converged data, I present the mixed methods findings organized and discussed according to the following categories:

i) The patient assessment: the TEWS;

ii) The patient assessment: the Discriminator;

iii) Use of the final SATS triage colour.

5.2.1 The patient assessment: the TEWS

Overall, the qualitative findings indicated that EMS providers felt positively about the TEWS. Respondents felt that the TEWS component of SATS was the easiest part of the tool to use (compared to the discriminators). Providers also appreciated the TEWS component because of the straightforward objectivity it provided vis-à-vis use of vital signs, mental status, mobility status, and presence of trauma. Respondents cited examples in which the TEWS helped them to "pick up" abnormal vitals and indicators that a patient was sicker than they appeared. Yet, the main finding from the quantitative data showed that the TEWS was calculated correctly in 42.6% of vignettes, under-calculated in 45.0% and over-calculated in 10.9%. The quantitative findings show that in cases in which the TEWS was correctly calculated, that it was most often correct in lower acuity green cases (60%), less frequently correct in yellow (43%) and orange cases (47%), and least correct in the most critical (red) cases (17%). Below, I triangulate reasons why the TEWS may be miscalculated, separating the mixed methods analysis and discussion into under- or over-calculation of the TEWS.

Under-calculation of the TEWS: In Chapter 3, we explained that under-calculation of TEWS could result in under-identification or under-resuscitation of harmful conditions which could be medically harmful. We showed that TEWS was disproportionately and most often under-calculated in vignettes with a final SATS triage of red. In the Discussion of Chapter 3, we hypothesized that under-calculation was possibly due to the omission of relevant parameters in the TEWS calculation (e.g., presence of injury; stretcher bound state), which was more likely to occur in cases of higher complexity wherein providers were more likely to forget to include one or more relevant variables into the TEWS calculation. Yet, in our focus group discussions, not a single respondent indicated that there were occasionally errors of omission (or even computational errors) that arose during prehospital use of SATS. Perhaps,

this could reflect a limitation of our focus group interview methodology and the parallel convergent design, and had we explicitly asked respondents this question (based on quantitative findings), perhaps we may have better ascertained experiences in which providers admitted to forgetting to include a TEWS variable in a sick patient. Another plausible explanation is that providers are cognitively unaware that they make errors of omission during the computation of the TEWS, especially during more critically ill cases. In fact, demonstrating that errors of omission exist are better ascertained from a quantitative study rather than a qualitative study given the inherent limitations of respondents' recall bias during an interview, compared to objectively demonstrating that the problem exists during a quantitative assessment.(52) Further proof of under-triage as a consequence of errors of omission is quantitative study findings of more errors in trauma patients compared to medical patients (59% versus 36%, respectively) – trauma patients receive an additional point during the TEWS calculation to represent the presence of injury, and may receive additional points if they ambulate with help (1 point) or are immobile or stretcher-bound (2-points), which is fairly common in injured patients. We noted that omitted points for trauma cases was one common issue in cases in which TEWS scores were incorrectly calculated. This helps to support the assertion of TEWS error by omission as a cause of TEWS score under-calculation.

Over-calculation of the TEWS: In our quantitative study, this form of mistriage occurred much less frequently compared to under-triage (11% versus 49%, respectively). Over-calculation of TEWS results in a TEWS score (and SATS triage) that is falsely higher than the true patient acuity, which may result in transport to a facility of unnecessarily high care or may result in ambulance over-treatment. Although less likely to cause patient harm, over-triage may result in waste of healthcare resources.(28, 30, 37) Further, our data showed no clear case or acuity types for which there was disproportionate over-calculation of TEWS. In Chapter 3, we hypothesized that over-calculation of the TEWS may be due to simple computational errors, given the consistency across all patient severities. However, due to the limitation with our parallel convergent mixed methods design, none of the focus groups were purposefully asked whether, nor elicited that, errors of computation were an issue for providers. Hence, it is difficult to cite computational errors as the principle explanation for over-calculation of the TEWS. Further, if computational errors were in fact an issue among

EMS providers, we should have discovered a higher proportion of over-calculation errors of TEWS in cases with higher triage scores (e.g., red and orange), but we did not see this – we actually found that red cases (the most computationally complex) had the lowest proportion of TEWS errors which refutes our assertion that more complex cases cause more computational errors. Further, the fact that there is a fairly consistent distribution of TEWS over-calculation across all case acuities and types (Table 3) suggest this could be a random error that is uniformly distributed across all case types and acuities.

We did, however, uncover one plausible explanation during our focus group interviews to help explain why over-calculation of TEWS may arise. Specifically, our focus group respondents explained that when providers' gestalt of acuity did not appear to correlate with SATS, that they would "adjust" the TEWS score (usually upwards) to help match the providers' perceived acuity and to justify transporting the patient to the relevant facility. In both trauma and medical cases, when the provider gestalt of the patient's acuity did not match the SATS final triage acuity, participants in all focus groups described how they adjusted the TEWS score by one or two points. The focus group respondents provided several examples to demonstrate this, and in all examples, they described over-calculating the TEWS compared to the true TEWS. One provider explained that he often marked the patient as not mobile because they were on the stretcher (even though the patient walked to the ambulance), to help justify increasing the TEWS and take the patients to a higher level of care facility which the provider felt was more appropriate.

It is important to note, however, that our vignette based assessment may not have provided study participants with the same realism as actual patient care (i.e., the influence of gestalt on TEWS calculations in our vignette-based assessments was likely lower compared to 'real life' clinical care), hence the quantitative study, by inherent virtue of its design, may have under-measured the extra TEWS points that may have been assigned during 'real life' clinical care. Hence, I suggest that a study to assess how TEWS is scored during 'real life' prehospital clinical care is warranted to further explore this nuance. Therefore, it is possible our quantitative (vignette-based) study under-reported the true over-triage rate. Hence, the true or 'real life' over-triage rate of SATS may be much higher than 13%, which may further challenge the validity of SATS as a prehospital tool.

One other important finding from the quantitative work was substantial inter-rater EMS provider agreement for the TEWS component (kappa score of 0.69). This finding suggested that EMS providers were using the TEWS similarly, albeit frequently incorrect, as a group. This indicated that providers were approaching the TEWS calculations (and mis-calculations) in a consistent manner as a group, which suggested a systematic or consistent issue (or way of thinking) that permeated across the studied cohort of providers. The aetiology of this could be due to EMS providers' foundational clinical training and/or the manner in which they were originally trained to use SATS – neither of these issues were specifically explored during focus group discussions. Regarding the initial training of EMS providers in SATS: the SATS training manual is predominantly focused on hospital scenarios and triage, with only 3 short paragraphs (out of the 33 page training manual) which provides non-clinical information about the value of triage in the prehospital context, without any specific prehospital triage or technical training.(35) In aggregate, I assert that these findings question whether the SATS tool has some inherent design flaws which manifest as consistent errors when used by EMS providers for EMS scenarios. Our findings suggest that EMS providers actually did a reasonable job using a tool that potentially has some fundamental flaws for EMS application. No published papers exist on this topic, and further research is warranted to draw more precise conclusions.

5.2.2 The patient assessment: Discriminators

The list of clinical discriminators was cited by all respondents as the most consistently challenging, most confusing, and most frustrating aspect of using SATS for prehospital triage. Generally, respondents did not have any positive comments or attributes about the discriminator list. Most respondents felt the discriminators were mostly inappropriate for EMS use because they required diagnostic results (e.g., requiring a point-of-care test result or X-ray finding), or were irrelevant and non-applicable to EMS providers (e.g., "Discretion of senior doctor"), or were too ambiguous for prehospital use (e.g., "moderate pain" or "high energy transfer"). Consequently, several respondents noted that they often "wrote in" (i.e., made-up) their own discriminators and assigned their own SATS triage colour to their made-up discriminators. It is also useful to consider that the ambiguous or vague

nature of certain discriminators may extend beyond the EMS provider population to include in-hospital personnel, however, this was not examined by this study.

For the above reasons, poor fit of the clinical discriminators for EMS triage was a major contributing factor to why SATS achieved an overall poor performance (i.e., poor validity) when tested , with an overall accuracy of only 57%. Table 3 of Chapter 3 shows that the discriminator, when indicated, was incorrect in 41.2% of cases, with a similar proportion of discriminator errors in cases that were under-triaged (26%) versus over-triaged (30%). Further, the discriminators were similarly erroneous in trauma (52%) versus medical cases (48%). We also noted that 70% of red cases had incorrect discriminators, compared with about 50% for green, yellow, and orange cases (Table 4). The assessments uncovered that in the majority (57%) of vignette cases in which there was under- or over-triage, respondents indicated that a discriminator was not indicated or not needed, which was incorrect. Even in cases in which the final SATS colour was correct, respondents selected incorrect discriminators 80% of the time (Table 4). Together, these findings suggest that the discriminators are challenging for prehospital providers in the prehospital setting to correctly apply.

The findings above from the quantitative study are interesting to converge with qualitative study findings that indicated that the EMS providers often “wrote in” their own (made up) discriminators. The EMS providers justified this practice by explaining that they created ‘new’ discriminators to better represent the patient’s condition when the existing SATS discriminators appeared to be a poor fit. This practice violates the very scientific premise and purpose of having a discriminator list which is firmly tied to a triage colour designation. This practice of making up discriminators may represent either or both of the following conditions: first, that EMS providers desire to better represent their patient’s acuity or better advocate for their patients; or, second, that it represents a compensatory mechanism used by EMS providers who have a poor understanding of the purpose and mechanism of the SATS discriminator list. The mixed methods findings suggest that our vignette assessment may have under-represented the practice of EMS providers writing in their own discriminators due to the paper-based formatting and nature of the assessment.

From the quantitative study, the following were the top three most frequent correctly used discriminators: chest pain, poisoning, and seizure-post ictal. Table 7 lists discriminators that consistently emerged, from both the qualitative and quantitative studies, as error-prone or problematic to use.

Table 7: Clinical discriminators that were problematic for prehospital triage

Discriminator	SATS Colour	Respondents Description of Challenge
Pain – mild	G	Too subjective
Pain – moderate	Y	Too subjective
Pain – severe	O	Too subjective
High energy transfer	O	Too subjective (no list of mechanisms exist)
Level of consciousness reduced-confusion	O	Too subjective (confused by substance use)
Haemorrhage-controlled	Y	Too subjective
Seizure-current	R	Clinically challenging
Psychosis/Aggression	O	Too subjective (confused by substance use)
Dislocation – other joint	O	Requires radiology or clinical diagnosis
Dislocation – finger or toe	Y	Requires radiology or clinical diagnosis
Fracture – closed	Y	Requires radiology or clinical diagnosis
Burn over 20%	O	Unable to measure in ambulance
Burn – circumferential	O	Unable to reliably assess
Pregnancy & trauma	Y	Unable to reliably assess; patient withholds info
Pregnancy & PV bleeding	Y	Unable to reliably assess; patient withholds info
Pregnancy & abdominal trauma or pain	O	Unable to reliably assess; patient withholds info
Hypoglycaemia	R	No (or unreliable) point-of-care test
Diabetic – glucose >17, no ketonuria	Y	No (or unreliable) point-of-care test
Diabetic – glucose>11 and ketonuria	O	No (or unreliable) point-of-care test

The EMS provider participants in our focus group discussions cited three principal reasons why the discriminator list was challenging to use:

1. Diagnostically based (e.g., requiring a point-of-care test result or X-ray finding) – As a practical matter, it is important to note that Western Cape Government EMS is a resource-limited system with very limited access to point-of-care tests aboard ambulances. For example, the finger stick glucose meter is one of the few point of

care testing devices available on some, not all, ambulances, despite being required by South African law; and yet, there are three discriminators that require a blood glucose levels to be known with or without the presence of ketonuria (ambulances do not carry urine dipsticks). Additionally, there are four discriminators that require the use of radiography or a clinical diagnoses, namely "compound fracture," "fracture closed", "dislocation – finger or toe", and "dislocation – other joint". While hospital clinicians may be able to make these diagnoses using physical exam and patient histories, these injuries may not be clinically apparent to EMS providers in all patients with a deformity, swelling, and/or pain overlying a long bone or joint. Last, respondents explained that the three pregnancy-related discriminators were also challenging because it wasn't always obvious, or known, if a female patient with abdominal pain or vaginal bleeding, for example, was pregnant or not. Hence, there are at least ten discriminators that proved challenging for EMS providers to consistently and accurately use for prehospital triage.

2. Too ambiguous for prehospital use (e.g., "moderate pain" or "high energy transfer") – Respondents frequently cited mild, moderate, and severe pain as being difficult to uniformly apply in the prehospital patient population. They explained that these terms were too subjective to consistently and objectively apply, and that patient's pain assessments could rapidly change, depending on if they were moving the patient, loading the patient, or if the patient was immobile on their stretcher. Hence, EMS providers relied on their own judgement and interpretations of the pain discriminators. However, findings from the quantitative study provides conflicting data – specifically, 14 of 50 (28%) of vignettes required a discriminator that was either "moderate pain" or "severe pain", and yet, both discriminators were often accurately used (compared to gold standard), and overall inter-rater reliability testing yielded a kappa score of 0.59 indicating moderate agreement. Again, this may be an artefact of the written assessment format which vignettes explicitly stated that the "patient had moderate or 6/10 pain" which may not have been easily ascertained or immediately available in 'real life' clinical practice. Respondents also explained that other discriminators, such as "high energy transfer" and "aggression" were confusing and difficult to apply. Providers struggled to determine what mechanistic or injury criteria constituted "high energy" or "severe pain", and

explained that almost no EMS providers used “severe pain” because “doctors don’t like it” or the EMS providers “just don’t consider it as a discriminator.”

3. Too objective for prehospital use (e.g., “circumferential burn” and “burn over 20%)” – Respondents explained that a lack of objectivity was particularly problematic for burns in which they could either not fully expose the patient to accurately calculate the percentage of body surface area burned, or could not control the patients’ pain (or other factors) to enable the provider to fully characterize the burns in the pre-hospital setting. We could not perform a subgroup analysis in the quantitative study to further assess this given there was only 1 vignette in which either discriminator was used. Further, even if we had several vignettes assessing this discriminator, the vignettes had no pictures so they would not have accurately tested the visual diagnosis or confirmation required by the provider.

Consequent to all the above factors, we found, and I similarly conclude that, that the discriminators were a challenge and source of frustration for the EMS providers. Discriminators achieved moderate inter-rater agreement and moderate agreement with gold standard (0.59 and 0.49, respectively) and inaccurate use of discriminators contributed to the overall poor validity of SATS as a prehospital triage tool. I provide recommendations to improve the discriminators in Chapter 6.

5.2.3 Final SATS triage colour

Overall, as evidenced by the qualitative findings, the respondents indicated that – despite its limitations – SATS was conceptually a valuable tool to have, although it posed substantial challenges for prehospital use. Respondents felt that SATS was useful to help objectively quantify degree of illness, and for use as a communication tool with hospital providers. The main drawbacks of prehospital SATS were that it inaccurately reflects the evolving prehospital course, it does not reflect prehospital care capabilities, and it occasionally conflicts with patient wishes or clinical needs. Although each of these findings was discussed in Chapter 4, they are summarized below. Of note, these findings are the opinions and perceptions expressed by the focus group respondents:

- SATS quantifies degree of illness – Focus group respondents explained that SATS generally helped prehospital providers to identify patients who initially appeared

well, but were actually sick. They also explained that the TEWS component, specifically, provided an objective measure of patient acuity, because it was dependent on objective criteria such as vital signs. Respondents also mentioned that the TEWS component was fairly easy, and quick, to use on most patients.

- SATS as a communication tool – Respondents explained that SATS provided them with a helpful and consistent 'language' and set of terms for communicating patient acuity to receiving hospital staff. EMS providers described often getting asked "Why are you bringing this patient here." Respondents explained that they often would just cite the TEWS criteria, the clinical discriminator, and/or the final SATS colour as a brief means of conveniently justifying their choice, especially when patients appeared more critically ill but didn't meet criteria for a higher level of care. However, respondents also cited numerous instances of when hospital providers gave them "pushback" using the SATS colour as a basis for disagreeing with the EMS provider's choice of facility. To clarify its original purpose and intent, SATS was designed to help predict the need for in-hospital resource utilisation at the point of in-hospital emergency unit triage. For example, an in-hospital triage designation of "Red" means "Immediate treatment." While the prehospital clinical interpretation of "Red" means a sicker and more critical patient, there is no explicitly defined meaning of "Red" for EMS providers to select a suitable destination facility. As a recommendation, the manner in which SATS triage colour designations interface with EMS personnel selection of designation facilities needs to be explicitly addressed by local standard operating procedures. For example, in the Western Cape Department of Health guidelines for Direct Transfer of Adult Major Trauma and Severe Head Injury Patients (Circular H186 of 2013), there is no mention of the role of SATS in selecting a destination – alignment between SATS and similar local operating procedures and destination guidelines may be helpful in minimizing friction that occurs between EMS and hospital providers.
- SATS poorly reflects the prehospital course – One main criticism of prehospital SATS is that it did not accurately portray the patient's prehospital course, especially among patients who improved upon arrival at the hospital due to EMS interventions. EMS providers stated that often caused conflict between them and hospital personnel who did not believe or understand why the patient was transported to

their facility. Additionally, EMS providers felt confused when a patient started out as a higher acuity, and a higher level of care was selected, but dramatically improved during transport thereby not requiring that level of care e.g., a simple seizure resolved, or hypoglycaemia was resolved after a dose of glucose. It is worth emphasizing that the Western Cape EMS clinical procedure for using SATS requires that a destination is selected based on the worst prehospital SATS triage colour which is most often dictated by the initial assessment done at upon initial patient contact (an unrelated study showed that there is only one "initial" set of vital signs and SATS collected in 67% of Western Cape EMS cases.(42) While re-triage upon arrival at the facility is important, it would be an "off label" application of SATS to collect serial SATS triage scores in an ambulance used to trend patients' evolution through the transportation. Hence, further sensitisation and training of EMS and hospital providers is required to clarify how the SATS triage colour influences destination selection.

- SATS does not represent prehospital capabilities - Providers explained that considering the limited resources in the ambulance, and the limited scope of practice of most EMS providers, that some conditions should be automatically upgraded for EMS due to risk of deterioration e.g., "seizures – post ictal" should be an automatic "Red" for EMS even though "Orange" for a hospital. This fear was especially magnified during long distance transports in which the potential for patient deterioration was heightened due to long durations of transport, or in certain conditions with eminent risk of deterioration (although presently stable). However, I think assigning the same complaint or issue to one hospital triage colour and a different EMS triage colour would violate the basic premise of SATS, which is "Red" means immediate attention required and connotes a critical patient. The SATS Working Group should consider convening a prehospital working subgroup to tackle this, and other, issues that could help improve the utility of SATS for prehospital care.
- SATS conflicts with patient wishes or clinical need – Respondents explained that they often encountered patients who clearly needed higher levels of care or sub-speciality care, but SATS would triage the patient to the nearest (low) level of care, which was not what the patient needed for management of their condition.

Additionally, providers described that transporting some patients far away from home, such as those who were financially destitute, because SATS triaged them to a distant referral centre, could be against patient wishes. Such situations often left the EMS providers in a tough predicament in which they had to choose between the patient's wishes and medical need driven by the SATS triage colour. Providers wished SATS allowed some flexibility to cater for non-traditional patients with extenuating circumstances, which was not an infrequent occurrence, per EMS provider participants. Allowing provider discretion and flexibility in using SATS is certainly a less desirable option, as that could introduce more inter-rater disagreement (especially considering that the overall SATS inter-rater agreement is not strong enough to withstand further disagreement). However, this specific issue may reflect a more fundamental issue regarding the manner in which the Western Cape health system is constructed and designed to operate i.e., the system operation is so rigid and immutable (for EMS providers) that it tends to repeat the same process regardless of the prior outcome. Hence, some health system level changes may be warranted to address this specific issue cited by respondents.

5.3 Unexplained findings

Even though we were able to demonstrate the under-triage was the dominant cause of poor SATS validity when SATS is used for prehospital triage, we did not explore this specific aetiology in focus groups because both the quantitative and qualitative work were conducted in parallel. This is a major limitation and downside of the parallel, convergent mixed methods approach. It would have been helpful to be able to specifically ask providers about issues with TEWS computation (and challenges using specific discriminators) in specific circumstances, which could contribute to under-triage.

5.4 Limitations

There are several limitations of the mixed methods approach. First, there are some noteworthy limitations of the quantitative and qualitative data that were entered into the mixed analysis, and separately, limitations of the converging (or mixing) of results.

The quantitative methodology had two key weaknesses. First, we conducted paper-based, not 'real life', assessments using clinical vignettes, and we infer that mistriage rates and other trends found during these paper-based assessments may reflect real-life trends in clinical practice, which is an unproven assumption, although a common assumption of such validations. Additionally, we previously explained that the paper-based assessments likely under-represented and under-measured some aspects of care that may have been magnified in a clinical assessment of 'real life' patient care, including the inability of our study participants to use their gestalt in the paper-based assessments – this may have been especially important in better understanding how the clinical discriminators are actually used in clinical practice. Second, the sample size was only 102 providers out of about 1500 providers across the Western Cape Government EMS system. Although these providers were from diverse locations, qualifications, and years of experience, our sample may have inherently been different than the larger Western Cape EMS provider population. This could limit the generalizability of our study findings to the larger Western Cape EMS provider population.

The key limitations inherent to our focus group discussions were three-fold. First, although we reached thematic saturation, we only conducted three focus group discussions, divided into three tiers of providers: basic, intermediate, and advanced. It is unclear, although unlikely, that additional themes would have emerged had we conducted additional group discussions. Second, and most importantly, we did not interview EMS leaders, trainers, dispatchers, or hospital staff to learn about their perspective of prehospital SATS. While we have better understood the perspective of the EMS providers, there are additional end-users of SATS whose perspectives were not included in this work. Hence, our conclusions are limited by this. Last, although we asked respondents to provide examples of discriminators that were problematic or worked well, we did not ask respondents to comment on each and every discriminator. Hence, we are unable to provide a conclusive list of strengths and weaknesses of all discriminators, but rather a subset.

Inherent in the mixed methods study approach is that the limitations of the qualitative and quantitative data are entered into the mixing of results. Further, since we did not conduct a sequential approach (e.g., quantitative data collection then analysis, before planning and

conducting focus group discussions), we cannot fully explain all our quantitative findings, and conversely, we do not have data to support some of the statements and assertions from our focus group discussions. This is the major limitation of our mixed methods approach.

5.5 Conclusions

Overall, through mixing of the qualitative and quantitative data, I was able to explain several of the key quantitative findings and discover several important themes from the qualitative work. In sum, EMS providers appreciated the TEWS component of SATS due to its objectivity and relative ease of application, but there is an unacceptably high proportion of TEWS under-calculation (likely due to errors of omission) which can result in harmful under-triage, especially in more seriously ill and injured patients. Over-calculation of TEWS was acceptable and appeared uniformly distributed across all patient types and acuities. The discriminators were largely confusing and inconsistently used by EMS providers across all patient subtypes. This markedly contributed to SATS attaining overall poor validity. Additionally, the respondents provided a few explanations for positive aspects about using SATS for prehospital triage, including having a standardized acuity communication tool and a quantitative measure of acuity. However, the respondents mostly recounted examples of challenges, and frustrations, experienced with SATS and reasons it was poorly compatible with prehospital use.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Overall Conclusions

Drawing from the main observations and findings from Chapters 3, 4, and 5, I hereby make the following overall conclusions:

1. EMS providers appreciate having SATS as a prehospital triage tool because it provides an objective measure of acuity and facilitates communication with in-hospital providers;
2. SATS has poor prehospital validity – it has low accuracy (56%) in predicting true acuity (when assessed using clinical vignettes, and not real-life clinical assessment);
3. SATS has moderate inter-rater reliability overall (i.e., the final colour generated is consistent among prehospital providers assessing clinical vignettes, despite the clinical discriminators attaining only moderate reliability);
4. The TEWS component, although favoured by EMS providers for its objectivity, is frequently miscalculated (57%), especially on critically ill patients and trauma patients;
5. The clinical discriminators component are frequently used incorrectly (41%) without a specific trend for case type or patient acuity;
6. EMS providers cited frustrations with using SATS, including poor compatibility with the prehospital environment and care context.

6.2 Recommendations

6.2.1 Recommendations for future research

I recommend the following as areas for future research:

1) Conduct qualitative research with other end users – I suggest that the opinions and perspectives of other prehospital SATS end users be assessed to gain a holistic picture of the impact, limitations, and strengths of prehospital SATS. Other end users to consider include the following, but the list is not exhaustive: EMS physicians and medical director, EMS dispatch officers, EMS managers (e.g., station managers, quality assurance managers), EMS educators, hospital emergency centre staff (doctors, nurses), and hospital in-patient staff (doctors, nurses). The end users

should reflect a mixture of those from private and government sector to gain a comprehensive understanding.

2) Perform clinical validity testing of prehospital SATS – Our vignette-based assessments suggest that the overall SATS triage tool has poor validity but substantial reliability when used for prehospital triage (notwithstanding the lower reliability by the discriminator component). However, before any adaptations or modifications of prehospital SATS can be suggested, I strongly suggest that further testing of actual clinical data be performed to assess validity of SATS using hospital outcomes and measures of acuity (e.g., need for emergency centre interventions, emergency centre disposition, hospital length of stay, etc). This validity testing will help to inform if or how extensively SATS needs to be re-formulated for prehospital use.
3) Conduct further assessment of prehospital SATS validity in trauma – There is an incredibly high burden of disease due to trauma in the Western Cape, and Western Cape Government provides care and transport for over 200,000 trauma patients annually.(42, 53-55) Given these facts, and considering we found that TEWS performed poorly in trauma (it was derived from MEWS),(32) and that several trauma discriminators were problematic to use, researchers may need to further interrogate and assess the clinical applicability and performance of SATS for prehospital trauma triage. While it less pragmatic to have two versions of SATS – one for trauma and one for non-trauma – the reliability and validity of prehospital SATS for trauma patients warrants further critical exploration. The scoping review identified that the majority of published prehospital triage tools were either for trauma or stroke, suggesting that there may be a compelling reason unique triage tools exist for these specific clinical entities. This warrants further exploration, perhaps by the SATS Working Group which could answer the following potential questions, including: Should there be different vital signs scoring criteria for trauma vs non-trauma? Should the presence of penetrating trauma or obvious blood loss be considered? Can the “severe mechanism” discriminator be better classified or rewritten? What trauma discriminators perform poorest and should be modified? The answers to these questions, among many others, could help in improving the performance of prehospital SATS for trauma populations.

6.2.2 Recommendations for local action

Below are actionable recommendations for consideration by local stakeholders:

1) Continue to use SATS as a prehospital triage tool – This recommendation is based on the key findings that SATS is, overall, positively perceived by prehospital providers, allows an objective indicator of illness (especially the TEWS), and provides a consistent standard language and terminology for communication with hospital providers and the health system in general. Further, the absence of any prehospital tools from other low-and-middle income settings implies that SATS fills an important void in prehospital triage.
2) Simplifications to calculation of TEWS are needed – The TEWS requires a multi-step computational process to arrive at a score, which was more often erroneous in trauma and critical patients. Options are needed to help simplify calculation of the TEWS, which may include the use of simplified scoring tables, workflow reminders/prompts, and semi-automation of the TEWS process (full automation may have the inadvertent consequence of providers not paying attention to the score). I recommend stakeholders convene a 'Prehospital SATS workgroup' comprised of Western Cape Government EMS providers and relevant EMS administrative leads (e.g., quality assurance, education, operations) who can critically discuss the prehospital challenges and propose some feasible solutions.
3) Improve contextual relevance of discriminators for prehospital care – To help reduce mistriage rates, to improve EMS provider satisfaction with SATS, and to allow SATS to be more responsive to the EMS environment, the discriminator list may require some re-formulation such that it is better tailored to the prehospital context. A starting point may be to address those discriminators that are inherently subjective, by trying to make them more objective via clear definitions and enhanced training. For those discriminators that were perceived to require point-of-care testing (e.g., urine ketones, urine pregnancy) or diagnostic imaging results (e.g., X-rays), further education may be warranted to explain how those discriminators may be used in the prehospital context. Further, gentle re-labelling of such discriminators may help to add clarity for the EMS providers. A multi-disciplinary 'Prehospital SATS workgroup' – comprised of prehospital providers, prehospital physicians, emergency medicine

physicians, trauma physicians, SATS experts, and researchers – may be well-positioned to critically review and appraise the existing list, and provide recommendations for changes that are prehospital specific and contextually appropriate.

4) A tailored "prehospital SATS tool" is needed – Notwithstanding the need for additional research, an abundance of quantitative and qualitative evidence from this project strongly suggest that the prehospital SATS performance characteristics (most notably, validity and under-triage rates) are poor, and EMS provider experiences and perspectives strongly indicate that providers are frustrated with the clinical discriminators in their current form. Respondents were clear that they conceptually enjoyed having SATS (specifically, the TEWS and the final SATS triage colours) as a standard acuity scale and a common communication tool, so those attributes should be preserved as much as possible if any adaptations are made to a prehospital SATS tool. One approach is to direct the 'Prehospital SATS workgroup' (as recommended in #2 and #3 above) to provide actionable list of recommendations to the South African Triage Working Group who can use the recommendations to deliberate and consider the merits of adaptation to yield an EMS tailored version of SATS. This is one key recommendation of this study.
5) A prehospital SATS training manual and strategy is needed – There are two scenarios to consider. First, if the South African Triage Working Group concludes that no changes should be made to SATS, I recommend a deliberate and focused effort to retrain existing Western Cape Government EMS providers on SATS, using contextually relevant prehospital examples and case studies. This will require updating the SATS Manual to be more EMS contextually relevant (perhaps a "prehospital SATS training manual"), and in conjunction with a plan for on-the-job training of existing operational providers to help improve accuracy of SATS use. Focal topics for retraining could include: adding a point to the TEWS for trauma status; the role and purpose of discriminators; and, correctly applying confusing or subjective discriminators). Alternatively, if adaptations or changes will be made to SATS, then it may be best to defer the creation of a manual (along with a retraining and re-sensitization strategy) until the SATS revisions are complete, and at which time, the

re-training effort should be focused on the reformulation of SATS, using contextually relevant EMS examples.

6) Embed SATS into local standard operating procedures and guidelines: Regardless of whether or not a prehospital tailored version of SATS will be created, if Western Cape EMS will continue to use SATS for triage, then it is imperative there be deliberate alignment of SATS with local transfer or clinical guidelines and policies (including the Direct Trauma Transfer criteria). As a suggestion, SATS could be woven into guidelines and policies using combinations of acuity (i.e., final triage colour) and/or concerning mechanisms (e.g., from the discriminator list) and/or physiologically based criteria (e.g., using TEWS cutoffs) – this is a similar concept to the US Field Triage Guidelines for prehospital trauma triage. There may need to be specific considerations made that help EMS providers account for the effect of rurality or distance, and EMS provider qualification, on how SATS may interplay with local policies/guidelines.

6.3 Implications

Assuming that no prehospital SATS adaptation is undertaken, nor any further research conducted, the findings of this work raise serious concerns regarding the clinical safety and prehospital utility of SATS (considering the very high under-triage rate, the low validity, and the fact that EMS providers often use SATS in an 'off label' manner, which likely further threatens the validity and reliability of prehospital SATS). Our findings have raised a red flag and serve as an initial urgent call to action by local stakeholders, the EMS community, the academic and research community, and within the Western Cape emergency care system. If left unchanged, there is the potential for continued, or exacerbated, misuse of SATS by EMS providers (including 'off label application such as selecting destinations and trending acuity), which could result in mistriage with patient harm and poor utilization of precious healthcare system resources. Further, without further local adaptation or research, it will be difficult to promote the concept of "exporting" SATS to other prehospital systems outside of the Western Cape or outside of South Africa. This would represent a huge missed opportunity considering the scarcity (or absence) of prehospital triage tools for undifferentiated patients in Africa and other LMICs which we discovered in our scoping review.

However, if purposeful adaptations are made, informed by expert stakeholder consensus and biomedical research, it is plausible that a prehospital version of SATS could be produced or meaningful adaptations created. In theory, the direct local benefits of a prehospital tailored version of SATS include improved and safer patient care (via enhanced accuracy and validity), judicious healthcare system resource utilization (via accurate triage and alignment with destination criteria), improved EMS provider job satisfaction (via an easier triage tool), and enhanced compliance with EMS protocols and policies (assuming alignment of prehospital SAT with local policies). Beyond the Western Cape, a prehospital-appropriate SATS tool would likely be highly desirable by other EMS both in South Africa and in other LMICs globally, given the unique value it adds to prehospital clinical care. However, other EMS systems outside of the Western Cape will need to further adapt the tool in consideration for their local burden of disease, health system configuration, EMS system in general, and overall desired performance characteristics of a prehospital triage tool.

6.4 Conclusion

Across the world, the majority of evidence-based prehospital triage tools are either trauma or stroke-focused. A few triage tools are relevant for undifferentiated patients, but have only modest performance characteristics. Alarmingly, no published prehospital triage tools have originated from low-and-middle income countries. The South Africa Triage Scale (SATS), originally developed for hospital emergency unit triage, has been innovatively used by Western Cape Government EMS for prehospital triage since 2012. EMS providers appreciate SATS because it serves as useful communication tool and provides objective indicators of acuity. However, in prehospital clinical vignettes, SATS achieved poor validity, predominantly due to an unacceptably high under-triage rate (29.5%). Mistriage is commonly due to miscalculation of the TEWS score (likely due to errors of omission), and misuse of the clinical discriminators (due to poor contextual fit for prehospital care and providers' confusion with many discriminators). SATS, however, is reliably used by EMS providers evidenced by moderate consistency of use among the cohort of EMS providers we assessed. EMS providers consistently expressed frustration with the clinical discriminators, but are generally satisfied with the TEWS (although they often incorrectly use the TEWS).

This first assessment has identified challenges and opportunities for SATS when used for triage by EMS providers in a resource-constrained prehospital setting. Our findings, and my recommendations, strongly suggest that additional clinical based validation studies are warranted, but have also identified that changes are needed to the clinical discriminators to improve their applicability and use for prehospital triage. I recommend that expert stakeholder input and empiric research data be used to inform whether a prehospital version of SATS is warranted. Prehospital SATS could be strengthened via integration of SATS with local health system guidelines and policies. Overall, SATS fills an important void, locally and globally, in the prehospital triage of undifferentiated patients – if SATS is tailored to the prehospital environment, and if its performance characteristics are improved, SATS is a promising innovation to improve patient care in the Western Cape of South Africa and in other resource-limited settings globally.

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LIST OF APPENDICES

Appendix 1: University of Cape Town HREC Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: churetta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

28 October 2016

HREC REF: 705/2016

Dr SR Bruijns
Emergency Medicine
J-floor, OMB

Dear Dr Bruijns

PROJECT TITLE: ASSESSING USE OF THE SOUTH AFRICAN TRIAGE SCALE (SATS) IN WESTERN CAPE GOVERNMENT EMERGENCY MEDICAL SERVICES (EMS)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study, subject to the provision of formal research ethics approval from UC Denver.

Approval is granted for one year until the 30th October 2017.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period. (Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator must obtain appropriate institutional approval before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical

HREC 705/2016

Appendix 2: Colorado Multiple Institutional Review Board Approval

University Research
Colorado Multiple Institutional Review Board, CB F490
University of Colorado, Anschutz Medical Campus
13001 E. 17th Place, Building 500, Room N3214
Aurora, Colorado 80045

303.724.1055 [Phone]
303.724.0990 [Fax]
COMIRB Home Page [Web]
comirb@ucdenver.edu [E-Mail]
FWA00005070 [FWA]

University of Colorado Hospital
Denver Health Medical Center
Veteran's Administration Medical Center
Children's Hospital Colorado
University of Colorado Denver
Colorado Prevention Center

Certificate of Acknowledgment
06-Dec-2016

Investigator:	Nee-Kofi Mould-Millman
Sponsor(s):	No Sponsor~
Subject:	COMIRB Protocol 16-2271 Initial Application
Effective Date:	27-Oct-2016
Title:	Assessing use of the South African Triage Scale (SATS) in Western Cape Government Emergency Medical Services (EMS) Cape Town University IRB

This study is approved by COMIRB via the Cooperative Agreement with the designated IRB of Record.

The designated IRB of Record will provide oversight and continuing review for the remainder of time that the protocol is active. It is the PI's responsibility to ensure that the protocol remains approved by, and in good standing with, the IRB of record.

Please report to COMIRB any unanticipated problem or complaint that occurs locally, and notify COMIRB when this protocol is closed by the IRB of record.

Review Comments:

This activity will be overseen by the Cape Town University IRB.

Sincerely,

UCD CIRB

Appendix 3: Western Cape Government EMS Approval

Western Cape Government
Health

DIRECTORATE: **EMERGENCY MEDICAL SERVICES**
ENQUIRIES: **Dr Shaheem de Vries**
EMAIL: shaheem.devries@westerncape.gov.za
☎: +27 21 508 4523

17 June 2021

Re: Confirmation of Western Cape EMS Organizational Approval for Prehospital SATS Study

To whom it may concern,

I hereby confirm that Dr. Mould-Millman and his research team received approval by our organization for the conduct of the following study, following the ethical approval of the study:

Title: "Assessing use of the South African Triage Scale (SATS) in Western Cape Government Emergency Medical Service (EMS)": UCT HREC reference number: 705/2016; UCT approval date: 28-October-2016.

Since the research was done collaboratively, Dr. Mould-Millman was in full contact will all leaders and relevant members of the EMS organization in advance of, and during, the study. Please let me know if you have additional questions.

Sincerely,

DR SHAHEEM DE VRIES
DIRECTOR: EMERGENCY MEDICAL SERVICES

METRO EMS Emergency Service Centre, Private Bag X24, Bellville, tel: +27 21 937 0609
www.capegateway.go.v.za

Appendix 4: Scoping Review Database Search Strategies

MEDLINE (via Ovid MEDLINE® and Epub Ahead of Print, In-Proce & Other Non-Indexed Citation, Daily and Verion®, 1946 to present)

Search date = 12/23/2019

1	ambulance*.ab,ti.
2	emergency medical technician*.ab,ti.
3	EMT*.ab,ti.
4	paramedic*.ab,ti.
5	prehospital*.ab,ti.
6	pre-hospital*.ab,ti.
7	or/1-6
8	exp "Triage"/
9	triag*.ab,ti.
10	or/8-9
11	7 and 10
12	11 and English.la.
13	limit 12 to yr="2009 -Current"
14	13 not (exp case reports/ or exp "review"/ or exp meta-analysis/ or exp "systematic review"/ or exp comment/ or exp editorial/ or exp letter/)
15	remove duplicates from 14

Embase (via Elsevier, Embase.com, 1947 to present)

Search date = 12/23/2019

1	ambulance*:ab,ti
2	'emergency medical technician*':ab,ti
3	emt*:ab,ti
4	paramedic*:ab,ti
5	prehospital*:ab,ti
6	'pre hospital*':ab,ti
7	#1 OR #2 OR #3 OR #4 OR #5 OR #6
8	triag*:ab,ti
9	#7 AND #8
10	#9 AND [english]/lim
11	#10 AND [2009-2020]/py
12	#11 NOT ('case report'/exp OR 'case study'/exp OR 'review'/exp OR 'letter'/exp OR 'editorial'/exp OR 'note'/exp)
13	#12 AND ('article'/it OR 'article in press'/it OR 'review'/it)

Web of Science Core Collection (via Clarivate Analytics, including Science Citation Index Expanded and Social Sciences Citation Index, 1974 to present)

Search date = 12/23/2019

1	TS="ambulance*"
2	TS="emergency medical technician*"
3	TS="EMT*"
4	TS="paramedic*"
5	TS="prehospital*"
6	TS="pre-hospital*"
7	#1 OR #2 OR #3 OR #4 OR #5 OR #6
8	TS="triag*"
9	#7 AND #8
10	(#9) AND LANGUAGE: (English)
11	(#10) AND LANGUAGE: (English); Timespan=2009-2019
12	(#11) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article OR Correction OR Review); Timespan=2009-2019

Summary of database search strategies

Database	**# Results**
Ovid MEDLINE	1077
Embase	902
Web of Science	1171
Subtotal	3150
Duplicates removed	1629
Total unique results	**1521**

Appendix 5: Prose Summary of Included Articles

Anadani M, Almallouhi E, Wahlquist AE, Debenham E, Holmstedt CA. The Accuracy of Large Vessel Occlusion Recognition Scales in Telestroke Setting. Telemedicine Journal and e-Health. 2019;25(11):1071-6.

This study aimed to assess the accuracy of the most commonly used large vessel occlusion (LVO) recognition scales in the prehospital setting. The National Institutes of Health Stroke Scale (NIHSS) was calculated and documented by a consulting stroke neurologist during telestroke consults and used to calculate the following scales: 3-item stroke scale (3I-SS), Rapid Arterial Occlusion Evaluation Scale (RACE), Cincinnati Prehospital Stroke Severity Scale (CPSSS), Prehospital Acute Stroke Severity Scale (PASS), and the Field Assessment Stroke Triage for Emergency Destination (FAST-ED) stroke scale.

A retrospective chart review was performed of all consecutive telestroke patients who were transferred to the rural Medical University of South Carolina hub for suspected LVO during the period from May 2014 to March 2018. Using published cutoffs for each scale, the sensitivity, specificity, accuracy, positive and negative predictive values, false positive rate (FPR), and false negative rate (FNR) of each score were calculated. Secondarily, all possible cutoff values were considered for a given scale to identify the cutoff that maximized the sum of sensitivity and specificity.

A total of 439 patients were included in the final analysis. A total of 48.5% of patients had an LVO confirmed on computed tomography angiogram. RACE score (using cutoff of greater than or equal to 5) had the highest accuracy for predicting LVO (78%), with a FNR of 11% and FPR of 33%. All five derived prehospital LVO recognition scores had at least 10% FNR. In contrast, the NIHSS (cutoff of greater than or equal to 6) had a 3% FNR and 73% FPR (implying unnecessary transfer). Better diagnostic tools that maximize sensitivity with acceptable specificity are urgently needed.

Andsberg G, Esbjornsson M, Olofsson A, Lindgren A, Norrving B, von Euler M. PreHospital Ambulance Stroke Test - pilot study of a novel stroke test. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2017;25(1):37.

The objective of this study was to evaluate the performance characteristics of PreHospital Ambulance Stroke Test (PreHAST) in terms of sensitivity for stroke/transient ischemic attack (TIA) detection in the prehospital setting, along with ability to communicate stroke severity similar to the National Institutes of Health Stroke Scale (NIHSS).

The PreHAST is an eight-item test based on NIHSS which scores stroke severity from 0–19 points. It involves evaluation of neurological signs with high prevalence in stroke as compared to stroke mimics in the prehospital screening (e.g., Level of consciousness, gaze deviation, facial palsy, arm/leg paresis, dysarthria, hemianopia and sensory loss).

Ambulance nurses in rural Sweden prospectively applied PreHAST to assess adult patients with suspected stroke in the prehospital setting. Of 69 patients included in the study, 26 had stroke/TIA and 43 had other diagnoses. There was a sensitivity of 100% (95% CI 87-100%) and a specificity of 40% (95% confidence interval (CI) 25-56%) for Stroke/TIA when a positive score in any PreHAST item (PreHAST score 1–19 points) was found after prehospital assessment in patients with suspected stroke. Furthermore, the positive and negative predictive value was 50% and 100%, respectively, for a positive PreHAST score. The receiver operating characteristic (ROC) analysis showed an area under the curve (AUC) of 0.77 (95%CI; 0.66-0.88). In conclusion, PreHAST is a new screening test of stroke adapted for ambulance services that in addition to high sensitivity for stroke, provides a grading system with increasing specificity with higher scores.

Ardolino A, Cheung CR, Lawrence T, Bouamra O, Lecky F, Berry K, et al. The accuracy of existing prehospital triage tools for injured children in England: an analysis using emergency department data. Emergency Medicine Journal. 2015;32(5):397-400.

The objective of this study is to build on previous work using trauma registry data based in the Trauma Audit and Research Network (TARN) to assess the performance characteristics of pediatric prehospital trauma triage tools currently in use or under development in England. This study compares 8 tools: East Midlands standard operating procedure, London triage tool, North West, Northern, South West London and Surrey, Pediatric triage score, Pediatric triage tape, and the Wessex triage tool.

Retrospective clinical data of 2934 patient records from four emergency departments in England were used to interrogate each of the triage tools. Inclusion criteria were people aged below 16 years sustaining injury or trauma between January 2011 and June 2012 who attended the emergency department without using an ambulance. The constituent discriminators for each tool were then retrospectively applied to the dataset of injured children from each emergency department to derive sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio measures for each tool's efficacy in identifying seriously injured children (defined as those with ISS >15).

Three of the tools fulfilled acceptable criteria for both over and under-triage (East Midlands, North West and Northern), with over-triage rates of 18%, 21% and 19%, respectively, and under-triage

rates of 0% in each. The other five tools fell below the target sensitivity of 95%. All eight tools had acceptable specificity (with results between 79% and 99%). In this population of children with minor to moderate injuries, the prehospital triage tools in common use or in development across England all show high sensitivity and moderate specificity. Five of the eight tools analyzed (London, South West London/Surrey, Wessex, Pediatric trauma score and Pediatric triage tape) show a tendency to under-triage.

Barnett AS, Wang NE, Sahni R, Hsia RY, Haukoos JS, Barton ED, et al. Variation in prehospital use and uptake of the national Field Triage Decision Scheme. Prehospital Emergency Care. 2013;17(2):135-48.

The American College of Surgeons Committee on Trauma and the Centers for Disease Control's National Trauma Triage Protocol: Field Triage Decision Scheme (FTDS) is a national guideline that has been implemented widely for prehospital emergency medical services (EMS) and trauma systems. The objective of this study is to describe the use of field triage criteria by EMS personnel in six regions of the Western United States, including the timing of guideline uptake and the use of non-guideline criteria.

This study used a retrospective cohort of injured children and adults transported by 48 EMS agencies to 105 hospitals in six Western U.S. regions from 2006 through 2008. Descriptive statistics were used to compare the frequency of triage criteria use and to evaluate the timing of guideline uptake across multiple versions of the guidelines. A total of 260,027 injured patients were evaluated and transported by EMS over the three-year study period, of whom 46,414 (18%) met at least one field triage criterion and formed the primary sample for analysis. The three most common criteria cited were EMS provider judgment (26%), age <5 or >55 years (10%), and Glasgow Coma Scale (GCS) score <14 (9%). Of the 33 criteria in use, 5 (15%) were previously retired from the guidelines and 7 (21%) were never included in the guidelines. 11,048 (24%) of patients had more than 1 criteria applied (range 1 – 21).

This study found large variation between regions in the frequency and type of field triage criteria used. Field uptake of guideline revisions appears to be slow and variable, suggesting opportunities for improvement in dissemination and implementation of updated guidelines.

Bergs J, Sabbe M, Moons P. Prehospital stroke scales in a Belgian prehospital setting: a pilot study. European Journal of Emergency Medicine. 2010;17(1):2-6.

The aim of this study was to directly compare the diagnostic value of the Cincinnati Prehospital Stroke Scale (CPSS), Face Arm Speech Test (FAST), Los Angeles Prehospital Stroke Screen (LAPSS),

and the Melbourne Ambulance Stroke Screen (MASS) for identifying patients with a stroke in a specific Belgian emergency medical service (EMS).

The CPSS and FAST both evaluate the presence or absence of facial palsy, unilateral arm weakness, and speech impairment. If at least one item is present, stroke is suspected. The LAPSS and the MASS incorporate history criteria and a blood glucose measurement in addition to clinical assessment. The MASS contains the same items as the LAPSS with the addition of a speech impairment evaluation.

This prospective study was conducted from December 2005 through April 2006 in the emergency department (ED) of the University Hospitals in Leuven, Belgium. A questionnaire for every transported patient was used which contained 10 questions: four history questions, a blood glucose measurement, and a limited clinical examination. The results for each scale were compared with the diagnosis at discharge to determine prevalence, sensitivity, specificity, positive predictive value, negative predictive value, likelihood ratio, and accuracy.

Seventy patients were transported to the ED of the University Hospitals Leuven. The EMS staff completed a questionnaire for 31 (44%) patients. Finally, 19 (61.3%) patients had a diagnosis of a stroke. The FAST and CPSS demonstrate a high sensitivity (95%) but a lower specificity (33%). The sensitivity of the LAPSS and MASS was lower (74%), but the specificity increased (83 and 67%). Items investigating unilateral facial paralysis and unilateral loss/absence of motor response in upper extremities seemed to be most discriminating between the stroke group (68–78%) and the non-stroke group (17%), suggesting that items related to clinical assessment are more important in stroke recognition than history items. Further research is needed to determine the most adequate stroke scale

Brown JB, Forsythe RM, Stassen NA, Gestring ML. The National Trauma Triage Protocol: can this tool predict which patients with trauma will benefit from helicopter transport? The Journal of Trauma and Acute Care Surgery. 2012;73(2):319-25.

The American College of Surgeons Committee on Trauma and the Centers for Disease Control jointly developed the National Trauma Triage Protocol: Field Triage Decision Scheme (FTDS) to identify trauma patients who would benefit from trauma center care. The FTDS is based on the stepwise identification of four aspects of clinical presentation involving physiologic criteria (PHY), anatomic criteria (ANA), mechanism of injury criteria, and special considerations criteria that are evaluated in a sequential fashion to identify patients who should be transported to a trauma center. Physiologic criteria focus on vital signs and Glasgow Coma Scale (GCS); anatomic criteria include specific injury patterns such as penetrating trauma, flail chest, crush injury, etc; mechanism of injury criteria focuses on high risk patterns such as falls from specific height, high speed vehicular crash,

motorcycle accident etc; and special considerations include extremes of age, comorbidities, burns, pregnancy, anticoagulated status, etc.

The study objective was to determine if the criteria included in the FTDS could be used by field emergency medical services providers to predict which patients would benefit from helicopter transport after injury. Subjects in the United States transported by helicopter or ground transport from the scene of injury in 2007 were identified using the National Trauma Databank version 8. Criteria from the stepwise FTDS available in the data set were collected. Subgroups of patients who met specific triage criteria were evaluated using logistic regression to determine if transport modality was an independent predictor of survival after controlling for demographics, injury severity, prehospital time, and presence of other FTDS triage criteria. Standard test characteristics were calculated for each criterion to predict trauma center need (TCN). The performance of triage criteria to predict TCN was compared between the groups using independent receiver operating characteristic area under the curve analysis.

There were 258,387 subjects transported either by helicopter (16%) or by ground (84%). Helicopter transport was an independent predictor of survival to discharge when compared with ground transport in the presence of penetrating injury, GCS score of less than 14, respiratory rate of less than 10 breaths per minute or more than 29 breaths per minute, and age of more than 55 years. In addition, subjects that had any one PHY plus any one ANA had a survival advantage if transported by helicopter when compared with ground transport. In conclusion, patients who meet certain triage criteria in the field seem to have an independent survival benefit if transported to a trauma center by helicopter. Furthermore, these criteria are highly specific and more reliably predict TCN in the helicopter transport group.

Brown JB, Gestring ML, Guyette FX, Rosengart MR, Stassen NA, Forsythe RM, et al. External validation of the Air Medical Prehospital Triage score for identifying trauma patients likely to benefit from scene helicopter transport. The Journal of Trauma and Acute Care Surgery. 2017;82(2):270-9.

The Air Medical Prehospital Triage (AMPT) score was developed to identify injured patients who may benefit from scene helicopter emergency medical services (HEMS) transport. One point is assigned for Glasgow Coma Scale<14, respiratory rate <10 or >29, unstable chest wall fracture, suspected hemothorax or pneumothorax, paralysis, or multisystem trauma involving 3 or more anatomic regions; 2 points are assigned if patient has any 1 physiologic criterion plus any 1 anatomic criterion present from American College of Surgeons Committee on Trauma national field triage

guidelines. If the summation of points is two or greater, the patient should be considered for helicopter transport.

The study objective was to validate the effectiveness of the AMPT score in identifying patients with a survival benefit from HEMS. Patients 16 years or older undergoing scene HEMS or ground EMS (GEMS) transport in the Pennsylvania Trauma Outcomes Study registry from 2000 to 2013 were included. Patients with 2 or higher AMPT score points were triaged to HEMS, while those with less than 2 points were triaged to GEMS. Multilevel Poisson regression determined the association of survival with actual transport mode across AMPT score triage assignments, adjusting for demographics, mechanism, vital signs, interventions, and injury severity. There were 222,827 patients included. For patients triaged to GEMS by the AMPT score, actual transport mode was not associated with survival (adjusted relative risk, 1.004; 95% confidence interval, 0.999–1.009; p = 0.08). For patients triaged to HEMS by the AMPT score, actual HEMS transport was associated with a 6.7% increase in the relative probability of survival (adjusted relative risk 1.067; 95% confidence interval, 1.040–1.083, p < 0.001). This study is the first to externally validate the AMPT score, demonstrating the ability of this tool to reliably identify trauma patients most likely to benefit from HEMS transport.

Brown JB, Stassen NA, Bankey PE, Sangosanya AT, Cheng JD, Gestring ML. Mechanism of Injury and Special Consideration Criteria Still Matter: An Evaluation of the National Trauma Triage Protocol. Journal of Trauma-Injury Infection and Critical Care. 2011;70(1):38-45.

The American College of Surgeons Committee on Trauma and the Centers for Disease Control jointly developed the National Trauma Triage Protocol: Field Triage Decision Scheme (FTDS), to identify trauma patients who would benefit from trauma center care. The FTDS is based on the stepwise identification of four aspects of clinical presentation including physiologic criteria (PHY), anatomic criteria (ANA), mechanism of injury criteria, and special considerations criteria that are evaluated in a sequential fashion to identify patients who should be transported to a trauma center. Physiologic criteria focus on vital signs and Glasgow Coma Scale; anatomic criteria include specific injury patterns such as penetrating trauma, flail chest, crush injury, etc; mechanism of injury criteria focuses on high risk patterns such as falls from specific height, high speed vehicular crash, motorcycle accident etc; and special considerations include extremes of age, comorbidities, burns, pregnancy, anticoagulated status, etc.

The study objective was to analyze whether trauma center need was accurately predicted solely by the physiologic (PHY) and anatomic (ANA) criteria of the CDC National Trauma Triage Protocol. Trauma patients aged 18 years and older were identified in the National Trauma Data Bank (2002–

2006). Trauma Center Need (TCN) was defined as Injury Severity Score (ISS) >= 15, intensive care unit admission, or need for urgent surgery. Logistic regression was performed to determine independent association of criteria with outcomes. A total of 1,086,764 subjects were identified. PHY criteria as a whole were more sensitive (32% vs. 26%) and specific (91% vs. 86%) than ANA criteria with lower rates of overtriage and undertriage. When the PHY and ANA criteria were applied sequentially as designed in the triage protocol, sensitivity rose to 49% sensitivity and specificity fell to 78% for identifying TCN. Undertriage using the first two steps of the triage protocol was 51%. Undertriage for TCN based on actual treating trauma center level was 11%. Current PHY and ANA criteria are highly specific for TCN but result in a high degree of undertriage when applied independently. This implies that additional factors such as mechanism of injury and the special considerations included in the Centers for Disease Control decision algorithm contribute significantly to the effectiveness of this field triage tool.

Buschhorn HM, Strout TD, Sholl JM, Baumann MR. Emergency medical services triage using the emergency severity index: is it reliable and valid? Journal of Emergency Nursing. 2013;39(5):e55-63.

The Emergency Severity Index is a 5-tiered system that uses both illness severity and anticipated resource needs of the patient to stratify patients into triage categories. Level 1 is assigned for patients requiring immediate life-saving intervention; level 2 is for those in high risk situations, and those having altered mental status, severe pain/distress, or with danger zone vitals (using specific cut offs for heart rate, respiratory rate and oxygen saturation by age); level 3 is for those with many anticipated resource needs; level 4 is those requiring one anticipated resource; level 5 is those requiring no resources. Resources include laboratory analysis, imaging, intravenous or intramuscular medications, specialty consultations, and/or bedside procedures such as laceration repair or conscious sedation. History and physical, point-of-care testing, oral medications, tetanus vaccine updates, and simple procedures like dressing changes and provision of crutches/slings are not classified as resources in the ESI algorithm.

This prospective, single center observational study evaluated interrater reliability in ESI scores assigned by prehospital personnel and emergency department nurses (RNs). Interrater reliability, differences based on provider experience, and validity of EMS triage assignments (sensitivity and specificity) were evaluated. Seventy-five paired, blinded triages were completed. Overall concordance between EMS providers and RNs was 0.41 (95% confidence interval [CI], 0.26-0.56). Concordance for EMS providers with less experience was 0.52 (95% CI, 0.26-0.78), and for those with more experience was 0.35 (95% CI, 0.16-0.54). Sensitivity ranged from 0% to 68% and specificity

ranged from 68% to 97%. There was moderate concordance between EMS and RN ESI triage assignments. EMS sensitivity for correct acuity assignment was generally poor, whereas specificity for correctly not assigning a particular level was better.

Carr K, Yang Y, Roach A, Shivashankar R, Pasquale D, Serulle Y. Mechanical Revascularization in the Era of the Field Assessment Stroke Triage for Emergency Destination (FAST-ED): A Retrospective Cohort Assessment in a Community Stroke Practice. Journal of Stroke and Cerebrovascular Diseases. 2019:104472.

The field assessment for stroke triage (FAST-ED) prehospital triage tool, is one of many stroke severity scales designed to decrease time to diagnosis in the field and optimize patient triage to comprehensive stroke centers. The FAST-ED scale (*F*acial Palsy [scored 0-1], *A*rm weakness [0-2], Speech changes [0-2], *T*ime [documentation for decision making but no points], *E*ye deviation [0-2], and *D*enial/neglect [0-2]) was designed based on items of the National Institutes of Health Stroke Scale (NIHSS) with higher predictive value for large vessel occlusion stroke.

The study objective was to assess the impact of the implementation of the FAST-ED triage tool on the activation of the stroke intervention team in a community stroke treatment practice in Florida, United States. This was a retrospective chart review of admitted stroke alert patients brought in to a single center by EMS between March 2017 and September 2018. The association between EMS-documented FAST-ED scores and impact on time to revascularization as well as the association between FAST-ED scores and the presence of emergent large vessel occlusion were analyzed. Admission FAST-ED scores for the overall cohort of 402 patients was 3.3 ± 2.3 (mean ± SD) versus 5.1 ± 2.1 (mean ± SD) in patients with radiographically identified emergent large vessel occlusion. In general, there was a direct but weak correlation between FAST-ED scores and National Institutes of Health Stroke Scale severity (Spearman rank test $p = 0.45$, $p<0.001$) on admission. Receiver operator curve analysis for the patient population suggested a FAST-ED cut off greater than or equal to 4 (Sensitivity 80%; Specificity 68%; PPV 40 %), and NIHSS greater than or equal to 12 (Sensitivity 76%; Specificity 74%; PPV 41%) for predicting an emergent vessel occlusion.

There was a statistically significant improvement in interventional team activation times in favor of the FAST-ED cohort (74 minutes vs. 110 minutes, $p < 0.05$). FAST-ED implementation demonstrated a statistically significant improvement on stroke team activation times for patients who are candidates for mechanical revascularization.

Carrera D, Gorchs M, Querol M, Abilleira S, Ribo M, Millan M, et al. Revalidation of the RACE scale after its regional implementation in Catalonia: a triage tool for large vessel occlusion. Journal of Neurointerventional Surgery. 2019;11(8):751-6.

The RACE scale is a prehospital tool that aims to detect acute stroke patients with a high probability of having a large vessel occlusion (LVO). The RACE scale evaluates five items: facial palsy, upper extremity paresis, lower extremity paresis, head and gaze deviation, and aphasia/agnosia, with a total score of 0–9.

The objective of this study was to revalidate the RACE scale after its region-wide implementation in Catalonia, Spain, and to analyze geographical differences in access to endovascular treatment (EVT). Prospective data from the Stroke Code Catalan registry was collected for all stroke code activations. The RACE score evaluated by emergency medical services, time metrics, final diagnosis, presence of LVO, and type of revascularization treatment were registered. Sensitivity, specificity, and area under the curve (AUC) for the RACE cut-off value ≥5 for identification of both LVO and eligibility for EVT were calculated. The RACE scale was evaluated in the field in 1822 patients, showing a strong correlation with the subsequent in-hospital evaluation of the National Institute of Health Stroke Scale (r=0.74, P<0.001). A RACE score ≥5 detected LVO with a sensitivity 0.84 and specificity 0.60 (AUC 0.77). Patients with RACE ≥5 harbored a LVO and received EVT more frequently than RACE <5 patients (LVO 35% vs 6%; EVT 20% vs 6%; all P<0.001). This large validation study confirms RACE accuracy to identify stroke patients eligible for EVT.

Cassignol A, Markarian T, Cotte J, Marmin J, Nguyen C, Cardinale M, et al. Evaluation and Comparison of Different Prehospital Triage Scores of Trauma Patients on In-Hospital Mortality. Prehospital Emergency Care. 2019a;23(4):543-50.

Several prehospital major trauma patient triage scores have been developed, including the triage revised trauma score (T-RTS), Vittel criteria, Mechanism/Glasgow Coma Scale/Age/Systolic blood pressure score (MGAP), and the new trauma score (NTS). These scoring schemes allow a rapid and accurate prognostic assessment of the severity of trauma. The scoring systems are used as follows. T-RTS is scored based on the Glasgow Coma Scale, systolic blood pressure, and respiratory rate. T-RTS ranges from 0 (no signs of life) to 12 (normal vital functions). The Vittel criteria include 5 parameters: abnormal vital signs including abnormal GCS, high risk mechanism of injury, certain anatomical injuries, high degree of prehospital resuscitation required, and special considerations (age > 65, pregnancy, comorbidities). The presence of only one Vittel criterion justifies patient care in a Level 1 trauma center. The MGAP score uses age, Glasgow Coma Scale, systolic blood pressure, and type of trauma (blunt or penetrating trauma), to group patients into low (23-29), intermediate

(18-22) or high risk for mortality (3-17). The NTS combines oxygen saturation, systolic blood pressure and the Glasgow Coma Scale to predict the risk of mortality as follows: very high risk (3–5), high risk (6–11), intermediate risk (12–17), and low risk (18–23).

The study objective was to compare these four scores with 30 day in-hospital mortality predictions in a cohort of consecutive admitted trauma patients. This was a single center retrospective study performed over a 4 year period (2013-2016) in a Level 1 trauma center in southern France. The diagnostic performance of each score to predict in-hospital mortality was assessed using receiver operating characteristic analysis. A total of 1,001 patients were included in the analysis, 238 (24%) females, aged 43 ± 19 years with ISS 15 ± 13. The area under the curve for each score was as follows: T-RTS, AUC= 0.84, [0.82–0.87]; Vittel criteria, AUC = 0.87 [0.85–0.89]; MGAP score, AUC = 0.91 [0.89–0.92] and NTS, AUC = 0.90 [0.88–0.92]. To test the ability of each score to be used for triage, sensitivity, specificity, positive predictive value, and negative predictive value were calculated at their usual thresholds (T-RTS <12, Vittel criteria >= 1, MGAP < 23, NTS < 18). With the current thresholds, the sensitivity, specificity, positive and negative predictive values of these scores were 91%, 35%, 10%, 98% for T-RTS, 100%, 2%, 8%, 100% for Vittel criteria, 91%, 71%, 24%, 99% for MGAP score, and 82%, 86%, 33%, 98% for NTS. Only Vittel's criteria achieved undertriage rates below 5% as recommended by the American College of Surgeons Committee on Trauma (ACS-COT). The MGAP and NTS scores had better performance compared with the T-RTS. Including the calculation of MGAP or NTS scores with the Vittel criteria would reduce the risk of overtriage in the Level 1 trauma centers by further directing patients at low risk of death to a lower-level trauma facility.

Cassignol A, Marmin J, Cotte J, Cardinale M, Bordes J, Pauly V, et al. Correlation between field triage criteria and the injury severity score of trauma patients in a French inclusive regional trauma system. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2019b;27(1):71.

In France, the pre-hospital field triage of trauma patients is currently based on the Vittel criteria algorithm which was originally created in 2002 before the stratification of trauma centers. The Vittel criteria include 5 parameters: abnormal vital signs including abnormal GCS, high risk mechanism of injury (also called kinetic elements), certain anatomical injuries, high degree of prehospital resuscitation required, and special considerations (age > 65, pregnancy, comorbidities). The presence of only one Vittel criterion justifies patient care in a Level 1 trauma center.

The study objective was to evaluate the correlation between each Vittel field triage criterion and the presence of an Injury Severity Score of greater than 15, mortality within 30 days, and admission to

the intensive care unit. This was a single center prospective observational study in France. Of the 1373 patients in the registry, 1151 were included in the analysis with a mean age of 43 years (± 19) and a median ISS of 13 (IQR = 5–22), where 887 (77%) were male. Nine of the 24 Vittel criteria were associated with an ISS > 15. For prediction of 30 day mortality, kinetic elements had a sensitivity of 77%, specificity of 13%, positive predictive value of 7% and negative predictive value of 86%. In a multivariate analysis, no criterion related to kinetic elements was significantly correlated with an ISS > 15, mortality within 30 days, or admission to intensive care. Criteria related to physiological variables, pre-hospital resuscitation, and physical injuries were the most relevant to predicting the severity of a trauma patient's condition, while kinetic variables were not.

Chenkin J, Gladstone DJ, Verbeek PR, Lindsay P, Fang J, Black SE, et al. Predictive value of the Ontario prehospital stroke screening tool for the identification of patients with acute stroke. Prehospital Emergency Care. 2009;13(2):153-9.

The Ontario Prehospital Stroke Screening Tool consists of three inclusion criteria (unilateral weakness, slurred speech or muteness, and facial droop), a two-hour time limit from symptom onset, and six exclusion criteria. The tool's exclusion criteria were designed to exclude patients with stroke mimics (hypoglycemia, seizure), patients needing emergent intervention (Canadian Triage and Acuity Scale Level 1, Glasgow Coma Scale score less than 10), and patients ineligible for fibrinolysis (symptoms resolved, terminally ill or palliative).

The study objective was to determine the positive predictive value (PPV) of the Ontario Prehospital Stroke Screening Tool for identification of acute stroke at a single stroke center. This was a retrospective analysis of consecutive patients transported to a regional stroke center under the prehospital acute stroke protocol over a 12-month period. Final diagnoses, treatments, and outcomes were abstracted from a provincial registry. Rates of fibrinolysis were compared with those for the 12-month period prior to implementation of the stroke protocol. 325 patients were triaged under the emergency medical services (EMS) acute stroke protocol over the study period. The PPV was 89.5% (95% confidence interval [CI]: 85.7–92.7%) for acute stroke. The rate of administration of tissue plasminogen activator (tPA) for all patients with suspected stroke increased from 5.9% to 10.1% (p = 0.04). The Ontario Prehospital Stroke Screening Tool had a high PPV for acute stroke. Following implementation of a citywide acute stroke protocol using this screening tool, there was an increase in the number of patients who were eligible for and received fibrinolysis at the stroke center.

Cox S, Currell A, Harriss L, Barger B, Cameron P, Smith K. Evaluation of the Victorian state adult pre-hospital trauma triage criteria. Injury. 2012;43(5):573-81.

The Victorian adult pre-hospital trauma triage criteria is modeled off the Centers for Disease Control National Trauma Triage Protocol: Field Triage Decision Scheme and consists of physiological, anatomical and mechanistic criteria to determine need for transport to a level I trauma center. The study objective was to evaluate the performance of the Victorian prehospital trauma triage criteria in discriminating between confirmed major trauma patients and non-major trauma patients and to propose refined criteria to improve under and over-triage rates. Major trauma was defined at hospital discharge as one or more of: death, Injury Severity Score > 15, ICU ventilation or urgent surgery.

The study was conducted in Melbourne, Victoria and consisted of patients age 16 and older. The data was sourced from the pre-hospital Victorian Ambulance Clinical Information System and the Victorian State Trauma Registry from October 2006 through September 2007. The triage criteria were evaluated using multivariate logistic regression and classification tree modeling. Diagnostic statistics, including sensitivity and specificity were calculated to assess triage performance. Of 45,332 trauma patients transported to metropolitan hospitals, there were 1166 patients identified as confirmed major trauma at hospital discharge. The current pre-hospital trauma triage criteria have a sensitivity of 95.3%, a specificity of 62.7%, and an overall accuracy of 63.4%. The over-triage rate is 37.3% and the under-triage rate is 4.7%.

Evaluation showed the current triage criteria needed refinement, and multiple revised pre-hospital trauma triage models were constructed. Based on the best overall combination of diagnostic statistics, a revised model was chosen. This updated model includes adjusted blood pressure, respiratory rate and heart rate parameters, removes rollover MVC as a mechanistic consideration, and introduces instructions to transport to a facility within 30 minutes. This model had a sensitivity of 97.8%, a specificity of 82.7% and an accuracy of 83.0%. The over-triage rate was 17.3% and the under-triage rate was 2.2%. The implementation of a revised triage model should identify more confirmed major trauma patients. Likewise, over-triage of non-major trauma patients to major trauma services would be significantly reduced. The refined criteria should also decrease discretionary decision-making by paramedics in the field.

Davidson GH, Rivara FP, Mack CD, Kaufman R, Jurkovich GJ, Bulger EM. Validation of prehospital trauma triage criteria for motor vehicle collisions. The Journal of Trauma and Acute Care Surgery. 2014;76(3):755-61.

The American College of Surgeons Committee on Trauma and the Centers for Disease Control jointly developed the National Trauma Triage Protocol: Field Triage Decision Scheme (FTDS), to identify trauma patients who would benefit from trauma center care. The FTDS is based on the stepwise identification of four aspects of clinical presentation including physiologic criteria (PHY), anatomic criteria (ANA), mechanism of injury criteria, and special considerations criteria that are evaluated in a sequential fashion to identify patients who should be transported to a trauma center. Physiologic criteria focus on vital signs and Glasgow Coma Scale; anatomic criteria include specific injury patterns such as penetrating trauma, flail chest, crush injury, etc; mechanism of injury criteria focuses on high risk patterns such as falls from specific height, high speed vehicular crash, motorcycle accident etc; and special considerations include extremes of age, comorbidities, burns, pregnancy, anticoagulated status, etc.

This study sought to determine the likelihood of serious trauma based on vehicle damage sustained in a crash as described in Step 3 of the FTDS. This was a retrospective cross-sectional study including all patients in the United States National Automotive Sampling System Crashworthiness Data System from the years 2003 to 2008. Of 85,761 participants included, 3.7% met step 3 mechanistic criteria alone (having not met step 1 or step 2 criteria). This group had a mean ISS of 5.1 (95% CI, 4.4 - 5.8) and a PPV of 9.7% (95% CI, 9.3 - 10.2%) for severe injury (defined as ISS > 15).

Crash characteristics that predict severe injury included intrusion of greater than 12 inches (PPV of 10.4%; 95% CI, 9.5 - 11.3) and steering wheel collapse (PPV of 25.7%; 95% CI, 23.0 - 28.4%). Older patients (age > 55 years) who met Step 3 mechanism criteria had higher predictive values for injury for nearly all crash characteristics. It was concluded that injury mechanism criteria alone predicted significant injury in a substantial proportion of patients who did not meet the physiologic or anatomic criteria. Vehicular crash data could improve the ability of emergency medical service providers to triage injured occupants. Consideration of transport to a trauma center should be given for elderly patients and drivers with steering wheel collapse.

Davis JS, Allan BJ, Sobowale O, Ivascu F, Orion K, Schulman CI. Evaluation of a new elderly trauma triage algorithm. Southern Medical Journal. 2012;105(9):447-51.

Compared with the younger cohort, elderly trauma patients have higher admission rates following injury, longer hospital stays, and higher mortality rates despite lower Injury Severity Scores (ISS). Much of this increased risk of death is the result of pre-existing medical conditions and the effect is greatest in patients with the least severe injuries. Because of these factors, some recommend that the threshold for scene triage or transfer to a trauma center be lowered for elderly adult patients

and that failing to do so may be linked to a higher number of unexpected deaths in injured elderly adults. Undertriage is common in patients 55 years and older and is even worse for those 65 and older. In 1999, the Florida legislature implemented a statewide trauma system, including a new Florida trauma triage algorithm (FTTA). The FTTA consists of a series of recommendations based on patient age and abbreviated injury scale scoring of identified injuries, guiding EMS providers to route polytrauma and majorly injured patients to trauma centers. The FTTA includes criteria that are more expansive and was conceived, in part, to combat suspected undertriage. It should be noted that FTTA-positive patients necessarily include all those with an ISS ≥ 16 as well as some ISS 9 to 14 because of specific criteria defined in the FTTA.

This study examined how the new system affected prehospital triage in younger versus older patients. A retrospective chart review of appropriate triage was conducted at the single regional trauma center (level 2) in Polk County, Florida during a one-year period between April 2001 to March 2002. The trauma registry of the trauma center, the hospital discharge dataset of the Florida Agency for Health Care Administration for all hospitals within the county, and Florida Vital Statistics were utilized for data collection. Patients were considered to have major trauma if they were FTTA positive or had an Injury Severity Score (ISS) of ≥16. An internal trauma review panel examined hospital discharge data to assess triage accuracy. A total of 49,726 patients were reviewed of which 2051 were trauma patients. In patients 15 to 54 years old, there was a significant increase in those treated in the trauma center over those treated in the non-trauma center. Eighty-three percent of those considered to be FTTA positive (OR 4.86, 95% CI 3.51 - 6.74) and 86% of those with an ISS ≥ 16 (OR 6.53, 95% CI 4.07- 10.47) were discharged from the trauma center. The same degree of success of the trauma triage criteria was not seen in patients 55 years old and older. In trauma patients in this age group, only 59% of those considered FTTA positive (OR 1.36, 95% CI 1.08 - 2.58) and 64% of those with an ISS ≥ 16 (OR 1.67, 95% CI 1.08- 2.58) were discharged from the trauma center. These percentages are nearly equivalent to the discharge distribution of non-trauma patients, suggesting a minimal effect of the triage criteria in the older age group. The reasons for this finding remain unknown, and further studies are needed to investigate and improve elderly triage.

Dinh MM, Oliver M, Bein KJ, Roncal S, Byrne CM. Performance of the New South Wales Ambulance Service major trauma transport protocol (T1) at an inner city trauma centre. Emergency Medicine Australasia. 2012;24(4):401-7.

The New South Wales trauma triage tool is similar to the Field Triage Decision Scheme, with mechanistic, anatomic, and physiologic parameters dictating need for transport to a trauma center in the acronym “MIST”: Mechanism, Injury, Signs and Symptoms, Transport. Mechanism criteria specify markers of high velocity impact such as fall from greater than 3 meters, ejection from vehicle, etcetera; injury criteria focus on a head to toe exam with high risk findings such as altered mentation, neck swelling, bruising from restraints, etcetera; signs and symptoms criteria focus on assessment of airway, breathing circulation and disability parameters. Pregnant women greater than 20 weeks gestation, those on anticoagulants, patients with pre-existing conditions, and pediatric and geriatric populations are highlighted as requiring a high index of suspicion for serious injury.

The study objective was to evaluate the performance of the newly implemented New South Wales prehospital trauma triage (T1) protocol for patients transported to an inner-city major trauma center in Sydney, Australia from March 2010 to October 2011. Ambulances transporting an injured patient on the T1 protocol were required to activate the protocol through an ambulance coordination center and document protocol activation on ambulance case sheets. Upon prehospital notification or arrival to the ED, all patients (whether T1 protocol was activated or not) were screened by the triage nurse using the hospital trauma team activation criteria to determine whether a trauma team response was required.

This was an observational study conducted over 1 year at a single major trauma center. Prehospital data and injury characteristics were collected prospectively for all hospital trauma team activations and injury presentations transported by Ambulance Service of New South Wales. Univariate comparison of T1- and non-T1-transported patients was performed and sensitivity, specificity, over-triage and under-triage rates were calculated. The outcomes studied were Injury Severity Score >15 and major outcome (composite of in-hospital death and/or transferred from the ED to operating theatre or intensive care unit). Factors associated with under-triage were determined with univariate analysis. A total of 2664 ambulance arrivals for trauma were studied with 767 (29%) transported on the T1 protocol. T1-transported patients were associated with more severe injury (23% vs 6%, $P < 0.001$) and major outcomes (30% vs 10%, $P < 0.001$) compared with non-T1-transported patients. The sensitivity of the T1 protocol for severe injury was 63% with a positive predictive value of 23%. The under-triage and over-triage rates for severe injury were 12% and 77%, respectively. Under-triaged patients were elderly with falls as the predominant mechanism of injury. The sensitivity and under-triage rates associated with the T1 protocol indicate the ongoing need for secondary triage at designated trauma centers and refinement of the protocol to include age as a criterion.

Fuller G, Lawrence T, Woodford M, Lecky F. The accuracy of alternative triage rules for identification of significant traumatic brain injury: a diagnostic cohort study. Emergency Medicine Journal. 2014;31(11):914-9.

Traumatic brain injury (TBI) is a leading cause of death and disability in young adults. Reorganization of trauma services with direct triage of suspected head injury patients to trauma centers may improve outcomes following TBI. This study aimed to determine the sensitivity of principal English triage tools for identifying significant TBI: the London Ambulance Service (LAS) and Head Injury Transportation Straight to Neurosurgery study (HITS-NS) triage criteria. The LAS criteria are similar to the National Trauma Triage Protocol, with physiologic, anatomic and mechanism of injury criteria, along with special considerations (old age, pregnancy, anticoagulated status, morbid obesity), that guide decision making to transport directly to a major trauma center. The main caveat for the LAS criteria is that if a patient has airway obstruction, they should be transported to the closest available hospital for definitive airway management. The HITS-NS rule recommends bypass to a major trauma center for signs of isolated TBI: Glasgow Coma Scale (GCS) ≤13, or evidence of open skull or depressed skull fracture, in the absence of compromised airway, breathing, or circulation. Each triage rule selects contrasting groups of patients for bypass, with the HITS-NS triage rule identifying a higher proportion of isolated TBI patients not requiring immediate ED resuscitation compared with the LAS rule.

The study objective was to evaluate the accuracy of the LAS and HITS-NS triage tools for identifying significant TBI. Distinct objectives were to: estimate the sensitivity and specificity of the LAS and HITS-NS triage rules for significant TBI; describe the characteristics of bypassed, true positive and false negative patients; and examine the relationship between prehospital Glasgow Coma Scale score and anatomical severity of head injury. This study utilized data prospectively collected as part of the English Trauma Audit and Research Network database between 2005 and 2011. Adult head injury patients were retrospectively classified according to the LAS and HITS-NS criteria. Sensitivity and specificity were then calculated against a reference standard of significant TBI, defined as head region abbreviated injury score (AIS) ≥3 or neurosurgical operation. 6559 patients were included in complete case analyses. The LAS and HITS-NS triage tools demonstrated sensitivities of 44.5% (95% CI 43.2 to 45.9) and 32.6% (95% CI 31.4 to 33.9), respectively, and specificities of 69.0% (66.0% to 71.8%) and 89.1% (87.0% to 80.9%) for identifying patients with significant TBI. False negative significant TBI cases were relatively older, more likely to be female, more frequently secondary to low-level falls, and were less likely to have very severe AIS five or six head injuries ($p<0.01$). Prehospital GCS did not appear to be a sensitive discriminator for identifying significant TBI; 11,794 of the 14,293 study sample patients were classified as having significant TBI with a head region AIS

≥3, of whom 44.9% presented with a prehospital GCS of ≥13. The study concluded that a considerable proportion of significant head injury patients may not be triaged directly to trauma centers. Investment is therefore necessary to improve the accuracy of existing triage rules and maintain expertise in TBI diagnosis and management in non-specialist emergency departments.

Fuller G, McClelland G, Lawrence T, Russell W, Lecky F. The diagnostic accuracy of the HITSNS prehospital triage rule for identifying patients with significant traumatic brain injury: a cohort study. European Journal of Emergency Medicine. 2016;23(1):61-4.

Diversion of suspected traumatic brain injury (TBI) patients to trauma centres may improve outcomes by expediting access to specialist neurosurgical care. The HITS-NS rule recommends bypass to a major trauma center for signs of isolated TBI: GCS≤13, or evidence of open skull or depressed skull fracture, in the absence of airway/breathing/circulation compromise.

This study aimed to determine the accuracy of the Head Injury Straight to Neurosurgery (HITS-NS) triage rule for identifying patients with significant TBI. A prospective diagnostic cohort study was performed using data from the HITS-NS trial, the Trauma Audit and Research Network registry and the North East Ambulance service database in the United Kingdom from January 2012 and April 2013. Sensitivity and specificity of the HITS-NS triage rule were calculated against a reference standard of significant TBI, defined by a cranial Abbreviated Injury Scale score of at least 3 or by the performance of a neurosurgical procedure. Eligible cases were coded according to whether they met the triage rule and reference standard criteria, on the basis of their first-recorded prehospital physiology values, clinical parameters and AIS injury codes. Contingency tables (2 × 2) were then constructed to determine true positives, false positives, true negatives and false negatives for the HITSNS triage rule. Prevalence of significant TBI, sensitivity and specificity, with their 95% confidence intervals (95% CIs), were subsequently assessed. A total of 3628 patients were included in the complete case analysis. The HITSNS triage tool demonstrated a sensitivity for severe TBI of 28.3% (95% CI 21.8–35.4) and a specificity of 94.4% (95% CI 93.6–95.2). The low sensitivity of the HITS-NS triage rule suggests that a considerable proportion of patients with significant TBI may not be triaged directly to trauma centers if this triage rule were applied, and further research is needed to improve the accuracy of bypass protocols.

Gaumont D, Cummins N, Hannigan A, Ryan D. ViEWS from the prehospital perspective: a comparison with a prehospital score to triage categorisation in the emergency department. Irish Medical Journal. 2016;109(6):423.

The aim of this observational study is to investigate how the recently introduced VitalPac National Early Warning Score (ViEWS) applied in the prehospital setting compares with the Manchester Triage System (MTS) used in most Emergency Departments (ED) in Ireland. To determine ViEWS (similar to the NEWS score), the provider assigns between 0 to 3 points for each of the following vital sign parameters: respiratory rate, oxygen saturation, temperature, systolic blood pressure, heart rate. Additionally, level of consciousness is assigned 0 points if normal, and 3 if abnormal. Any use of supplemental oxygen is assigned 2 points. These points are tallied to form the patient's ViEWS score. An aggregate score between 0 to 4 is considered low clinical risk; an individual parameter scoring 3, or aggregate score between 5-6 is considered medium clinical risk; an aggregate of 7 or more is considered high clinical risk.

The MTS is a triage algorithm that consists of 52 flowcharts, covering patients' chief signs and symptoms such as "Headache", "Shortness of breath" and "Wounds". Each flowchart in turn consists of additional signs and symptoms named discriminators, such as "Airway compromise", "Severe pain" or "Persistent vomiting", which are ranked by priority. Selection of a discriminator allocates the patient to the related urgency category, ranging from "immediate" (0 minutes maximum waiting time) to "non-urgent" (240 minutes maximum waiting time). Level 1 is classified as an emergency and level 5 as nonurgent.

It was hypothesized that most patients triaged with a MTS of 1 or 2 would have a high ViEWS score of ≥7. This was a retrospective observational study conducted at a single center in Ireland over a period of 6 months. 386 patients met the inclusion criteria of which 272 (69 %) had a complete set of values. Of 272 MTS 1 & 2 patients, only 114 (42%) had a Ph-ViEWS ≥7. This study found that a substantial number of patients deemed urgent at the time of triage do not have elevated prehospital ViEWS.

Giannakopoulos GF, Saltzherr TP, Lubbers WD, Christiaans HM, van Exter P, de Lange-de Klerk ES, et al. Is a maximum Revised Trauma Score a safe triage tool for Helicopter Emergency Medical Services cancellations? European Journal of Emergency Medicine. 2011;18(4):197-201.

The Revised Trauma Score is used worldwide in the prehospital setting and provides a snapshot of the patient's physiological state. In its current, commonly used form, the RTS ranges between 0 and 12 and is calculated from three physiologic parameters: the Glasgow Coma Scale (GCS), respiratory rate, and systolic blood pressure, which are weighted to compute a final score. A score of 12 suggests a physiologically stable patient. In the Netherlands, Helicopter Emergency Medical Services (HEMS) are mostly used for delivery of specialized trauma teams on scene and occasionally for

patient transportation. In the Dutch trauma system, the Emergency Medical Services crew performs triage after arrival on scene and cancels the HEMS-dispatch if deemed unnecessary.
This retrospective study examined the ability of a maximum on-scene Revised Trauma Score (RTS = 12) to be used as a triage tool for HEMS cancellation. All patients with a maximum on-scene RTS after blunt trauma (with or without receiving HEMS care) who presented to the trauma resuscitation room of two Level-1 trauma centers during a period of 6 months were included. Information concerning prehospital and in-hospital vital parameters, severity and localization of the injuries, and the in-hospital course were analyzed. Major trauma patients were classified using the following parameters: Injury Severity Score of at least 16, emergency intervention, Intensive Care Unit admission, and in-hospital death. 440 blunt trauma patients having a maximum RTS were included between 1 July and 31 December 2006. 80 patients received on-scene HEMS care. Almost 16% (n = 67) of the total study population consisted of major trauma patients, of which only 25 (36%) received HEMS care. In 17 patients (3.9%), the RTS deteriorated during transportation. Major trauma patients sustained more injuries to the chest, abdomen, and lower extremities. The authors concluded that the RTS alone is not a reliable triage tool for HEMS cancellations in the Dutch trauma system and will lead to a considerable rate of under-triage with one in every six cancellations being incorrect. Other criteria based on patient's vital signs, combined with anatomical and mechanism of injury parameters should be developed to safely minimize triage errors.

Helwig SA, Ragoschke-Schumm A, Schwindling L, Kettner M, Roumia S, Kulikovski J, et al. Prehospital Stroke Management Optimized by Use of Clinical Scoring vs Mobile Stroke Unit for Triage of Patients With Stroke: A Randomized Clinical Trial. JAMA Neurology. 2019;03:03.
The Los Angeles Motor Scale (LAMS) is a brief 3-item scale that focuses only on motor symptoms. It involves assessment of facial droop (0-1 point), arm drift (0-2 points) and grip strength (0-2 points) and patients with a score of 4 or greater are considered to be high risk for large vessel occlusion. The objective of this study was to determine how optimized prehospital management (OPM) based on use of the Los Angeles Motor Scale (LAMS) compares with management in a Mobile Stroke Unit (MSU) in accurately triaging patients to the appropriate hospital with or without interventional treatment (comprehensive vs. primary stroke center). In this randomized multicenter trial with 3-month follow-up, patients were assigned week-wise to one of the pathways between June 2015 and November 2017, in 2 regions of Saarland, Germany; 708 of 824 suspected stroke patients did not meet inclusion criteria, resulting in a study population of 116 adult patients.
Patients received either OPM based on a standard operating procedure that included the use of the LAMS (cut point 4) or management in an MSU (an ambulance with vascular imaging, point-of-care

laboratory, and telecommunication capabilities). The MSU intervention consisted of neurologic examination, POC testing, and non-contrast CT, as well as CT angiography for patients with no ICH. The primary endpoint was the proportion of patients accurately triaged to either CSCs (LVO, ICH) or PSCs (others). A predefined interim analysis was performed after 116 patients of the planned 232 patients had been enrolled. Of these, 53 were included in the OPM group (67.9% women; mean [SD] age, 74 [11] years) and 63 in the MSU group (57.1% women; mean [SD] age, 75 [11] years). The primary end point, an accurate triage decision, was reached for 37 of 53 patients (69.8%) in the OPM group and for 63 of 63 patients (100%) in the MSU group (difference, 30.2%; 95% CI, 17.8%-42.5%; P < .001).

Whereas 7 of 17 OPM patients (41.2%) with LVO or ICH required secondary transfers from a PSC to a CSC, none of the 11 MSU patients (0%) required such transfers (difference, 41.2%; 95% CI, 17.8%-64.6%; P = .02). The LAMS at a cut point of 4 or higher led to an accurate diagnosis of LVO or ICH for 13 of 17 patients (76.5%; 6 triaged to a CSC) and of LVO selectively for 7 of 9 patients (77.8%; 2 triaged to a CSC). Stroke management metrics were better in the MSU group, although patient outcomes were not significantly different. Whereas prehospital management optimized by LAMS allows accurate triage decisions for approximately 70% of patients, MSU-based management enables accurate triage decisions for 100%. Depending on the specific health care environment considered, both approaches are potentially valuable in triaging stroke patients.

Hoikka M, Silfvast T, Ala-Kokko TI. Does the prehospital National Early Warning Score predict the short-term mortality of unselected emergency patients? Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2018;26(1):48.

The National Early Warning Score (NEWS) was originally designed to detect deteriorating patients in hospital wards, specifically those at increased risk of ICU admission, cardiac arrest, or death within 24 hours. To determine NEWS, the provider assigns between 0 to 3 points for each of the following vital sign parameters: respiratory rate, oxygen saturation, temperature, systolic blood pressure, heart rate. Additionally, level of consciousness is assigned 0 points if normal, and 3 if abnormal. Any use of supplemental oxygen is assigned 2 points. These points are tallied to form the patient's NEWS score. An aggregate score between 0 to 4 is considered low clinical risk; an individual parameter scoring 3, or aggregate score between 5-6 is considered medium clinical risk; an aggregate of 7 or more is considered high clinical risk.

The use of NEWS in the prehospital setting may facilitate earlier identification of patients at risk. However, in daily practice the value of risk assessment to support decision-making in prehospital setting is unclear. This study aimed to examine the accuracy of the prehospitally implemented NEWS

in predicting 1-day and 30-day mortalities in an unselected EMS population. A secondary aim was to describe the causes of death in this prehospital patient population.
Data from all emergency medical service (EMS) situations were coupled to the mortality data obtained from the Causes of Death Registry during a six-month period in 2014 in Northern Finland. NEWS values were calculated post hoc from first clinical parameters obtained on the scene and patients were categorized to the low, medium and high-risk groups accordingly. Sensitivities, specificities, positive predictive values (PPVs), negative predictive values (NPVs), and likelihood ratios (PLRs and NLRs) were calculated for 1-day and 30-day mortalities at the cut-off risks. A total of 12,426 EMS calls were included in the study. The overall 1-day and 30-day mortalities were 1.5 and 4.3%, respectively. The 1-day mortality rate for NEWS values ≤12 was lower than 7% and for values ≥13 higher than 20%. The high-risk NEWS group had sensitivities for 1-day and 30-day mortalities of 0.801 (CI 0.74–0.86) and 0.42 (CI 0.38–0.47), respectively. In the prehospital environment, the high-risk NEWS category was associated with 1-day mortality well above that of the medium and low risk NEWS categories. This effect was not as noticeable for 30-day mortality. The authors conclude that use of NEWS in the prehospital setting may be of value when assessing the mortality risk within 24 hours and hence immediate need for medical care. However, based on this cohort, they conclude that NEWS alone cannot guide decision-making about the urgency of transport, the destination of transport, or whether to transport or not, and needed to be further studied.

Johansson N, Spindler C, Valik J, Vicente V. Developing a decision support system for patients with severe infection conditions in pre-hospital care. International Journal of Infectious Diseases. 2018;72:40-8.

The objective of this study was to develop and validate a pre-hospital decision support system (DSS) for the emergency medical services (EMS) in Sweden, enabling the identification and steering of patients with critical infectious conditions (i.e., severe respiratory tract infections, severe central nervous system (CNS) infections, and sepsis) to a specialized emergency department (ED) for infectious diseases. The development process involved four consecutive steps. The first step was gathering data from the electronic patient care record system (ePCR) on patients transported by the EMS, in order to identify retrospectively appropriate patient categories for steering. The second step was to let a group of medical experts give advice and suggestions for further development of the DSS. The third and fourth steps were the evaluation and validation, respectively, of the whole pre-hospital DSS in a pilot study.
The pilot study involved pre-hospital emergency nurses (PENS) from a single EMS agency in Sweden. The study included 72 patients, of whom 60% were triaged to a highly specialized emergency

department (ED-Spec) with an attending infectious disease physician (ID physician). The results demonstrated that the PENs adhered to the DSS in 66 of 72 patient cases (91.6%). For those patients steered to the ED-Spec, the assessment made by PENs and the ID physician at the ED was concordant in 94% of cases. It was concluded that the development of a specific DSS aiming to identify patients with three different severe infectious diseases appears to give accurate decision support to PENs when steering patients to the optimal level of care.
The DSS for respiratory infection is shared within the manuscript, but the DSS for CNS infection and sepsis are not. The respiratory infection DSS specifies that any patient with relatively stable vitals, or extremely unstable vitals have to be triaged to the closest emergency department, whereas those with moderately unstable vitals should be triaged to the ED-Spec.

Jumaa MA, Castonguay AC, Salahuddin H, Shawver J, Saju L, Burgess R, et al. Long-term implementation of a prehospital severity scale for EMS triage of acute stroke: a real-world experience. Journal of Neurointerventional Surgery. 2019;02:02.

The Rapid Arterial oCclusion Evaluation (RACE) Scale is one of the few prehospital scales that have been prospectively validated in the field. Patients testing positive for suspected stroke on the Cincinnati Stroke Scale are subsequently assessed by EMS using the RACE Scale. The RACE scale evaluates five items: facial palsy, upper extremity paresis, lower extremity paresis, head and gaze deviation, and aphasia/agnosia, with a total score of 0–9. Patients with a RACE score ≥5 and last seen normal within 24 hours or time of onset unknown are triaged as RACE-alerts (RA) and sent to the nearest ECC. Patients with a RACE score <5 are triaged as stroke-alerts (SA) and transported to the nearest hospital.
The study objective was to report the long-term experience of a US countywide emergency medical services (EMS) acute stroke triage protocol using the RACE score. A prospective database was used to identify all consecutive patients triaged within Lucas County, Ohio by the EMS with (1) a RACE score ≥5, taken directly to an endovascular capable center (ECC) as RACE-alerts (RA) and (2) a RACE score <5, taken to the nearest hospital as stroke-alerts (SA). Baseline demographics, RACE score, time metrics, final diagnosis, treatments, and clinical and angiographic outcomes were captured. The sensitivity and specificity for patients with a RACE score ≥5 with LVO, eligible for mechanical thrombectomy (MT), were calculated. Between July 2015 and June 2018, 492 RA and 1147 SA were triaged within this five-hospital network. Of the RA, 37% had AIS secondary to LVOs. Of the 492 RA and 1147 SA, 125 (25.4%) and 38 (3.3%), respectively, underwent MT (OR=9.9; 95% CI 6.8 to 14.6; p<0.0001). Median times from onset-to-ECC arrival (74 vs 167min, p=0.03) and dispatch-to-ECC arrival (31 vs 46 min, p=0.0002) were shorter in the RA-MT than in the SA-MT cohort. A RACE cut-off

point ≥5 showed a sensitivity and specificity of 77% and 75% for detection of patients with LVO eligible for MT, respectively. This study demonstrates the long-term feasibility of a countywide EMS-based prehospital triage protocol using the RACE Scale.

Kesinger MR, Sequeira DJ, Buffalini S, Guyette FX. Comparing National Institutes of Health Stroke Scale among a stroke team and helicopter emergency medical service providers. Stroke. 2015;46(2):575-8.

The National Institutes of Health Stroke Scale (NIHSS) has been traditionally used in the in-hospital setting to quantify stroke severity. Providers calculate a score ranging from 0 to 42 based on the following parameters: level of consciousness, orientation, ability to follow motor commands, horizontal gaze, visual fields, facial palsy, motor drift of all extremities, limb ataxia, sensation, language/aphasia, dysarthria, and extinction/inattention. A NIHSS score ≥12 is predictive of large vessel occlusion (LVO).

The objective of this study was to evaluate whether prehospital providers could reliably calculate NIHSS. The authors compared helicopter emergency medical services (HEMS) providers' calculated NIHSS compared with in-hospital stroke team physician scores for all patients with ischemic stroke transported by HEMS to a single comprehensive stroke center in Pennsylvania, USA, in 2010. HEMS NIHSS were compared with in-hospital stroke team physician scores and ability to predict LVO was investigated.

Three-hundred five patients met inclusion criteria, with 68.9% having LVO. Moderate agreement existed between HEMS and physicians (72.1%; κ=0.571). Interclass correlation was 0.879 (95% confidence interval, 0.849–0.904). Excluding patients with tissue-type plasminogen activator before HEMS transport, there were 216 patients and good agreement (82.7%; κ=0.619). Among patients presenting within 8 hours post-onset and NIHSS≥12, HEMS had a sensitivity of 55.9% and positive predictive value of 83.7% in predicting LVO. It was concluded that HEMS providers can administer NIHSS with moderate to good agreement with the receiving stroke team. The use of the NIHSS in HEMS may identify patients with LVO and inform triage decisions for patients' ineligible for tissue-type plasminogen activator.

Lavoie A, Emond M, Moore L, Camden S, Liberman M. Evaluation of the Prehospital Index, presence of high-velocity impact and judgment of emergency medical technicians as criteria for trauma triage. CJEM Canadian Journal of Emergency Medical Care. 2010;12(2):111-8.

The Prehospital Index (PHI) consists of 5 elements observed on scene: systolic blood pressure, heart rate, respiratory status, level of consciousness and penetrating torso injury. It increases with severity

and ranges from 0 to 24. A score of 4 serves as the cut-off point for transport to a trauma center. The evaluation of high velocity impact (HVI) presence is intended to identify injuries involving a high level of energy transfer. Specific examples include a fall greater than 7 m (20 ft), another victim killed in the same accident, ejection from a motor vehicle, cabin structural intrusion and pedestrian or cyclist hit by a motor vehicle travelling faster than 8 km/h (5 mile/h).

The objective of this study was to evaluate the performance of the PHI, the HVI criterion and emergency medical technician (EMT) judgment for the prehospital triage of injured patients. This study retrospectively evaluated the validity of 3 widely used trauma triage criteria on a consecutive series of adult patients served by 2 level-I urban trauma centers in Montreal, Canada. All consecutive trauma patients who were treated on scene by EMTs and directly transported to one of the 2 designated level-I trauma centers between Jan. 1, 1997, and Dec. 31, 2000, were identified and included if they met criteria. The main outcome was severe trauma, defined as death within 72 hours, admission to the intensive care unit within 24 hours or an Injury Severity Score greater than 15. The sensitivity, specificity and rates of overtriage (1 – positive predictive value) for each criterion and their combinations were assessed.

Of 16,805 patients in the study population, 1113 (6.62%) had severe trauma. The combination of all 3 triage criteria (PHI score ≥ 4, HVI presence and EMT judgment) performed best for identifying patients with severe trauma, with a sensitivity of 74.2%, specificity 70.0%, positive predictive value 14.9% and negative predictive value of 98.2%, with an overtriage rate of 85.1%. Alone, EMT judgment had the highest sensitivity and a PHI score of 4 or greater had the lowest rate of overtriage. Although the combination of PHI score, HVI presence and EMT judgment offers the highest sensitivity for the identification of patients that could benefit from direct transport to a level-I trauma centre, overall sensitivity remains low and overtriage is high. More research is required to improve prehospital triage.

Leeies M, Ffrench C, Strome T, Weldon E, Bullard M, Grierson R. Prehospital Application of the Canadian Triage and Acuity Scale by Emergency Medical Services. CJEM Canadian Journal of Emergency Medical Care. 2017;19(1):26-31.

The Canadian Triage and Acuity Scale is a validated five-level triage score utilized in Emergency Departments (EDs) across Canada and internationally. The CTAS consists of five triage levels combining severity of illness or risk with recommended fractile response times to medical assessment supported by a standardized patient presenting complaint list. Level 1 is considered most urgent and Level 5 least urgent. The objective of this study is to prospectively evaluate CTAS interrater reliability between emergency medical services (EMS) providers and ED triage nurses with

a system-wide implementation during routine clinical practice. This was a prospective, observational cohort study of all patients ≥17 years old transported to any ED in the Winnipeg Region, Canada by Winnipeg Fire and Paramedic Service (WFPS) EMS from July 1, 2014–December 31, 2014. Variables were extracted from hospital and EMS databases. The primary outcome was interrater reliability for triage nurse and EMS CTAS scores. The hospital arrival EMS CTAS (CTAS-arrival) score was compared to the initial nursing CTAS score (CTAS-initial) and the final nursing CTAS score (CTAS-final) including nursing overrides. Interrater reliability between ED CTAS-initial and EMS CTAS-arrival scores was assessed. Interrater reliability between ED CTAS-final and EMS CTAS-arrival scores, as well as proportion of patient encounters with perfect or near-perfect agreement, were evaluated. 14,378 consecutive adult patient encounters in the Winnipeg Region were evaluated. It was observed that, when compared to the triage nurses, EMS tended to score patients equal or lower for CTAS 1, 2, and 3 patients, but tended to score equal or higher for CTAS 4 and 5 patients. The primary outcome, interrater reliability between EMS CTAS arrival and ED CTAS initial scores (the CTAS score prior to overrides), indicated moderate agreement [κw = 0.437 (p<0.001, 95% CI 0.421-0.452)]. EMS CTAS-arrival and ED CTAS-initial scores had an exact or within one-point match 84.3% of the time. The secondary interrater reliability outcome between EMS CTAS-arrival and ED CTAS-final score (including nurse overrides) also showed moderate agreement [κw = 0.452 (p<0.001, 95% CI 0.437-0.466)] and an exact or within one-point match 86.5% of the time. Further research is needed to define the role of CTAS in EMS systems where alternate levels of care and/or delayed- or non-transport processes are incorporated.

Lerner EB, Cushman JT, Drendel AL, Badawy M, Shah MN, Guse CE, et al. Effect of the 2011 Revisions to the Field Triage Guidelines on Under- and Over-Triage Rates for Pediatric Trauma Patients. Prehospital Emergency Care. 2017;21(4):456-60.

The Field Triage Decision Scheme was developed and first published by The American College of Surgeons – Committee on Trauma (ACS-COT) in 1987. This initial guideline laid the foundation for EMS providers to recognize patients who would benefit from transport to a specialized trauma center. After its initial publication in 1986, the American College of Surgeons Committee on Trauma updated the Field Triage Decision Scheme in 1990, 1993, and 1999. In 2005, the ACS-COT collaborated with the Centers for Disease Control and Prevent (CDC) to form a National Expert Panel on Field Triage. The objective of the study was to determine the change in under- and over-triage rates when the 2011 Field Triage Guidelines are compared to the 2006 and 1999 versions. A three-year prospective cohort study was conducted in 3 pediatric hospitals that also served as the regional pediatric trauma center located in Dallas, Texas, Milwaukee, Wisconsin, and Rochester, New York,

United States. Pediatric patients were defined as those less than 15 years old. The 1999, 2006, and 2011 Field Triage Guidelines were each retrospectively applied to the collected data and descriptive statistics were used to compare between Guideline versions.
Applying the 1999, 2006, or 2011 Guidelines to the EMS interview data the over-triage rate was 32.6%, 27.9%, and 28.0%, respectively. The under-triage rate was 26.5%, 35.1%, and 34.8%, respectively. The 2011 Guidelines resulted in an 8.2% (95% CI 0.6–15.9%) absolute increase in under-triage and a 4.6% (95% CI 2.8–6.3%) decrease in over-triage compared to 1999 Guidelines.

Leung SC, Leung LP, Fan KL, Yip WL. Can prehospital Modified Early Warning Score identify non-trauma patients requiring life-saving intervention in the emergency department? Emergency Medicine Australasia. 2016;28(1):84-9.

The prehospital Modified Early Warning Score (MEWS) was first validated by Subbe *et al.* in 2001 in a medical admission unit and was thereafter reported to be useful in identifying those at risk among acute medical patients, surgical in-patients and those requiring inter-facility transfer. It may also be a good predictor of need for acute hospitalisation and adverse in-hospital outcomes. It is calculated from the first set of clinical observation data and physiological parameters recorded by ambulance crews. MEWS comprises the alert, voice, pain, unresponsive (AVPU) score and four physiological domains: systolic blood pressure, heart rate, respiratory rate and body temperature. The overall MEWS is calculated to produce a score ranging between 0 and 14. The objective of this study was to investigate whether prehospital MEWS could predict the need for life-saving intervention (LSI) within 4 h of ED presentation in ambulance patients. This was a prospective study of non-trauma ambulance patients who were 16 years or older and treated in the ED from 1 to 27 November 2013 in a university-teaching hospital in Hong Kong. Data on patients' demographics, triage category, LSI within 4 h of ED presentation and 24 h mortality were retrieved.
Regarding the need for LSI, the sensitivity, specificity, predictive values and likelihood ratios of prehospital MEWS were calculated. A score equal to or greater than a chosen cut-off point suggested an indication to pre-alert the receiving ED. The overall performance of MEWS was assessed with the area under the receiver operating characteristic curve (AUC). Of 1493 recruited patients, 321 (21.5%) required LSI within 4 h of ED presentation. Recruited patients' prehospital MEWS ranged from 0 to 11. The distribution of scores was positively skewed, and the median MEWS was 2 (interquartile range, 1–3). Both LSI implementation and mortality increased with MEWS in general. The median MEWS to predict at least one mode of LSI was 4 or above. All cases required LSI among those with MEWS ≥9. There was no mortality among cases with MEWS ≥10. True and false positive rates of LSIs with 95% CI were calculated for each cut-off point of MEWS for the

construction of a ROC curve. The AUC was 0.72 (95% CI 0.69 to 0.75), which indicated a fair discrimination between those with or without LSIs. The sensitivity, specificity, positive PV, negative PV, positive LR and negative LR were 0.57, 0.76, 0.40, 0.87, 2.43 and 0.56, respectively, when prehospital MEWS ≥3 was chosen as the cut-off value.

In conclusion, prehospital MEWS may perhaps play a role in predicting the need for LSI within 4 h of ED presentation, with a trade-off between number of cases to pre-alert the receiving ED and sensitivity of detection. Its addition to any ED pre-alert or triage protocol should be considered. Future validation work with a larger sample size in multicentre settings is advocated, in comparison with clinical decisions by staff with variable years of experience, to substantiate the use of prehospital MEWS to predict LSI and short-term mortality.

Li JL, McMullan JT, Sucharew H, Broderick JP, Katz B, Schmit P, et al. Potential Impact of C-STAT for Prehospital Stroke Triage up to 24 Hours on a Regional Stroke System. Prehospital Emergency Care. 2019:1-5.

The Cincinnati Stroke Triage Assessment Tool (CSTAT) is a prehospital tool intended to be applied in suspected stroke patients to screen for severe versus non-severe stroke. It comprises of Conjugate Gaze Deviation (2 points), Incorrectly answering age/month AND not following at least one command (close your eyes, open and close your hand) (1 point), and Arm (right, left, or both) falling to bed within 10 seconds (1 point). Having a score of 2 or greater equals a high likelihood of large vessel occlusion (LVO) stroke.

The objective of this study was to estimate the potential impact of the expanded thrombectomy time window on suspected AIS-LVO cases transported to the regional comprehensive stroke center (CSC). The study population consisted of all patients transported to any urban hospital by the Cincinnati Fire Department with a prehospital clinical impression of stroke or transient ischemic attack (TIA) from June 1 to November 30, 2015. Patients 18 years or older were included in the data analysis if they were both CPSS positive by EMS and had a calculable C-STAT, and had outcome data in their medical records. For this analysis, the outcome was the proportion of patients with a suspected stroke/TIA and Last Known Normal of 0–6 or 6–24 hours that would be transported to a CSC with prehospital C-STAT-based triage. C-STAT test characteristics, sensitivity and specificity, for LVO (defined as ICA and M1 occlusions only) were calculated with 95% confidence intervals (CI) using the Wilson interval.

Of 158 patients with prehospital suspicion for stroke/TIA, 105 were CPSS positive within 24 hours of onset and had complete C-STAT and clinical data available for analysis. C-STAT sensitivity and specificity for LVO were 71% (95% CI 36–92) and 67% (95% CI 58–80), respectively. C-STAT triage

would increase transport of prehospital suspected stroke cases to the CSC by 11% (12/105) within six hours and 21% (22/105) within 24 hours. Of 37 C-STAT positive patients, only 5 (13.5%) had LVO as final diagnosis. Preferential triage of prehospital suspected stroke patients using C-STAT would increase the number of patients transported to the CSC by 11% within six hours and an additional 10% from six to 24 hours. For every patient with LVO as final diagnosis, approximately an additional 6 non-LVO patients would be triaged to a comprehensive stroke center.

Lima FO, Silva GS, Furie KL, Frankel MR, Lev MH, Camargo EC, et al. Field Assessment Stroke Triage for Emergency Destination: A Simple and Accurate Prehospital Scale to Detect Large Vessel Occlusion Strokes. Stroke. 2016;47(8):1997-2002.

The FAST-ED scale (Facial Palsy (scored 0–1), Arm Weakness (0–2), Speech Changes (0– 2), Time (documentation for decision making but no points), Eye Deviation (0-2), and Denial/Neglect (0-2)) was designed based on items of the NIHSS with higher predictive value for large vessel occlusion stroke (LVOS). In addition, time was included considering its importance in the prehospital decision algorithm. The objective of this study was to evaluate performance of the Field Assessment Stroke Triage for Emergency Destination (FAST-ED) tool for LVO detection. The scale was tested on data from 741 consecutive patients enrolled in a prospective cohort study at two university-based hospitals (STOPStroke cohort), in California, USA, in which patients underwent CT angiography within the first 24 hours of stroke onset.

Receiver operating characteristic (ROC) curve, sensitivity, specificity, positive (PPV) and negative predictive values (NPV) of FAST-ED were compared with the NIHSS, Rapid Arterial occlusion Evaluation (RACE) scale and Cincinnati Prehospital Stroke Severity Scale (CPSSS). LVO was detected in 240 of the 727 qualifying patients (33%). The FAST-ED scale had comparable accuracy to predict LVO to the more complex NIHSS and higher accuracy than RACE and CPSS (area under the ROC curve: FAST-ED = 0.81 as reference; NIHSS = 0.80, p = 0.28; RACE = 0.77, p = 0.02; and CPSS = 0.75, p = 0.002). A FAST-ED ≥4 had sensitivity of 0.60, specificity 0.89, PPV 0.72, and NPV 0.82 versus RACE ≥5 of 0.55, 0.87, 0.68, 0.79 and CPSS ≥2 of 0.56, 0.85, 0.65, 0.78, respectively. FAST-ED is a simple scale that if successfully validated in field might be useful for medical emergency professionals to accurately identify LVOS in the prehospital setting enabling rapid triage of patients to primary versus endovascular capable stroke centers.

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

The assessment of children in the Emergency Medical Service (EMS) is infrequent representing 5.4% of the patients in an urban area in the western part of Sweden. In Sweden, patients are assessed on scene by an EMS nurse whom independently decides on interventions and level of care. To aid the EMS nurse in the assessment a triage instrument, Rapid Emergency Triage and Treatment System-pediatrics (RETTS-p) developed for Emergency Department (ED) purpose has been in use the last 5 years.

The Rapid Emergency Triage and Treatment System-pediatrics (RETTS-p) was initially developed for triaging within the pediatric Emergency Department (pED). The RETTS-p is made up of two parts, vital signs (VS) and emergency signs and symptoms (ESS). The level of severity is based on the highest color of ESS or VS that becomes the final triage level. Red is stated as life threatening, orange is potentially life threatening and both levels are, from a time perspective, defined as emergency care directly. Yellow and green are defined as no individual medical risk if put on wait for assessment by a physician. Five VS, respiratory rate, oxygen saturation, pulse frequency, body temperature and level of consciousness, are recorded and adjusted to age intervals, including pulse correction for patients presenting with fever.

The aim of this study was to evaluate the EMS nurse assessment, management, the utilization of RETTS-p and patient outcome. A prospective, observational study was performed on 651 children aged < 16 years from January to December 2016. Statistical tests used in the study were Mann-Whitney U test, Fisher's exact test and Spearman's rank statistics.

The dispatch centre indexed life-threatening priority in 69% of the missions but, of all children, only 6.1% were given a life threatening RETTS-p red colour by the EMS nurse. A total of 69.7% of the children were transported to the ED and, of these, 31.7% were discharged without any interventions. Among the non-conveyed patients, 16 of 197 (8.1%) visited the ED within 72 h but only two were hospitalised. Full triage, including five out of five vital signs measurements and an emergency severity index, was conducted in 37.6% of all children. A triage colour was not present in 146 children (22.4%), of which the majority were non-conveyed. The overall 30-day mortality rate was 0.8% (n = 5) in children 0–15 years. Despite the incomplete use of all vital signs according to the RETTS-p, the EMS nurse assessment of children appears to be adapted to the clinical situation in most cases and the patients appear to be assessed to the appropriate level of care but indicating an over triage. It seems that the RETTS-p with full triage is used selectively in the pre-hospital assessment of children with a risk of death during the first 30 days of less than 1%.

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

The Rapid Emergency Triage and Treatment System-pediatrics (RETTS-p) was initially developed for triaging within the pediatric Emergency Department (pED) and has been used by the emergency medical services (EMS) in the west of Sweden since 2014. The RETTS-p is made up of two parts, vital signs (VS) and emergency signs and symptoms (ESS). Five VS, respiratory rate, oxygen saturation, pulse frequency, body temperature and level of consciousness, are recorded and adjusted to age intervals, including pulse correction for patients presenting with fever. The level of severity is based on the highest color of ESS or VS that becomes the final triage level. Red is stated as life threatening, orange is potentially life threatening and both levels are, from a time perspective, defined as emergency care directly. Yellow and green are defined as no individual medical risk if put on wait for assessment by a physician. The aim of this study was to evaluate the performance of the RETTS-p in the EMS and the agreement between the EMS field assessment and the hospital diagnosis.

This study is an observational prospective study of pediatric patients assessed by an EMS nurse and transported to the pediatric Emergency Department in a single-site urban setting in the western part of Sweden. All children below 16 years of age in this sample were included if the inclusion criteria were met. A total of 716 children were initially identified in the sample and 65 children were excluded as they did not fulfil the inclusion criteria. Positive and negative predicted values and likelihood ratios from data were used to calculate sensitivity and specificity. Under-triage and over-triage was defined as 1-Sensitivity (proportion of yellow/green triaged among all emergent patients) and 1-Specificity (proportion of red/orange triaged among all nonemergent patients) respectively. If triaged to yellow or green, the predictive value of not being life threatening or potentially life threatening was 91.7, 95% CI [88.5,94.1]. The RETTS-p triage levels of red and orange had a sensitivity of 66.7% for detecting an emergent patient, 95% CI [53.3,78.3], i.e. an under-triage of 33.3%. The corresponding specificity was 67.0, 95% CI [61.6,72.0], i.e. an over-triage of 33.0%. The positive likelihood ratio was 2.02, 95% CI [1.59, 2.56], and the negative likelihood ratio was 0.47, 95% CI [0.33, 0.67]. The EMS field assessment agreed with the final hospital diagnosis in 80% of the cases.

The RETTS-p sensitivity in this study is considered moderate. Two thirds of the children triaged to life threatening or potentially life threatening were later identified as non-emergent. Of those, one in six was discharged from the PED without any intervention. Further, one third of the children were under triaged, the majority were found in the yellow triage level (can wait). The highest proportion of hospitalised patients was found in the yellow triage level. The result agreed with previous studies

using other triage instruments. A computerized decision support system might help the EMS triage to increase sensitivity and specificity.

Martin-Rodriguez F, Lopez-Izquierdo R, Del Pozo Vegas C, Delgado-Benito JF, Del Pozo Perez C, Carbajosa Rodriguez V, et al. A Multicenter Observational Prospective Cohort Study of Association of the Prehospital National Early Warning Score 2 and Hospital Triage with Early Mortality. Emergency Medicine International Print. 2019;2019:5147808.

The National Early Warning Score 2 (NEWS2) is the most used internationally and validated scale for assessment of patient acuity in the prehospital context. The clinical variables for the NEWS2 are: respiratory rate, oxygen saturation, heart rate, systolic blood pressure, temperature, confusion state (confusion was defined as a score of less than 15 points on the Glasgow Coma Scale), and the use of oxygen.

The aim of this study was to evaluate the capacity of the prehospital scale NEWS2 in relation to the classification of Spanish hospital triage to predict early mortality within 48 hours of the index event. In addition, the performance of this scale in estimating mortality at 7 and 30 days was explored. A prospective multicenter longitudinal observational cohort study was carried out in three provinces of Spain on all patients cared for by the Advanced Life Support (ALS) system. Patients were included in the study if they had been evaluated and transferred by an ALS to the ED of the reference hospital and did not meet any exclusion criteria. Between April 1 and November 30, 2018, a total of 1054 patients were included in the study. The predictive power of the NEWS2 scale to discriminate mortality at 2, 7, and 30 days is evidenced by an AUC of 0.88 (95% CI: 0.82-0.94), 0.86 (95% CI: 0.81-0.91), and 0.82 (95% CI: 0.77-0.87). In the stratification by the Spanish five level triage system, the AUC of the NEWS2 obtained for short-term mortality varied between 0.77 (95% CI: 0.65-0.89) for level I (resuscitation) and 0.94 (95% CI: 0.79-1) for level III (urgent). In the analysis of short-term mortality, it was observed that a NEWS2 score greater than or equal to 7 among patients with priority III had a sensitivity of 100 (95% CI 56.6-100) and a specificity of 78.7 (95% CI 75.1-81.9) with a PPV of 4.1 (1.8-9.3) and a NPV of 100 (99.1- 100). Meanwhile, in patients with priorities I and II, the cutoff point with better sensitivity and joint specificity rose to 9 points in both cases, with associated NPV of 92.5 (95% CI: 82.1-97.0) for level I and 98.4 (95% IC: 96.2-99.3) for level II. The Prehospital Emergency Medical Services should evaluate the implementation of the NEWS2 as a routine evaluation, which, together with the structured hospital triage system, effectively serves to predict early mortality and detect high-risk patients.

McMullan JT, Katz B, Broderick J, Schmit P, Sucharew H, Adeoye O. Prospective Prehospital Evaluation of the Cincinnati Stroke Triage Assessment Tool. Prehospital Emergency Care. 2017;21(4):481-8.

FAST (also known as the Cincinnati Prehospital Stroke Scale) and C-STAT assessments were performed by EMS personnel at the time of initial patient evaluation. FAST consists of three elements: facial droop, arm drift, and speech abnormality (dysarthria or aphasia). The C-STAT is comprised of select NIHSS items (1b and 1c—level of consciousness commands and questions, 2—gaze, and 5—arm motor) and simplified to either normal or abnormal. The objective of this study is to describe the feasibility of prehospital implementation of the C-STAT to identify subjects with severe stroke (NIHSS ≥ 15) among all prehospital patients with clinical suspicion of stroke. Secondarily, the ability for the tool to identify subjects with NIHSS ≥10, the presence of LVO, or the need for services available only at a comprehensive stroke center (CSC) was evaluated.
Over a period of six months (June–November 2015), all patients transported by Cincinnati Fire Department with a prehospital clinical impression of stroke or transient ischemic attack (TIA) were screened with FAST and evaluated with C-STAT. C-STAT performance among FAST positive subjects was assessed for predicting stroke severity (NIHSS15, NIHSS10), LVO, and CSC need. Sensitivity, specificity, and positive (PLR) and negative likelihood ratios (NLR) were calculated with 95% confidence intervals. Complete prehospital and outcome data were available for 58 FAST-positive subjects among 158 subjects with prehospital suspicion for stroke/TIA. For NIHSS ≥ 15, C-STAT had a sensitivity of 77% (95% CI 46–95) and a specificity of 84% (95% CI 69–93). For NIHSS ≥10, the sensitivity of C-STAT was 64% (95% CI 41–83) and specificity 91% (95% CI 76–98). For presence of LVO, the sensitivity was 71% (95% CI 29–96) and specificity 70% (95% CI 55–83); and for overall CSC need sensitivity was 57% (95% CI 34– 78) and specificity was 79% (95% CI 61–91). In this pilot study, the C-STAT was easily performed in the prehospital setting by EMS providers without formalized training, is comparable to other published tools in test characteristics, and may inform appropriate CSC triage beyond LVO ascertainment alone in patients with suspected stroke in the prehospital setting. Larger prospective studies are warranted to advance prehospital stroke care.

Meisel ZF, Mathew R, Wydro GC, Mechem C, Pollack CV, Katzer R, et al. Multicenter Validation of the Philadelphia EMS Admission Rule (PEAR) to Predict Hospital Admission in Adult Patients Using Out-of-hospital Data. Academic Emergency Medicine. 2009;16(6):519-25.

The Philadelphia EMS Admission Rule (PEAR) was developed to discriminate between hospital admission and discharge for a general population of ED patients transported by EMS. The score consisted of six weighted elements that generated a total score (0–14): age ≥ 60 years (3 points);

chest pain (3); shortness of breath (3); dizzy, weakness, or syncope (2); history of cancer (2); and history of diabetes (1). The objective of this study was to validate PEAR for predicting hospital admission using routinely collected out-of-hospital information.

The authors performed a multicenter retrospective cohort study of 1,500 randomly selected, adult patients transported to six separate emergency departments in Philadelphia (EDs; three community and three academic hospitals in three separate health systems) by a city-run emergency medical services (EMS) system over a 1-year period. A total of 1,102 patients met inclusion criteria. The admission rate for the entire cohort was 40%, and individual hospital admission rates ranged from 28% to 57%. Overall, 34% had a score of ≥4, and 29% had a score of ≥ 5. Area under the ROC curve (AUC) for the combined cohort was 0.83 for all admissions and 0.72 for intensive care unit (ICU) admissions; AUCs at individual hospitals ranged from 0.72 to 0.85. The admission rate for a score of ≥ 4 was 77%; for a score of ≥ 5 the admission rate was 80%. Use of the PEAR scoring system may help inform systems that seek to use directed diversion to match patients who are likely to need inpatient resources with hospitals that have adequate bed capacity. Implementation and impact analysis studies are needed before this rule can be broadly implemented.

Newgard CD, Zive D, Holmes JF, Bulger EM, Staudenmayer K, Liao M, et al. A Multisite Assessment of the American College of Surgeons Committee on Trauma Field Triage Decision Scheme for Identifying Seriously Injured Children and Adults. Journal of the American College of Surgeons. 2011;213(6):709-21.

The American College of Surgeons Committee on Trauma and the Centers for Disease Control jointly developed the National Trauma Triage Protocol: Field Triage Decision Scheme (FTDS) to identify trauma patients who would benefit from trauma center care. The FTDS is based on the stepwise identification of four aspects of clinical presentation involving physiologic criteria (PHY), anatomic criteria (ANA), mechanism of injury criteria, and special considerations criteria that are evaluated in a sequential fashion to identify patients who should be transported to a trauma center. Physiologic criteria focus on vital signs and Glasgow Coma Scale (GCS); anatomic criteria include specific injury patterns such as penetrating trauma, flail chest, crush injury, etc; mechanism of injury criteria focuses on high risk patterns such as falls from specific height, high speed vehicular crash, motorcycle accident etc; and special considerations include extremes of age, comorbidities, burns, pregnancy, anticoagulated status, etc.

The aim of this study was to evaluate the diagnostic performance of the FTDS for identifying major trauma patients (Injury Severity Score [ISS] ≥16) among a large and diverse population of injured patients evaluated by EMS providers across multiple sites. This was a retrospective cohort study of

injured children and adults transported by 94 EMS agencies to 122 hospitals in 7 regions of the Western U.S. from 2006 through 2008. Patients who met any of the field trauma triage criteria (per EMS personnel) were considered triage positive. The majority of sites were urban and suburban, though some outlying rural areas are also included. All sites have established trauma systems with designated Level I/II trauma centers and standardized trauma triage protocols. The primary analysis to validate the ability of the FTDS was designed to identify patients with ISS ≥ 16, regardless of the type of hospital to which they were initially transported. Sensitivity was calculated as the proportion of seriously injured patients identified by field triage criteria and specificity as the proportion of non-seriously injured patients that did not meet triage criteria. Under-triage (the proportion of major trauma patients missed by the triage criteria) was calculated from 1 - sensitivity and over-triage (the proportion of minimally injured patients meeting triage criteria) as 1 – specificity.
A total of 122,345 injured patients were evaluated and transported by EMS over the 3-year period, of whom 34.5% met at least one triage criterion and 5.8% had ISS ≥ 16. The overall sensitivity and specificity of the criteria for identifying major trauma patients were 85.8% (95% CI 85.0 – 86.6%) and 68.7% (95% CI 68.4 – 68.9%). Triage sensitivity and specificity differed by age: 84.1% and 66.4% (0 – 17 years); 89.5% and 64.3% (18 – 54 years); and 79.9% and 75.4% (≥ 55 years). The sensitivity of the Field Triage Decision Scheme for identifying major trauma patients is lower and specificity higher than previously described, particularly among elders.

Newton M, Tunn E, Moses I, Ratcliffe D, Mackway-Jones K. Clinical navigation for beginners: the clinical utility and safety of the Paramedic Pathfinder. Emergency Medicine Journal. 2014;31(e1):e29-34.

Two general triage protocols named Pathfinders were developed, one for patients who had suffered trauma and the other for patients with medical conditions. The Pathfinders were derived from the Manchester Triage System to safely categorize patients into four groups (or pathways): those requiring emergency care, those requiring urgent care, those whose care could be safely delivered in the community with appropriate support and those who could self-care. The aim of the study was to evaluate the clinical utility and safety of these triage support tools (Pathfinders) using a mixed clinician sample.
Pathfinders were then applied by ambulance clinicians to 481 patients who had been transported to eight evaluation sites in England. Preferred (gold standard) patient dispositions were established by senior medical practitioners using both ambulance and ED clinical records. The clinical utility of ambulance clinicians using Pathfinders was evaluated against this gold standard. Both Pathfinders pre-exclude patients with Pre-Hospital Early Warning Score (PHEW) of >4.

The Medical Pathfinder was applied to 367 patients (76.3%) and the Trauma Pathfinder to 114 (23.7%). Agreement between ambulance clinician and gold standard was achieved in 387 cases (80.5%) giving the tools a combined sensitivity of 94.83% and specificity of 57.9%. A total of 20.9% of medical patients and 30.7% of trauma patients who had been transported to hospital could have been safely cared for elsewhere. Ambulance clinicians using Pathfinders have demonstrated acceptable levels of sensitivity in identifying patients who require ED care. The actual impact of the tools in clinical practice will be dependent on the provision of suitable alternatives to ED.

Ng CJ, Chien CY, Seak JC, Tsai SL, Weng YM, Chaou CH, et al. Validation of the five-tier Taiwan Triage and Acuity Scale for prehospital use by Emergency Medical Technicians. Emergency Medicine Journal. 2019;36(8):472-8.

The Taiwan Triage and Acuity Scale, implemented by the Taiwan Ministry of Health and Welfare in 2010, retains most of the features of the Canadian Triage and Acuity Scale (CTAS). It has been modified by dividing the chief complaint into a non-trauma category, comparable to the CTAS, and a trauma category with the chief complaint list organized by anatomical region and environmental injury. In addition, vital sign ranges for hemodynamic stability and pain severity ratings that omit chronic pain differ from the CTAS. The TTAS triage levels are categorized as follows: level 1, resuscitation; level 2, emergency; level 3, urgent; level 4, less urgent; and level 5, non-urgent. This study aimed to determine the inter-rater reliability of the five-level Taiwan Triage and Acuity Scale (TTAS) when used by emergency medical technicians (EMTs) and triage registered nurses (TRNs). This was a prospective observational study in Taoyuan City, Taiwan, between 1 July and 31 December 2014. After training in five-level triage, EMTs triaged patients arriving to the ED and agreement with the nurse triage (TRN) was assessed. Subsequently, these trained research EMTs rode along on ambulance calls and assigned TTAS scores for each patient at the scene, while the on-duty EMTs applied their standard two-tier Taiwan prehospital triage scale (TPTS) and followed standard practice, blinded to the TTAS scores. 493 patients were assigned two-tier Taiwan Prehospital Triage System (TPTS) priority scores by working EMTs and TTAS scores by the research EMT. The accuracy of the TTAS scores in the field for prediction of hospitalization and medical resource consumption was analyzed using logistic regression and a linear model, respectively, and compared with the accuracy of the current two-tier prehospital triage scale.

Inter-rater agreement between EMTs and TRNs for triage of ED patients was very good (κw=0.825, CI 0.750 to 0.900). The hospitalisation rate was 73.9% and 20.1% for TPTS emergent and non-emergent level patients, respectively. Using TTAS, the hospitalisation rates for acuity levels I–V were 90.9%, 53.4%, 26.5%, 7.2% and 0.0%, respectively. For the outcome of hospitalization, TTAS five-level

system (Akaike's Information Criteria (AIC)=486, area under the curve (AUC)=0.75) showed better discrimination compared with TPTS two-level system (AIC=508, AUC=0.66). In conclusion, the five-level TTAS assignment by EMTs showed good inter-rater agreement with triage RNs in the hospital setting. The application of TTAS by EMTs at the scene proved to be more accurate in predicting the need for hospitalization and medical resources than the current two-level TPTS.

Noorian AR, Sanossian N, Shkirkova K, Liebeskind DS, Eckstein M, Stratton SJ, et al. Los Angeles Motor Scale to Identify Large Vessel Occlusion: Prehospital Validation and Comparison With Other Screens. Stroke. 2018;49(3):565-72.

Prehospital scales have been developed to identify patients with acute cerebral ischemia (ACI) due to large vessel occlusion (LVO) for direct routing to Comprehensive Stroke Centers (CSCs), but few have been validated in the prehospital setting, and their impact on routing of intracranial hemorrhage (ICH) patients has not been delineated. The LAMS is a 3-item (Facial Droop, Arm Drift, and Grip Strength), 0- to 10-point motor stroke-deficit scale, which had initially been developed from the Los Angeles Prehospital Stroke Screen (LAPSS), for the general purpose of characterizing stroke deficit severity in the field. The purpose of this study was to validate the Los Angeles Motor Scale (LAMS) for LVO and CSC-appropriate (LVO ACI and ICH patients) recognition and compare the LAMS to other scales. The performance of LAMS was assessed in identifying: 1) LVOs among all ACI patients, and 2) CSC-appropriate patients among all suspected strokes. Additionally, the LAMS administered post-arrival was compared concurrently with 6 other scales proposed for paramedic use and the full National Institutes of Health Stroke Scale (NIHSS).

Data were prospectively analyzed from consecutive patients transported to UCLA Medical Center in Los Angeles, California, USA, throughout the study period (2004–2012). Patients with likely stroke, indicated by a positive modified LAPSS, and within 2 hours of last known well, were enrolled in the trial and LAMS was administered prehospital by paramedics. Among 94 patients, final diagnoses were acute cerebral ischemia in 76% (due to LVO in 48% and non-LVO in 28%), ICH in 19%, and neurovascular mimic in 5%. The prehospital LAMS score cutoff at ≥ 4 showed good performance both in identifying LVOs among cerebral ischemia patients (sensitivity 0.76, specificity 0.65, and accuracy 0.72) and in identifying CSC-Appropriate patients among all suspected stroke transports (sensitivity 0.73, specificity 0.71, and accuracy 0.72). When concurrently performed in the Emergency Department post-arrival, the LAMS showed comparable or better accuracy versus the 7 comparator scales, for LVO among ACI (accuracies: LAMS 0.70, other scales 0.62–0.68) and CSC-appropriate case (accuracies: LAMS 0.73, other scales 0.56–0.73). The LAMS performed in the field

by paramedics identifies large vessel occlusion and CSC-Appropriate patients with good accuracy. The LAMS performs comparably or better than more extended prehospital scales and the full NIHSS.

Okuno Y, Yamagami H, Kataoka H, Tahara Y, Tonomura S, Tokunaga H, et al. Field Assessment of Critical Stroke by Emergency Services for Acute Delivery to a Comprehensive Stroke Center: FACE2AD. Translational Stroke Research. 2019;12:12.

The FACE2AD scale was designed to predict large vessel occlusion. It assigns one point each for the presence of facial palsy, arm weakness, consciousness impairment, atrial fibrillation, and diastolic blood pressure ≤ 85 mmHg and assigning two points for the presence of eye deviation.
The aim of this study was to design a simple prehospital stroke scale for emergency medical service (EMS) paramedics to identify patients with LVO. The derivation cohort was extracted from the database of the National Cerebral and Cardiovascular Center, Osaka, between April 2012 and February 2015. 1157 out of 1419 eligible patients transferred to the hospital by the EMS because of suspected stroke within 24 h of onset were retrospectively examined.
The accuracy of this scale was then prospectively validated in 502 consecutive patients who were transferred to 4 stroke centers in Japan during a 5-month period. Its accuracy was compared with those of 4 previously reported scales. Logistic regression was used to examine how well the FACE2AD scale could predict the probability of LVO. Sensitivity and specificity measurements were calculated for LVO (+) to produce a receiver operating characteristic (ROC) curve and to determine the optimum FACE2AD scale threshold for the diagnosis of LVO.
The prevalence of LVO in the total cohort was 2% for score 0 or 1, 8% for score 2, 18% for score 3, 35% for score 4, 59% for score 5, 67% for score 6, and 76% for score 7. Conveniently enough, when the FACE2AD scale score was 5 or more, the prevalence of LVO (%) was estimated to be the 10-fold value of the score. Clearly, a FACE2AD scale score ≥ 5 was associated with a high likelihood of LVO (> 50%), whereas a score < 3 was associated with a low likelihood of LVO (< 10%). With the cutoff ≥ 3, the AUC was 0.87 (95% CI; 0.86–0.88) and the sensitivity, specificity, positive predictive value, and negative predictive value to predict LVO were 0.83, 0.78, 0.39, and 0.97, respectively. The FACE2AD scale is a simple tool to detect ischemic stroke patients with LVO by the EMS.

Silcock DJ, Corfield AR, Gowens PA, Rooney KD. Validation of the National Early Warning Score in the prehospital setting. Resuscitation. 2015;89:31-5.
The National Early Warning Score (NEWS) stratifies patients into risk categories based on observed heart rate, respiratory rate, systolic blood pressure, arterial oxygen saturation, temperature, and

conscious level; plus an additional weighting if the patient receives oxygen therapy. Patients are then risk stratified based on the resulting aggregate score into low, medium, and high-risk groups. Patients with a low aggregate score but who score in the highest category for any single observation are classified as at least medium risk.

This study aimed to retrospectively evaluate the performance of the NEWS in identifying patients at risk of death or deterioration in the prehospital setting in Scotland. Details of all emergency ambulance crews dispatched with an intention to transfer to the Royal Alexandra Hospital (RAH) were obtained from the Scottish Ambulance Service data warehouse and collated along with information relating to hospital outcome over a two-month period between October 1st and November 30th, 2012. NEWS values for each patient encounter were calculated retrospectively from the clinical parameters obtained.

Studied outcomes included survival to discharge or 30 days, death within 48 hours of hospital admission, ICU admission within 48 hours of hospital admission, and a composite adverse outcome of death or ICU admission within 48 hours. 1684 patients were analysed. All three of the primary endpoints and the combined endpoint were associated with higher NEWS scores ($p < 0.01$ for each). The medium-risk NEWS group was associated with a statistically significant increase in ICU admission (RR = 2.466, 95% CI 1.0–6.09), but not in-hospital mortality relative to the low risk group. The high-risk NEWS group had significant increases in 48 h mortality (RR 35.32 [10.08–123.7]), 30 day mortality (RR 6.7 [3.79–11.88]), and ICU admission (5.43 [2.29–12.89]). Similar results were noted when trauma and non-trauma patients were analysed separately. Elevated NEWS among unselected prehospital patients is associated with a higher incidence of adverse outcomes. Calculation of prehospital NEWS may facilitate earlier recognition of deteriorating patients, early involvement of senior Emergency Department staff and appropriate critical care.

Skjot-Arkil H, Pontoppidan LL, Laursen JO, Giebner M, Andersen JD, Mogensen CB. Do prehospital providers and emergency nurses agree on triage assignment?: an efficacy study. European Journal of Emergency Medicine. 2019;26(1):29-33

The Danish Emergency Process Triage (DEPT) is a five-level triage system based on a combination of vital signs and a presenting complaint algorithm. DEPT categorizes the condition of the patient into five degrees: red (life threatening), orange (critical), yellow (stable, but potentially unstable), green (stable), and blue (unaffected). The color determines the urgency of medical attention required: red requires immediate action, whereas blue demands reevaluation every fourth hour. First, the triage level based on the measured vital signs is determined. Second, the triage based on the presenting complaint is determined. The presenting complaint algorithm consists of 50 main presenting

complaints. The triage level based on vital signs and based on presenting complaints are then combined, and the final triage level is determined by the variable that indicates the highest degree of urgency. The aim of this study was to investigate the agreement on triage level between prehospital providers and emergency department (ED) nurses in clinical practice when using the DEPT triage system.

This prospective and observational efficacy study was performed between 1 April 2015 and 1 July 2015. The study involved 80 ED nurses at the urban Hospital of Southern Denmark, a level-2 trauma center, and 160 prehospital providers working in the hospital's coverage area. Of the 724 paired data charts, 292 (40%) paired data charts were used correctly by both professionals. Patients were triaged by prehospital providers while being transported by ambulance to the ED, and by ED nurses upon arrival. The inter-rater agreement was determined using the κ [9] with 0.5 weights. The vital signs were categorized into triage levels according to the triage model. A two-sided probability of P value of less than 0.05 was considered statistically significant.

The triage agreement was measured only if DEPT was used correctly by both prehospital providers and ED nurses. DEPT was used correctly by both professions in 292 patients. In 182 (62%) patients the prehospital providers and the ED nurses agreed on the same triage level. This equals to κ = 0.47 [95% confidence interval (CI): 0.41–0.56]. When considering the triage based on vital signs the agreement was 72% (κ = 0.46; 95% CI: 0.41–0.47), and based on presenting complaint the agreement was 46% (κ = 0.41; 95% CI: 0.37–0.44). There was a moderate interrater agreement on triage assignment between ED nurses and prehospital providers. They agreed on final triage more often if they agreed on triage based on vital signs rather than presenting complaints.

Smith DT, Snyder A, Hollen PJ, Anderson JG, Caterino JM. Analyzing the Usability of the 5-Level Canadian Triage and Acuity Scale By Paramedics in the Prehospital Environment. Journal of Emergency Nursing. 2015;41(6):489-95.

The Emergency Severity Index (ESI) and the Canadian Triage and Acuity Scale (CTAS) are two 5-level triage instruments with similar reliability and validity findings. CTAS and ESI classify patient acuity on a scale from 1 to 5, with 1 being most urgent and 5 being least urgent. The ESI triage process uses an algorithm based on patient acuity and anticipated resource need to determine triage category. In contrast, CTAS uses an extensive list of clinical complaints, symptoms, and modifiers, at strategic times, to direct users toward a specific classification.

This study sought to determine if a relationship exists between the CTAS scores assigned by prehospital paramedics and the ESI score assigned by nurses in the emergency department, as well as to determine whether either instrument correlates with patient admission. Data analyses

included descriptive statistics, χ2 statistics, and hierarchical regression analysis. This descriptive correlational study was conducted with the city of Columbus (Ohio) Division of Fire (CFD) and The Ohio State University (OSU).

The analysis included 2,222 patients. There was a poor relationship between the CTAS and the ESI at the facility (P = .599, κ = –0.003). The final regression model explained 32.9% of the admission variance (P b .001). The model correctly predicted 61.5% of admissions, with an 82% accuracy rate for all other forms of disposition and an overall model prediction rate of 73.7%. Using the CTAS, paramedics can predict admission comparably with nurses using the ESI. However, both instruments showed weakness in over- and under-triage rates. Additional studies are indicated to better understand prehospital paramedic triage and its impact on throughput.

Sung S, Kang CY, Lee HY, Lee JH, Kim OH, Youk H, et al. Correlation between the pre-hospital triage scale and emergency department triage scale. Hong Kong Journal of Emergency Medicine. 2019;26(5):281-7.

The Simple Triage and Rapid Treatment (START) triage system was classified by paramedics into five stages of patient triage: Emergent (E)—patients with at least one unstable vital sign, major symptoms of chest pain, unconsciousness, dyspnea, respiratory arrest, palpitations, cardiac arrest, paralysis, severe trauma patients and patients judged by paramedics to require prompt treatment within minutes; Less Emergent (LE)—if not Emergent but need treatment within a few hours; Potentially Emergent (PE)—all patients who are not Emergent, Less Emergent, but need emergency care; Extra: this is not an emergency transfer and for outpatient visits, reserved patients, and so on; and Death (D). This study aimed to analyze the correlation between the triage systems at the pre-hospital and in-hospital stages (START vs Korean Triage and Acuity Scale, KTAS) to better determine the priority of medical care for emergency patients and to utilize the results as basic data for the future development of a pre-hospital triage system.

This retrospective study was conducted with data obtained from a regional emergency medical center in Korea. A total of 1028 patients were included in the study from April to May 2016 out of 7141 patients who visited the center. The inter-rater agreement was used to analyze the correlation between the pre-hospital and in-hospital triage systems. The significance level was judged to be statistically significant when it was less than 0.05.

Upon reclassifying the pre-hospital and in-hospital triage systems into three levels, among the 289 patients (28.1%) in level 3 of the pre-hospital triage, 79 (27.3%) were reclassified as the highest level (Resuscitation) in the in-hospital triage. The kappa coefficient as a measure of agreement between the two triage systems was very low at 0.211 (95% confidence interval, 0.164–0.258), and the kappa

coefficient of the paramedic category was 0.232 (95% confidence interval, 0.161–0.303). There is a low agreement between the pre-hospital and in-hospital triage systems. Therefore, there is a need to develop a more systematic and unambiguous pre-hospital triage system based on the KTAS.

Suzuki J, Nakai N, Kondo N, Tsuji H, Inagaki R, Furukawa S, et al. Ten-Year Evaluation of the TOYOTA Prehospital Stroke Scale for Tissue Plasminogen Activator Intravenous Therapy in the Real World. Cerebrovascular Diseases. 2018;46(3-4):184-92

The TOPSPIN prehospital stroke scale for tissue plasminogen therapy consists of 5 items each scored from 0 to 10 points: consciousness, atrial fibrillation, language disorder, hemiparesis of the upper extremities, and hemiparesis of the lower extremities. EMS crew recorded the TOPSPIN score at the time of contact with the patient. The aim of this study was to analyze the performance characteristics of TOPSPIN for stroke recognition 10 years after its implementation. Consecutive patients who were transferred to the hospital and evaluated by Toyota city ambulance services, which services approximately 420,000 people in the Aichi prefecture, central Japan, were prospectively enrolled using the TOPSPIN from December 2006 to January 2017.

The correlation between total TOPSPIN scores and NIHSS scores for patients with ischemic stroke was assessed using Spearman's rank correlation test. Independent predictors of outcome were determined using multivariate logistic regression analysis by entering significant variables from the univariate analysis. A total of 1482 patients were enrolled; stroke was definitively diagnosed in 1,134 patients (76.5%), including 628 ischemic stroke, 34 TIA events, and 472 hemorrhagic stroke events; the remaining 348 (23.5%) patients did not have a stroke. Among 628 patients with ischemic stroke, 130 (20.7%) received intravenous recombinant t-PA treatment, endovascular therapy, or both. The PPV for EMS stroke recognition was 82.8% when the total TOPSPIN score was ≥3 points. A moderate correlation was observed between the total TOPSPIN score and the NIHSS score in patients with ischemic stroke ($r2 = 0.53$, $p < 0.001$). The presence of atrial fibrillation, older age, lower blood pressure, and lower total TOPSPIN score was more commonly associated with ischemic stroke than with hemorrhagic stroke. In multivariable logistic regression analysis, the presence of atrial fibrillation was independently associated with ischemic stroke (OR 2.33; 95% CI 1.61–3.40). The TOPSPIN is a simple prehospital stroke scale that includes an assessment of atrial fibrillation. Detection of atrial fibrillation in the prehospital stage may point to a higher probability of ischemic stroke.

Taqi MA, Sodhi A, Suriya SS, Quadri SA, Farooqui M, Salvucci AA, et al. Design, Application and Infield Validation of a Pre-Hospital Emergent Large Vessel Occlusion Screening Tool: Ventura

Emergent Large Vessel Occlusion Score. Journal of Stroke and Cerebrovascular Diseases. 2019;28(3):728-34.

The Ventura Emergent LVO Scale (VES) comprises 4 components: eye deviation, aphasia, neglect, and obtundation with score range 0-4. The score of greater than or equal to 1 is considered as LVO positive. A positive VES along with positive Cincinnati scale prompts ELVO activation.

The performance characteristics of VES were evaluated retrospectively by collecting unidentified data from the electronic medical charts from a single center and EMS agency in Ventura County, Los Angeles, California, from 2016 to 2017. A total 184 patients were included in the final analysis. Of 62 (33.7%) patients who were called VES positive from the field, 36 (58%) were diagnosed with LVO. The mean NIHSS on arrival was 16 in VES positive and 5 in VES negative patients. VES had 94.7% sensitivity, 82.4% specificity, with 58.1% PPV and 98.4% NPV. It showed 84.9% accuracy. VES is an effective and simplified prehospital screening tool for detection of LVO in the field.

Tsai LH, Huang CH, Su YC, Weng YM, Chaou CH, Li WC, et al. Comparison of prehospital triage and five-level triage system at the emergency department. Emergency Medicine Journal. 2017;34(11):720-5.

This study aimed to compare the two-level Taiwan Prehospital Triage System (TPTS) with the five-level Taiwan Triage and Acuity Scale (TTAS) at ED arrival regarding the prediction of patient outcomes and the utilization of medical resources.

In the prehospital phase, patients were triaged using the two-level TPTS. The criteria for TPTS emergent level patients are those who present with abnormal vital signs, including a GCS score <14, or high or low blood sugar via finger stick, or critical chief complaints suggestive of acute stroke, ischemic heart disease, seizures, life-threatening intoxication, precipitate labor, snake bite, or drowning. In trauma events, criteria for emergent level of acuity include the presence of a specific physiological or anatomical injury or the evidence of a high-risk mechanism of injury, in addition to abnormal vital signs. All other patients were considered non-emergent.

This was a retrospective cohort study of adult patients transported via EMS in northern Taiwan in 2012. In order to compare the predictability of hospitalization rate between these two triage systems, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), negative likelihood ratio (LR−) in TPTS (emergent vs non-emergent) and TTAS (levels 1–2 vs 3–5) were calculated. Among 4430 enrolled patients, 25.2% and 74.8% were classified as emergent and non-emergent by TPTS; 44.1% and 55.9% were classified as levels 1–2 and levels 3–5 by TTAS. Of the TPTS emergent patients, 15.2% were classified as TTAS levels 3–5, whereas 30.4% of TPTS non-emergent transports were classified as TTAS levels 1–2 at the ED. TTAS

levels 1–2 better predicted hospitalization rate than TPTS emergent level with a sensitivity of 70.3% (95%CI 68.3% to 72.2%) versus 41.1% (95% CI 39.0% to 43.2%), and a negative predictive value of 74.8% (95%CI 73.4% to 76.0%) versus 62.6% (95% CI 61.7% to 63.5%). This study concludes the current prehospital triage system is insufficient and inappropriate in classifying patients transported to the ED. The present study offers supporting evidence for the introduction of a five-level triage system to prehospital EMS systems.

Vaclavik D, Bar M, Klecka L, Holes D, Cabal M, Mikulik R. Prehospital stroke scale (FAST PLUS Test) predicts patients with intracranial large vessel occlusion. Brain and Behavior. 2018;8(9):7.
The FAST PLUS test has two parts. The first part is the FAST test, which is employed in all possible cases of stroke occurrence. This test consists of the following items: Facial palsy, any failure of Arm motor function, and Speech. The FAST test is considered positive if the score is at least one. The second part of the FAST PLUS test evaluates only the presence of severe arm or leg motor deficit. The FAST PLUS test results are considered positive when there is a positive general FAST test score and severe paresis of a leg or an arm or both.
The aim of this study was to determine the performance characteristics of the FAST PLUS test as administered by paramedics for predicting LVO confirmed by CT angiography (CTA). This is a prospective observational cohort study of prehospital patients with suspected stroke (FAST test positive) who were transported by emergency medical services to one of the three stroke centers in Ostrava, Czech Republic, according to their territory.
The study included 435 patients. LVO were found in 124 patients (28%). Sensitivity was 93%, specificity was 47%, PPV was 41%, NPV was 94%, and AUC was 0.65 for LVO. Intracerebral hemorrhage (ICH) was identified in 48 patients (11%). It was found that the FAST PLUS test had a high sensitivity for LVO stroke.

van Laarhoven JJ, Lansink KW, van Heijl M, Lichtveld RA, Leenen LP. Accuracy of the field triage protocol in selecting severely injured patients after high energy trauma. Injury. 2014;45(5):869-73.
In the Netherlands, the Dutch field triage protocol is utilized for major trauma triage. The parameters in the field triage protocol can be categorized into three groups: physiological condition (P), mechanism of trauma (M) and injury type (I). The aim of the present study was to evaluate the diagnostic accuracy of the current field triage protocol in high-energy trauma patients. This was a prospective cohort study of all high-energy trauma patients from 2008 to 2011 in the region Central Netherlands. 1607 patients were included of which 13.8% had major trauma, defined as ISS>=16. Sensitivity and specificity of the field triage protocol was 89.1% (95%CI 84.4–92.6) and 60.5% (95% CI

57.9–63.1), respectively. Positive predictive value was 26.5% (95%CI 23.4-29.8) and negative predictive value was 97.2% (95CI 95.9-98.1). The undertriage rate was 10.9% (95%CI 7.4–15.7) and the overtriage rate was 39.5% (95%CI 36.9–42.1). The overall rate of under-triage (10.8%) was mainly influenced by a high rate of undertriage in the group of patients with only a positive mechanism criterion.

Voskens FJ, van Rein EAJ, van der Sluijs R, Houwert RM, Lichtveld RA, Verleisdonk EJ, et al. Accuracy of Prehospital Triage in Selecting Severely Injured Trauma Patients. JAMA Surgery. 2018;153(4):322-7.

In the Netherlands, allocation of trauma patients to the appropriate level of trauma care is guided by the Dutch Field Triage Protocol made for EMS professionals. This protocol is based on the CDC/ASCOT Field Triage Decision Scheme. The aim of the study was to prospectively evaluate the ability of the Dutch field triage system to identify severely injured adult trauma patients. Undertriage was defined as the proportion of severely injured patients (Injury Severity Score, ISS ≥16) erroneously transported to level II or III hospitals. Overtriage was defined as the proportion of patients with an ISS of less than 16 transported to a level I trauma center.
Prehospital and hospital data of all adult trauma patients during 2012 to 2014 transported with the highest priority by emergency medical services professionals to 10 hospitals in Central Netherlands were prospectively collected. A total of 4950 trauma patients were evaluated of which 436 (8.8%) patients were severely injured. The under-triage rate based on actual destination facility was 21.6% (95% CI, 18.0-25.7) with an over-triage rate of 30.6% (95% CI, 29.3-32.0). Analysis of the protocol itself, regardless of destination facility, resulted in an under-triage of 63.8% (95% CI, 59.2-68.1) and over-triage of 7.4% (95% CI, 6.7-8.2). The compliance to the field triage trauma protocol was 73% for patients with a level 1 indication. The undertriage rate in elderly patients is high at 38.6% (95% CI, 30.8-47.2). A high-energy trauma mechanism resulted in an undertriage rate of 9.1% (95% CI, 5.8-14.2). More than 20% of the patients with severe injuries were not transported to a level I trauma center. These patients are at risk for preventable morbidity and mortality. This finding indicates the need for improvement of the prehospital triage protocol.

Zhao H, Coote S, Pesavento L, Churilov L, Dewey HM, Davis SM, et al. Large Vessel Occlusion Scales Increase Delivery to Endovascular Centers Without Excessive Harm From Misclassifications. Stroke. 2017;48(3):568-73.

The Rapid Arterial Occlusion Evaluation (RACE), Los Angeles Motor Scale (LAMS), Cincinnati Prehospital Stroke Severity Scale (CPSSS), Field Assessment Stroke Triage for Emergency Destination

(FAST-ED), and Prehospital Acute Stroke Severity scale (PASS) are all recently published scales, using simplifications of items from the National Institutes of Health Stroke Scale (NIHSS) to optimize prediction of LVO.

The aim of this study was to examine the diagnostic performance of published LVO triage scales in a representative Australian cohort of suspected acute stroke, with a specific emphasis on scale performance in atypical clinical presentations. The prehospital stroke scale values were derived from the baseline National Institutes of Health Stroke Scale (NIHSS) scored by doctors and analyzed for diagnostic performance compared with imaging. Prospective data were collected from consecutive ambulance-initiated stroke alerts at 2 stroke centers, with patients stratified into typical (LVO with predefined severe syndrome and non-LVO without) or atypical presentations (opposite situations). Of a total of 565 patients, atypical presentations occurred in 31 LVO (38% of LVO) and 50 non-LVO cases (10%). The negative predictive values were similar for all scales (91%–93%), but there was a trend to higher positive predictive value for RACE, LAMS, and FAST-ED (all with PPV 48%). Most scales correctly identified >95% of typical presentations but <20% of atypical presentations. Misclassification attributable to atypical presentations would have resulted in 4 M1/internal carotid artery occlusions, with NIHSS score ≥6 (5% of LVO) being missed and 9 non-LVO infarcts (5%) bypassing the nearest thrombolysis center. Atypical presentations accounted for the bulk of scale misclassifications, but the majority of these misclassifications were not detrimental, and use of LVO scales would significantly increase timely delivery to endovascular centers, with only a small proportion of non-LVO infarcts bypassing the nearest thrombolysis center.

Zhao H, Pesavento L, Coote S, Rodrigues E, Salvaris P, Smith K, et al. Ambulance Clinical Triage for Acute Stroke Treatment: Paramedic Triage Algorithm for Large Vessel Occlusion. Stroke. 2018;49(4):945-51.

A 3-step ambulance clinical triage for acute stroke treatment (ACT-FAST) was created to improve specificity by recognizing only severe clinical syndromes and optimizing paramedic usability and reliability. It was designed by identifying clinical deficits associated with a high predictive value for LVO using the Royal Melbourne Hospital stroke database. The ACT-FAST algorithm consists of (1) unilateral arm drift to stretcher <10 seconds, (2) severe language deficit (if right arm is weak) or gaze deviation/hemineglect assessed by simple shoulder tap test (if left arm is weak), and (3) eligibility and stroke mimic screen.

The study objective was a retrospective and prospective validation the ACT-FAST LVO identification algorithm. In retrospective (n=565) and prospective paramedic (n=104) validation, ACT-FAST displayed higher overall accuracy and specificity, when compared with existing LVO triage scales. Agreement of ACT-FAST between paramedics and doctors was excellent (κ=0.91; 95% confidence interval, 0.79–1.0). The full ACT-FAST algorithm assessed by paramedics on 60 patients showed high overall accuracy (91.7%), sensitivity (85.7%), specificity (93.5%), positive predictive value (80%) and negative predictive value (95.6%) for recognition of endovascular-eligible LVO.

Appendix 6: Summary Table of Articles Included in Scoping Review

Study	Tool Name	Country	Pop	Primary Research Question	Major Findings	QR
Category: Infectious disease triage						
Johansson 2018	DSS	Sweden	A	To validate DSS tool for triage to specialized ED for infectious diseases (ID). Studying concordance between prehospital RN using tool and ID specialist	60% patients triaged to specialized ED. 94% concordance. n =72	VL
Category: Medical chief complaint triage						
Gaumont 2016	ph-ViEWS	Ireland	A	To compare acuity assigned using prehospital ViEWS to Manchester Triage System (MTS) used in Ireland EDs for non-traumatic patients	114 (42%) MTS high-acuity patients had a Ph-ViEWS ≥7 (high clinical risk) in prehospital triage. n =272	VL
Category: General undifferentiated triage						
Meisel 2009	PEAR	USA	A	To validate PEAR for predicting hospital admission using routinely collected out-of-hospital information	AUC for combined cohort was 0.83 for all admissions and 0.72 for ICU admissions. n =1102	M
Buschhorn 2013	ESI	USA	All	To evaluate interrater reliability in ESI scores assigned by prehospital personnel and emergency department nurses (RNs).	Concordance was 0.41 (95% CI, 0.26-0.56). n =75	VL
Newton 2014	Pathfinders	UK	All	To evaluate the clinical performance of of Pathfinders general triage protocols compared to physician gold-standard	Sensitivity 94.8% and specificity of 57.9% for accurate triage decision. n =481	L
Silcock 2015	NEWS	Scotland	A	To evaluate the performance of the prehospital NEWS in identifying patients at risk of death or deterioration	High risk NEWS group had significant risk of 48 h mortality (RR 35.32), 30 day mortality (RR 6.7), and ICU admission (RR 5.43). n =1684	VL
Hoikka 2018	NEWS	Finland	All	To examine the accuracy of the prehospitally implemented NEWS in predicting 1-day and 30-day mortalities in an unselected EMS population.	The high-risk NEWS group (score ≥ 7) had sensitivities for 1-day and 30-day mortalities of 0.801 (CI 0.74–0.86) and 0.42 (CI 0.38–0.47), respectively. n =12426	M
Martin-Rodriguez 2019	NEWS2	Spain	A	To evaluate the ability of the prehospital NEWS2 to predict 48 hour mortality	AUC of 0.88 (95% CI: 0.82-0.94) of NEWS2 for 48 hr mortality. n =1054	L

Leung 2016	MEWS	Hong Kong	A	To investigate whether prehospital MEWS could predict the need for life-saving intervention (LSI) within 4 h of ED presentation in ambulance patients.	AUC of prehospital MEWS relating to LSI was 0.72 (95%CI 0.69 to 0.75). For MEWS ≥3, sensitivity 57%, specificity 76%, PPV 40%, NPV 87%. n =1493	VL
Smith 2015	CTAS	USA	A	To determine if a relationship exists between paramedic CTAS scores and emergency nurses' ESI scores	Poor relationship between the paramedic-assigned CTAS and the RN-assigned ESI (P = .599, κ = –0.003). n =2222	L
Leeies 2017	CTAS	Canada	A	To prospectively evaluate CTAS interrater reliability between EMS providers and ED triage nurses	Interrater reliability κw = 0.437 (p<0.001, 95% CI 0.421-0.452). n =14378	M
Magnusson 2018	RETTS-p	Sweden	P	To evaluate the initial priority given by the dispatcher vs the EMS nurse when utilizing RETTS-p in children < age 16.	The dispatch centre indexed life-threatening priority in 69% of the missions but, of all children, only 6.1% were given a life threatening RETTS-p red colour by the EMS nurse. n =651	L
Magnusson 2019	RETTS-p	Sweden	P	To evaluate the performance of the RETTS-p in the EMS and the agreement between the EMS field assessment and the hospital diagnosis.	Sn 66.7% and Sp 67.0%, with under-triage rate 33%, over-triage rate 33.3%. n =716	L
Skjot-Arkil 2019	DEPT	Denmark	A	To investigate the inter-rater reliability of triage level assignment between prehospital providers and emergency department (ED) nurses using DEPT	Same triage level assigned in 62% of cases. κ=0.47 (95% CI: 0.41–0.56). n=292	VL
Sung 2019	START	Korea	A	To analyze the correlation between the triage systems at the pre-hospital and in-hospital stages (START vs Korean Triage and Acuity Scale)	Agreement between two systems was very low at 0.211 (95%CI 0.164–0.258), and the kappa coefficient of the paramedic category was 0.232 (95% CI 0.161–0.303). n =1028	L
Tsai 2017	TPTS	Taiwan	A	To compare the two-level TPTS with the five-level Taiwan Triage and Acuity Scale (TTAS) at ED arrival to predict hospitalisation	TTAS levels 1–2 better predicted hospitalisation compared to TPTS emergent level designation with a sn 70.3% versus 41.1%, sp 89.1% versus 79.5%. n =4430	VL
Ng 2019	TTAS & TPTS	Taiwan	A	To compare two-tier TPTS versus five-tier TTAS administered prehospital in predicting hospitalization.	TTAS AUC 0.73 compared to TPTS AUC 0.66 for hospitalization. n =493	L
Category: Stroke triage						
Chenkin 2009	Ontario	Canada	A	To determine the PPV of the Ontario Prehospital Stroke Screening Tool for identification of acute stroke at a single stroke center.	PPV 89.5% (95% CI: 85.7–92.7%) for acute stroke. tPA administration rate for patients with suspected stroke increased from 5.9% to 10.1% (p = 0.04).n =325	VL

Kesinger 2015	NIHSS	USA	A	To evaluate whether Helicopter Emergency Services (HEMS) providers could reliably calculate NIHSS compared to in-hospital stroke team physicians.	Excluding patients who received tissue-type plasminogen activator before HEMS transport, there were 216 patients and good agreement (82.7%; κ=0.619) between NIHSS assignments made by HEMS providers and stroke team physicians. n =305	L
Andsberg 2017	PreHAST	Sweden	A	To evaluate prehospital PreHAST performance for stroke/TIA recognition	PreHast ≥ 1 had sn 100%, sp 40%, PPV 50%, NPV 100%, AUC 0.77 for stroke/TIA. n =69	VL
Noorian 2018	LAMS	USA	A	To validate the LAMS for LVO and comprehensive stroke center appropriate patients.	LAMS ≥ 4 identifies LVO among cerebral ischemia patients with Sn 76%, Sp 65% and accuracy 72%. LAMS ≥ 4 identifies CSC-Appropriate patients among all suspected stroke transports with Sn 73%, Sp 71%, and accuracy 72%. n =94	VL
Helwig 2019	LAMS	Germany	A	To compare LAMS to Mobile Stroke Unit (MSU) in accurately triaging patients to the appropriate stroke hospital (CSC vs PSC)	An accurate triage decision was reached for 69.8% in the LAMS group and 100% in the MSU group (difference, 30.2%; 95% CI, 17.8%-42.5%; P < 0.001). n =116	M
Carr 2019	FAST-ED	USA	A	To assess the impact of the implementation of the FAST-ED triage tool on single center stroke intervention team activation in Florida.	FAST-ED ≥ 4 predicted LVO with Sn 80%; Sp 68%; PPV 40 %. Stroke team activation times in favor of the FAST-ED cohort (74 minutes vs. 110 minutes, p < 0.05). n =402	VL
Carrera 2019	RACE	Spain	A	To revalidate RACE after its region-wide implementation in Catalonia	RACE ≥5 showed Sn 84%, Sp 60%, AUC 0.77, for detecting LVO. N=1822	M
Jumaa 2019	RACE	USA	A	To report performance characteristics of RACE for LVO eligible for mechanical thrombectomy	A RACE cut-off point of ≥5 had Sn 77%, Sp 75%, PPV 0.97, NPV 0.25, accuracy 75.3% (95%CI 73.1 - 77.4). n =1147	M
Li 2019	C-STAT	USA	A	To evaluate performance characteristics of C-STAT	C-STAT had Sn 71% and Sp 67% for LVO. C-STAT triage would increase transport of prehospital suspected stroke cases to the CSC by 11% within six hours and 21% within 24 hours. n =158	VL
McMullan 2017	C-STAT	USA	A	To describe the performance of prehospital C-STAT to identify subjects with severe stroke (NIHSS ≥ 15), presence of LVO, and need for CSC.	For NIHSS ≥ 15, C-STAT Sn 77% and Sp 84%; for presence of LVO, Sn 71% and Sp 70%; and for overall CSC need Sn 57% and Sp 79%. n =158	VL
Okuno 2019	FACE2AD	Japan	A	To design and prospectively validate the FACE2AD tool for LVO prediction	FACE2AD ≥ 3 predicts LVO with Sn 85%, Sp 80%, PPV: 0.39, NPV: 0.97, AUC 0.88. n =502	L
Suzuki 2018	TOPSPIN	Japan	A	To analyze performance of TOPSPIN for stroke detection	TOPSPIN ≥3 points with PPV 82.8% for stroke. n =1482	VL

Taqi 2019	VES	USA	A	To evaluate VES performance characteristics for LVO prediction	Sn 94.7%, Sp 82.4% , PPV 58.1%, NPV 98.4%, accuracy 84.9%. n =184	VL
Zhao 2018	ACT-FAST	Australia	A	Validation of ACT-FAST LVO identification tool.	Sn 85.7%, Sp 93.5%, PPV 80% and NPV 95.6% for recognition of endovascular-eligible LVO. Validation n=669, application/statistical analysis n= 60.	VL
Vaclavik 2018	FAST PLUS	Czech Republic	A	To determine tool's performance characteristics for LVO detection.	Sn 93%, Sp 47%, PPV 41%, NPV 94%, and AUC 0.65 for LVO. n =435	L
Bergs 2010	CPSS, FAST, LAPSS, MASS	Belgium	A	To compare diagnostic value of the CPSS/FAST, LAPSS, and the MASS for identifying patients with a stroke in Belgian EMS	FAST/CPSS had Sn 95% and Sp 33%. LAPSS had Sn 74%, Sp 83%; and MASS had Sn 74%, Sp 67%. n =31	VL
Lima 2016	FAST-ED, RACE, CPSS, NIHSS	USA	A	To evaluate performance of FAST-ED for LVO prediction.	The FAST-ED scale had comparable accuracy to predict LVO to NIHSS and higher accuracy than RACE and CPSS (AUC: FAST-ED = 0.81, reference; NIHSS = 0.80, p = 0.28; RACE = 0.77, p = 0.02; and CPSS = 0.75, p = 0.002). FAST-ED ≥4 had Sn of 0.60, Sp 0.89, PPV 0.72, and NPV 0.82 versus RACE ≥5 of 0.55, 0.87, 0.68, 0.79 and CPSS ≥2 of 0.56, 0.85, 0.65, 0.78, respectively. n =741	L
Zhao 2017	RACE, LAMS, CPSS, FAST-ED,PASS	Australia	A	To examine stroke scale performance in atypical clinical presentations	Most scales correctly identified >95% of typical presentations but <20% of atypical presentations. n= 565.	L
Anadani 2019	RACE, FAST-ED, CPSS, 3I-SS, PASS	USA	A	To assess the accuracy of LVO recognition scales with NIHSS as gold standard	RACE≥ 5 had the highest accuracy (78%) for CT-confirmed LVO with 11% FNR and 33% FPR. n =439	L
Category: Trauma triage						
Brown 2011	FTDS	USA	A	To analyze whether trauma center need was accurately predicted solely by the physiologic (PHY) and anatomic (ANA) criteria of the FTDS.	Application of only the PHY and ANA criteria identifies trauma center need with Sn 49%, Sp 78% and undertriage rate of 51%. Mechanism of injury and special considerations criteria play an important role in minimizing under-triage rates. n =1,086,764	M
Newgard 2011	FTDS	USA	All	To evaluate diagnostic performance of FTDS for identifying major trauma (Injury Severity Score [ISS] ≥16)	Sn 85.8% and Sp 68.7%. n =122,345	M
Barnett 2013	FTDS	USA	All	To describe the use of field triage criteria by EMS personnel in the Western United States	The three most common criteria cited (of 33 in use) were EMS provider judgment, age <5 or >55 years, and Glasgow Coma Scale (GCS) score <14. n =46,414	M

Davidson 2014	FTDS	USA	All	To determine the likelihood of serious trauma based on vehicle damage sustained in a crash as described in Step 3 of the FTDS.	Crash characteristics that predict severe injury included intrusion of greater than 12 inches (PPV of 10.4%; 95% CI, 9.5 - 11.3) and steering wheel collapse (PPV of 25.7%; 95% CI, 23.0 - 28.4%). n =85761	M
Lerner 2017	FTDS	USA	P	To determine the change in under- and over-triage rates when the 2011 Field Triage Guidelines are compared to the 2006 and 1999 versions.	Applying the 1999, 2006, or 2011 Guidelines to the EMS interview data the over-triage rate was 32.6%, 27.9%, and 28.0%, respectively. The under-triage rate was 26.5%, 35.1%, and 34.8%, respectively. The 2011 Guidelines resulted in an 8.2% (95% CI 0.6–15.9%) absolute increase in under-triage and a 4.6% (95% CI 2.8–6.3%) decrease in over-triage compared to 1999 Guidelines. n =5594	M
Ardolino 2015	PTS	England	P	To assess performance of English pediatric prehospital trauma triage tools	East Midlands (18%), North West (21%) and Northern (19%) tools had the best over-triage rates. All had under-triage rates of 0%. n =2934	M
Cassignol 2019a	T-RTS, NTS, MGAP	France	A	To compare the diagnostic performance of four trauma triage scoring systems (T-RTS, Vittel, MGAP, NTS) to predict 30 day in-hospital mortality in admitted trauma patients	T-RTS, AUC= 0.84; Vittel criteria, AUC = 0.87; MGAP score, AUC = 0.91 and NTS, AUC = 0.90. n =1001	VL
Cassignol 2019b	Vittel	France	A	To evaluate the correlation between each Vittel field triage criterion and major trauma.	In a multivariate analysis, kinetic elements criteria were not significant predictors of major trauma. n =1151	VL
Cox 2012	VSTTC	Australia	A	To evaluate performance of the Victorian prehospital trauma triage criteria in discriminating for major trauma	The Victorian criteria had sensitivity 95.3%, specificity 62.7%, under-triage rate 4.7%, and over-triage rate 37.3% for major trauma. n =45,332	M
Davis 2012	FTTA	USA	All	To determine rates of undertriage comparing younger and older patient populations using the FTTA algorithm	83% of FTTA positive patients age 15-54 were discharged from a trauma center compared to only 59% of those age > 55. n =2051	VL
Dinh 2012	T1	Australia	A	To determine performance characteristics of the T1 protocol in predicting major trauma	T1 protocol has Sn 63%, PPV 23%, undertriage rate 12%, overtriage rate 77% for severe injury (ISS >15). n =2664	VL
Lavoie 2010	PHI	Canada	A	To evaluate the performance of the PHI, the high-velocity impact (HVI) criterion and emergency medical technician (EMT) judgment for the prehospital triage of injured patients.	Combination of PHI score ≥ 4, HVI presence and EMT judgment had Sn 74.2%, Sp 70.0%, PPV 14.9%, NPV 98.2%, and overtriage rate of 85.1% for severe trauma. n= 16805	L

vanLaarhoven 2014	Dutch	Netherlands	A	To evaluate the protocol's ability to identify severely injured adult trauma patients (ISS >=16).	Sn 89.1%, Sp 60.5%, PPV 26.5%, NPV 97.2%, undertriage rate 10.9%, overtriage rate 39.5%. n= 1607	M
Voskens 2018	Dutch	Netherlands	A	To evaluate the protocol's ability to identify severely injured adult trauma patients (ISS >=16).	Undertriage rate of 63.8% and overtriage of 7.4%. n =4950	L
Category: Trauma triage for helicoper EMS						
Brown 2012	FTDS	USA	All	To determine which FTDS criteria can be used by field EMS providers to predict which trauma patients would benefit from helicopter transport	Odds of increased survival to discharge by helicopter transport found in following conditions: GCS<14 (aOR 1.22); respiratory rate <10 or >29 (aOR 1.32); penetrating injury (aOR 1.40), age> 55 (aoR 1.15). n =258,387	M
Brown 2017	AMPT	USA	A	To validate the effectiveness of the AMPT score to identify patients with a survival benefit from helicopter EMS (HEMS).	For AMPT score ≥ 2, HEMS increases odds of in-hospital survival by 6.7% (ARR 1.067; 95% CI 1.040—1.083, p<0.001). n =222,827	M
Giannakopoulos 2011	RTS	Netherlands	A	To assess if a maximum on-scene RTS (score of 12) can be used as a safe triage tool for HEMS cancellation	Of blunt trauma patients with a maximum RTS on scene, 16% had major trauma, and 3.9% had RTS deteriorate during transport. Maximum RTS not a safe indicator for HEMS cancellation. n =80	VL
Category: Trauma triage for traumatic brain injury						
Fuller 2014	HITS-NS, LAS	England and Wales	A	To evaluate the accuracy of the LAS and HITS-NS triage tools for identifying significant TBI.	LAS had Sn 44.5% and Sp 69%, and HITS-NS had Sn 32.6% and Sp 89.1% for significant TBI. n =6559	L
Fuller 2016	HITS-NS	England and Wales	A	To determine the accuracy of the HITS-NS triage rule for identifying patients with significant TBI.	HITS-NS had Sn 28.3% and Sp 94.4% for significant TBI. n =3828	M

Legend

Pop	Population
A	Adult
P	Pediatric
QR	Quality Rating
VL	Very low quality
L	Low quality
M	Moderate Quality
n	number of cases
RR	Relative risk
3I-SS	3-item stroke scale
ACT-FAST	Ambulance clinical triage for acute stroke treatment
AMPT	Air Medical Prehospital Triage
C-STAT	Cincinnati Stroke Triage Assessment Tool
CPSS	Cincinnati Prehospital Stroke Scale
CTAS	Canadian Triage and Acuity Scale
DEPT	Danish Emergency Process Triage
DSS	Decision support system
Dutch	Dutch Field Triage Protocol

CI	Confidence interval
Sn	Sensitivity
Sp	Specificity
PPV	Positive predictive value
NPV	Negative predictive value
aOR	adjusted odds ratio
AUC	Area under the curve

ESI	Emergency Severity Index
FACE2AD	Field Assessment of Critical Stroke by Emergency Services for Acute Delivery to a Comprehensive Stroke Center
FAST	Face Arm Speech Test
FAST-ED	Field Assessment Stroke Triage for Emergency Destination
FTDS	Field Triage Decision Scheme
FTTA	Florida Trauma Triage Algorithm
LAMS	Los Angeles Motor Scale
LAPSS	Los Angeles Prehospital Stroke Screen
MASS	Melbourne Ambulance Stroke Screen
MEWS	Modified Early Warning Score
MGAP	Mechanism/-Glasgow Coma Scale/Age/Systolic blood pressure score
MTS	Manchester Triage System
NEWS	National Early Warning Score
NIHSS	National Institutes of Health Stroke Scale
NTS	New trauma score
Pathfinders	Pathfinders medical and trauma triage protocols
PEAR	Philadelphia EMS Admission Rule
Ph-ViEWS	Prehospital Vitalpac Early Warning Score
PHI	Prehospital Index
PreHAST	PreHospital Ambulance Stroke Test
PTS	Pediatric trauma score, pediatric triage tape, East Midlands, London, Northwest, Northern, Southwest London, Wessex tools
RACE	Rapid Arterial Occlusion Evaluation
RETTS-p	Rapid Emergency Triage & Treatment System-paediatrics
RTS	Revised Trauma Score
START	Simple Triage and Rapid Treatment
T-RTS	Triage revised trauma score
T1	New South Wales major trauma transport protocol
TOPSPIN	TOYOTA prehospital stroke scale for tissue plasminogen activator intravenous therapy
TPTS	Taiwan Prehospital Triage System
TTAS	Taiwan Triage and Acuity Scale
VES	Ventura ELVO Scale
VSTTC	Victorian state prehospital trauma triage criteria

Appendix 7: Clinical Vignettes (with Answers) used in Validation Study

FOR EACH OF THE FOLLOWING PATIENT VIGNETTES PLEASE:

- Calculate and circle the correct TEWS
- Indicate if you would use a discriminator in this case (yes or no)
- If yes, which discriminator would you use? Write it
- Calculate the correct (final) SATS colour

YOU MAY USE THE ADULT SATS TABLE PROVIDED TO HELP YOU COMPLETE YOUR RESPONSES.

EXAMPLE:

You arrive at a private residence and find a 39 year old female who complains of moderate pain in her right leg. She does not appear to be in any distress, and she is able to walk to the ambulance. She tells you she takes a blood thinner and has a history of a blood clot in her leg.

Vital signs: RR 14 HR 76 BP 119/77 Temp 37C

TEWS (circle one):	(0) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	(Yes) No
If yes, write the discriminator:	*Moderate pain*
Final SATS (circle one):	Green (Yellow) Orange Red Blue

BEGIN VIGNETTES:

1. You are called to the scene of a 59 year old male with a known history of epilepsy. According to bystanders the patient just had a seizure. Currently, he only responds to pain.

Vital signs: RR 25 HR 163 BP 150/81 Temp 36.4°C HGT 2.8

TEWS (circle one):	0 1 2 3 4 5 6 7 8 **9** 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Hypoglycaemia
Final SATS (circle one):	Green Yellow Orange **Red** Blue

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2. You are called to an attempted suicide and respond to a patient laying on the ground outside a building where an adult man jumped out of a fourth floor window. There is blood on his face and around both legs. He complains of severe pain in his whole body and appears to have multiple fractures of his lower limbs. You immobilize him on spinal board.

Vital signs: RR 20 HR 88 BP 105/58 Temp 37.2°C HGT 10.2

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No

If yes, write the discriminator:	High energy transfer
Final SATS (circle one):	Green Yellow **Orange** Red Blue

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3. You are called to the private residence of a 78 year old female for vomiting and severe abdominal pain (9/10). She looks unwell, and is a known diabetic on insulin. She has not eaten properly for 2 days. You bring her into the ED in a wheelchair.

Vital signs: RR 28 HR 95 BP 147/75 Temp 36°C HGT 9.3

TEWS (circle one):	0 1 2 **3** 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Severe Pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

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4. You are called to the private residence of a 56 year old female. Her husband answers the door. She appears exhausted, groaning, weak and unable to walk. Her face is pale and sweaty. She says she is short of breath and in severe body pain.

Vital signs: RR 29 HR 123 BP 84/57 Temp 37.5°C HGT 8.3 O2 Sat 96%

TEWS (circle one):	0 1 2 3 4 5 6 **7** 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Shortness of breath - acute
Final SATS (circle one):	Green Yellow Orange **Red** Blue

---

5. You are called to the private residence of a 62 year old female with an arm injury. She states that she fell over her cat this morning and is now in moderate pain (6/10). She is mobile, and it appears that she has fractured her left wrist.

Vital signs: RR 20 HR 52 BP 121/78 Temp 36.9°C

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate Pain, Fracture - Closed
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

6. You are called to the workplace of a 34 year old male. He is complaining of severe abdominal pain and walks to the ambulance.

Vital signs: RR 12 HR 88 BP 157/97 Temp 37.1°C

TEWS (circle one):	**0** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Severe pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

7. You are called to the private residence of a 19 year old female. She tells you "My boyfriend had too much alcohol last night and hit me over the head". She is mobile, and there is some dry blood around the laceration on her head, but it appears to be superficial.

Vital signs: RR 12 HR 88 BP 106/68 Temp 36.4°C HGT 5.3

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	Yes **No**
If yes, write the discriminator:	
Final SATS (circle one):	**Green** Yellow Orange Red Blue

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8. You are called to the work place of a 27 year old male. He reports that his foot got caught in a machine and complains of moderate pain. His foot is covered in blood, and you help him into a wheelchair.

Vital signs: RR 18 HR 49 BP 135/69 Temp 36°C

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

9. You are called to the workplace of a 23 year old healthy looking male. He tells you "I was grinding an axe 2 days ago, and I think a piece of metal landed in my left eye". He walks to the ambulance and claims that this foreign body in his eye is causing moderate pain.

Vital signs: RR 12 HR 59 BP 138/88 Temp 36.3°C

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

10. You are called to the day hospital for a 43 year old male who states he was assaulted 3 days ago and has moderate pain above his left eye. He has been referred for a review and has not experienced any new trauma since he was hit with a stick on his eyebrow.

Vital signs: RR 20 HR 55 BP 146/43 Temp 36°C

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

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11. You are called to the private residence of a 93 year old female. She is very well looking and states, "I was shifting my bed and now have moderate left sided chest pain." She lives alone and has no other medical problems. You assist her with a wheelchair.
Vital signs: RR 12 HR 83 BP 171/89 Temp 36.8°C

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Chest pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

12. You are called to the scene for a 32 year old male. He is very vocal and stating that he was allegedly assaulted. He complains of severe chest pain after being kicked in the left rib and has a productive cough. He walks to the ambulance.
Vital signs: RR 20 HR 106 BP 173/101 Temp 35°C

TEWS (circle one):	0 1 2 **3** 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Severe pain, chest pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

13. You are called to the private residence of a 49 year old female. She has been very depressed and suicidal and overdosed on medication. She is alert and mobile but very despondent.
Vital signs: RR 22 HR 90 BP 135/64 Temp 36.9°C HGT 6.1

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Poisoning/Overdose
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

14. You are called to the private residence of a 44 year old female who walks to the door. She is complaining of moderate anal pain due to thrombosed external piles.

Vital signs: RR 20 HR 70 BP 154/94 Temp 36.9°C

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

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15. You are called to the private residence of a 35 year old male. He is immobile and has a past history of pulmonary TB. He is a known ethanol abuser and has been confused and unable to speak for the past 2 days. He responds to pain only.
Vital signs: RR 23 HR 148 BP 129/83 Temp 36.8°C

TEWS (circle one):	0 1 2 3 4 5 6 7 8 **9** 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Level of consciousness reduced/confused
Final SATS (circle one):	Green Yellow Orange **Red** Blue

---

16. You are called to the private residence of a 37 year old male. He is complaining of moderate back pain. He is not able to walk and is feeling extremely weak. He is otherwise well.
Vital signs: RR 17 HR 76 BP 121/75 Temp 36°C HGT 4.2

TEWS (circle one):	0 1 2 **3** 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

17. You are called to a private residence by police for an aggressive 23 year old female. She is mobile, alert but crying and very disruptive and psychotic.
Vital signs: RR 12 HR 91 BP 151/89 Temp 36.6°C O2 Sat 100%

TEWS (circle one):	**0** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Aggression
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

18. You are called to the private residence of a frail and dehydrated 79 year old female. She complains of persistent vomiting and abdominal pain. She is a known diabetic and has a past history of renal failure. You bring her into the ED in a wheelchair.

Vital signs: RR 18 HR 76 BP 209/76 Temp 37.4°C HGT 7.8

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Abdominal pain, Persistent vomiting
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

19. You are called to the jail to assess a 29 year old male prisoner who complains of shortness of breath and weight loss. He appears pale, tired, and weak and has a history of Pulmonary TB.
Vital signs: RR 37 HR 135 BP 103/67 Temp 36.7°C HGT 5.4

TEWS (circle one):	0 1 2 3 4 5 **6** 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Shortness of breath - acute
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

20. You arrive at an industrial building, and your patient walks to the ambulance. He is a 40 year old male with a history of asthma, and he has been working with acid earlier in the day. He appears tachypneic (breathing fast), and the symptoms have been worsening over the last several hours.
Vital signs: RR 19 HR 93 BP 133/72 Temp 37.2°C HGT 4.9

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Shortness of breath – acute, Poisoning/overdose
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

21. You arrive at a private residence and are led by family to a 70 year old male laying in bed. He responds to voice and appears to be short of breath. He is normally independent, and this is the first time family has seen him in 2 days.
Vital signs: RR 44 HR 163 BP 113/69 Temp 36.4°C HGT 12.4

TEWS (circle one):	0 1 2 3 4 5 6 7 8 **9** 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Level of consciousness reduced
Final SATS (circle one):	Green Yellow Orange **Red** Blue

---

22. You are called to the shopping mall for an 18 year old female accompanied by her mother. The patient fainted and fell to the ground. She is now bleeding from her right eardrum and vomiting persistently. She is alert but looks extremely pale and tells you she "feels awful" and vomits. She requires assistance to stand up. The patient informs you she is 13 weeks pregnant.
Vital signs: RR 17 HR 80 BP 97/61 Temp 37°C HGT 5.5

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Persistent vomiting, Pregnancy & trauma
Final SATS (circle one):	Green **Yellow** Orange Red Blue

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23. You are called to a private residence of a 40 year old female who walks out to the ambulance complaining of moderate lower abdominal pain. She has a heavy PV bleed but feels well and appears comfortable.
Vital signs: RR 18 HR 85 BP 148/89 Temp 36.5°C

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain, abdominal pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

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24. You are called to a private clinic for a 76 year old female complaining of chest pain. She is mobile and in no distress and says that she has experienced sharp central pain since last night.
Vital signs: RR 16 HR 55 BP 150/68 Temp 36.5°C HGT 7.2

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Chest pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

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25. You are called to the private residence of 58 year old male who has been fitting for 6 hours on and off pre-arrival. He is alert but really doesn't feel so well. You bring him into the ED on a stretcher.
Vital signs: RR 23 HR 67 BP 126/81 Temp 36.9°C HGT 5.2 O2 Sat 100%

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Seizure – post ictal
Final SATS (circle one):	Green Yellow **Orange** Red Blue

26. You are called to the scene and find a 42 year old homeless male who is a known non compliant epileptic. He claims to have fallen on his head and there is dry blood around the 2cm laceration on his head. He is unkempt and smells of alcohol. You must assist him with a wheelchair.
Vital signs: RR 24 HR 78 BP 111/69 Temp 36°C HGT 11.8

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	Yes **No**
If yes, write the discriminator:	
Final SATS (circle one):	Green **Yellow** Orange Red Blue

27. You are called to the private residence of a 20 year old pregnant female. She has a history of abdominal pain during pregnancy but is otherwise healthy. She walks out the ambulance and states she would like a check up.
Vital signs: RR 12 HR 87 BP 126/68 Temp 36.8°C

TEWS (circle one):	**0** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	Yes **No**
If yes, write the discriminator:	
Final SATS (circle one):	**Green** Yellow Orange Red Blue

28. You are called to the private residence of a talkative 57 year old male who walks to the door with extremely swollen legs and a distended abdomen. He has a history of hypertension and COAD but nothing else of note. He complains of moderate pain (5/10) and was well until his legs swelled up.
Vital signs: RR 16 HR 106 BP 126/77 Temp 36.8°C HGT 11.2

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

29. You are called to a private clinic for a 24 year old female. She is sweaty and appears to be in a lot of discomfort. She states that she is feeling really unwell, has severe backache and fever. She feels hot to touch. She has felt really unwell for 2 days now and walks out to the ambulance.
Vital signs: RR 16 HR 114 BP 95/60 Temp 40°C

TEWS (circle one):	0 1 2 3 4 5 **6** 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No

If yes, write the discriminator:	Severe pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

30. You are called to the work place of a 32 year old male with a swollen left eye and face. He complains of moderate pain and explains that he has a 2 day old eye injury from a blunt assault, which was treated in the hospital. He states his vision is getting worse and walks with you to the ambulance.
Vital signs: RR 12 HR 67 BP 122/73 Temp 36.5°C

TEWS (circle one):	**0** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

31. You are called to the private residence of a 40 year old woman. She walks to open the door and appears weak. She states that she has been vomiting fresh blood.
Vital signs: RR 42 HR 131 BP 127/74 Temp 38°C HGT 7

TEWS (circle one):	0 1 2 3 4 5 **6** 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Vomiting – fresh blood
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

32. You are called to the private residence of a 31 year old female. She tells you "Someone pushed me into a fire 1 hour ago" and complains of a burn surrounding her entire right lower leg. You assist her into the ambulance.
Vital signs: RR 16 HR 80 BP 125/65 Temp 36.8°C

TEWS (circle one):	0 1 2 **3** 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Burn - circumferential
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

33. You are called to the scene for a 32 year old male who was stabbed. He is bleeding from his left parietal lacerations but able to stop the bleeding with direct pressure. He is walking around the scene and states he had an argument with someone who then tried to stab him.
Vital signs: RR 18 HR 61 BP 126/81 Temp 36°C

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Haemorrhage - controlled
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

34. You are called to the scene of an accident for a 46 year old male in a pedestrian vehicle accident 1 hour ago. He was struck by a truck going over 100-Km/Hr. He appears to have multiple devastating injuries to his head, chest, arms, and legs. He is pulseless and not breathing.
Vital signs: RR 0 HR 0 BP 0

TEWS (circle one):	0 1 2 3 4 5 6 7 8 9 10 11 12 **13** 14 15
Discriminator present?	Yes **No**
If yes, write the discriminator:	
Final SATS (circle one):	Green Yellow Orange Red **Blue**

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35. You are called to the workplace of a 39 year old male. He experienced blunt trauma to his right hand, looks healthy and is able to walk.
Vital signs: RR 20 HR 45 BP 130/71 Temp 36°C

TEWS (circle one):	0 1 2 **3** 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	Yes **No**
If yes, write the discriminator:	
Final SATS (circle one):	Green **Yellow** Orange Red Blue

---

36. You are called to the private residence of a 27 year old female. She states that she has had heavy PV bleeding for past days with clots. Her pregnancy test came out negative and she appears pale but states she is in no pain. She had a miscarriage about 2 months ago.
Vital signs: RR 20 HR 66 BP 114/74 Temp 36.5°C HGT 4.9

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	Yes **No**
If yes, write the discriminator:	
Final SATS (circle one):	**Green** Yellow Orange Red Blue

---

37. You are called to the scene for a 46 year old female who fell. She is mobile and complaining of severe pain in her arm. She has no history of other medical problems.

Vital signs: RR 17 HR 82 BP 164/110 Temp 36.4°C HGT 5

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Severe pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

38. You are called to the work place of a fit and healthy looking 35 year old male. He stated he hit his thumb with a hammer. He does not appear to have a dislocation, is mobile and does not appear distressed.
Vital signs: RR 20 HR 68 BP 145/92 Temp 36°C HGT 4.9

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	Yes **No**
If yes, write the discriminator:	
Final SATS (circle one):	**Green** Yellow Orange Red Blue

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39. You are called to the private residence of a 29 year old male complaining of severe chest pain. He is mobile but looks tired.
Vital signs: RR 16 HR 58 BP 112/61 Temp 36.2°C

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Severe pain, chest pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

40. You are called to the private residence of a 17 year old female who complains of hoarseness. She is mobile and does not appear to be distressed.
Vital signs: RR 16 HR 62 BP 121/71 Temp 36.5°C

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	Yes **N**o
If yes, write the discriminator:	
Final SATS (circle one):	**Green** Yellow Orange Red Blue

---

41. You are called to the scene of a 33 year old male. He was stabbed over his left scapula and in his right leg. He is cold and sweaty and responds to voice only sitting in a wheelchair. He appears to be in severe pain.
Vital signs: RR 30 HR 100 BP 116/74 Temp 37°C

TEWS (circle one):	0 1 2 3 4 5 6 **7** 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Level of consciousness - reduced
Final SATS (circle one):	Green Yellow Orange **Red** Blue

---

42. You are called to the private residence of a 39 year old female. She stated that she is experiencing the worst abdominal pain ever. She is mobile and alert, but appears to be in extreme agony. She has had a previous evacuation of an ulcer.
Vital signs: RR 12 HR 91 BP 134/91 Temp 37°C HGT 4.5

TEWS (circle one):	**0** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Severe pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

43. You are called to the private residence of a 48 year old female who complains of headache and weakness in her left arm. She is mobile and has had a previous CVA.
Vital signs: RR 20 HR 117 BP 205/136 Temp 36°C HGT 7.9

TEWS (circle one):	0 1 2 3 4 **5** 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Focal neurology - acute
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

44. You are called to the private residence of a 30 year old female. She appears fragile laying in bed. She presents with right sided weakness and aphagia. She is HIV+ and reacts to pain only.
Vital signs: RR 24 HR 98 BP 106/78 Temp 36.9°C HGT 5.2

TEWS (circle one):	0 1 2 3 4 5 **6** 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Focal neurology – acute, Level of consciousness reduced
Final SATS (circle one):	Green Yellow **Orange** Red Blue

45. You are called to the scene for a 65 year old male with a gun shot wound to the abdomen. You place him on a stretcher. He complains of mild pain over the right iliac fossa. There is blood on his abdomen over the entry wound.
Vital signs: RR 20 HR 84 BP 147/91 Temp 37°C HGT 5.5

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	High energy transfer
Final SATS (circle one):	Green Yellow **Orange** Red Blue

46. You are called to a private residence of a 40 year old woman. You find the patient drowsy and she states she overdosed on cocaine and benzodiazepines. She is a known drug addict with a history of depression. She is alert but uncooperative and a little confused.
Vital signs: RR 12 HR 65 BP 120/80 Temp 37°C

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Poisoning/overdose
Final SATS (circle one):	Green Yellow **Orange** Red Blue

47. You are called to a private residence and find a 42 year old male complaining of "The worst pain I have ever felt" and rates it as 9 on a scale of 1 to 10. The pain is in his left buttock and he has a history of buttock abscesses and pulmonary TB.
Vital signs: RR 16 HR 73 BP 150/85 Temp 37°C HGT 5.8

TEWS (circle one):	0 **1** 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Severe pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

48. You are called to a street corner for a 34 year old male who reports "They just started assaulting me - hitting and kicking my chest". You found him walking and complaining of severe chest pain with no other obvious injuries.
Vital signs: RR 24 HR 108 BP 116/82 Temp 36.5°C

TEWS (circle one):	0 1 2 3 **4** 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No

If yes, write the discriminator:	Severe pain, chest pain
Final SATS (circle one):	Green Yellow **Orange** Red Blue

---

49. You arrive at a private residence and family leads you to an unresponsive 33 year old male. Family states they found him unconscious in bed this morning. He appears to going into episodic convulsions. He smells of alcohol, is unkempt and has been incontinent of urine.
Vital signs: RR 26 HR 138 BP 79/60 Temp 37°C HGT 3.1 O2 Sats 95%

TEWS (circle one):	0 1 2 3 4 5 6 7 8 9 10 11 **12** 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Seizure - current
Final SATS (circle one):	Green Yellow Orange **Red** Blue

---

50. You are called to an old age home to transport a 91 year old female. She walks with assistance and complains of moderate left hip and left ankle pain. She has not experienced any recent trauma but fell 5 years ago and has an old hip injury. She is very chatty but a little confused, which is normal for her apparently.
Vital signs: RR 16 HR 65 BP 127/64 Temp 37.4°C HGT 4.1

TEWS (circle one):	0 1 **2** 3 4 5 6 7 8 9 10 11 12 13 14 15
Discriminator present?	**Yes** No
If yes, write the discriminator:	Moderate pain
Final SATS (circle one):	Green **Yellow** Orange Red Blue

END VIGNETTES.

Thank you for participating! Please leave us any comments here:

Appendix 8: Informed Consent Form

UNIVERSITY OF CAPE TOWN, DIVISION OF EMERGENCY MEDICINE
Consent to be a Research Subject

TITLE: Assessing use of the South African Triage Scale (SATS) in the Prehospital Environment

PRINCIPAL INVESTIGATORS: *Wallis L, Mould-Millman NK*

SPONSOR'S NAME: *University of Cape Town, Division of Emergency Medicine and University of Colorado, Department of Emergency medicine*

INTRODUCTION/PURPOSE:

- *We would like to ask for your help by asking you to briefly volunteer in a study.*
- *We would like to study the use of the South African Triage Scale (SATS) in the Western Cape prehospital setting*
- *We are asking for your help because you have some valuable knowledge and experience on this topic*
- *We expect you to spend about 1 hour completing a written assessment, then 1 hour in a peer-group discussion*

PROCEDURES:

- *We want to conduct an individual written assessment in which you will assign a TEWS and SATS score to a written case*
- *Following that, we want to conduct a group interview to understand your perception of using the SATS*
- *We will record the interview using audio and pen and paper*
- *We will perform an anonymous analysis on all the case scenarios*

RISKS:

- *There are no significant risks of physical, mental, emotional, or financial harm to you*
- *None of the information that we collect will have your name or personal information on it.*
- *Your employers and supervisors at Metro EMS will not have direct access to this interview or your responses.*
- *There will be no adverse effects to your job or job security from participation in this interview.*

BENEFITS:

- *Taking part in this research study may not benefit you directly. However, the researchers may learn new things that may positively impact patient care and improve your daily experience using SATS..*

CONFIDENTIALITY:

- *We will keep information about you strictly confidential. The study staff will keep the interview sheet anonymous. The study files and audio recordings will be locked in a file cabinet in a private office.*
- *People, other than those doing this research study may have access to your responses, including:*
    - *The University of Cape Town Human Research Ethics Committee and other offices in the University of Cape Town that help run and/or oversee studies*
    - *The Colorado Multiple Institution Review Board and other offices at the University of Colorado that help run and/or oversee studies*
    - *Any agencies that make rules and policy about how research is done that are not listed above, in South Africa and the USA*
    - *We will keep your records private to the extent required by USA and South African law.*
    - *Ultimately, all the data will be saved on password protected files, the passwords known only to the investigators of this study.*

COMPENSATION:

- *There is no financial or other compensation for your time and effort in participation in this study*

COSTS:

- *All study-related costs will be absorbed by the study investigators*

CONTACT PERSONS:

If you have any questions, concerns, or complaints about this study you can contact a member of the study staff:

Dr. Nee-Kofi Mould-Millman. Tel:+1-404-558-1110. E-mail: Nee-Kofi.Mould-Millman@UCDenver.edu
12401 E. 17th Ave, Leprino Room 754, Dep't of Emergency Medicine, Aurora, CO, 80045 – USA
Prof. Lee Wallis. Tel: +27 (0) 21 948 9908 □ Fax: +27 (0) 21 949 7925
E-mail: lee.wallis@uct.ac.za; Private Bag X24. Bellville, 7535 □ South Africa

If you want to speak to someone who is not a member of the study to discuss problems, ask questions or voice concerns, you can call:

The University of Cape Town Human Research Ethics Committee
Old Main Building of Groote Schuur Hospital, Floor E52, Room 23, Observatory, 7925

If you have any questions about your rights as a participant in this research study, call the University of Cape Town Human Research Ethics Committee

VOLUNTARY PARTICIPATION AND WITHDRAWAL:

- *Your participation is voluntary and you have the right to refuse to be in this study. You can stop at any time after giving your consent. This decision will not negatively affect your employment in any way.*
- *The study doctors have the right to end your participation in this study for any of the following reasons:*
  - *It would be dangerous for you to continue and/or*
  - *You do not follow study procedures as directed by the study doctors and/or*
  - *The sponsor decides to end the study.*

We will give you a copy of this consent form to keep. If you are willing to volunteer for this research, please sign below.

RESEARCH PARTICIPANT'S SIGNATURE AND DATE:

_____
Research Participant's name **(Western Cape EMS medic)**

_____ _____ _____
Research Participant's Signature Date Time

_____
Name of Approved Individual Obtaining Consent **(Study Investigator)**

_____ _____ _____
Signature of Approved Individual Obtaining Consent Date Time

Appendix 9: Interview guide for focus group discussions

TITLE: Assessing use of South African Triage Scale (SATS) by Western Cape EMS

INVESTIGATORS: *Bruijns S, Mould-Millman NK, Dixon J*

SPONSOR'S NAME: *University of Cape Town, Division of Emergency Medicine*
University of Colorado, Department of Emergency Medicine

INTERVIEWER NAME: _____

DATE OF INTERVIEW: _____ **TIME:** _____ **LOCATION:**_____

COHORT: EMS Medics [ ]ALS [ ]ILS [ ] BLS Number of participants:_____

*Introductory Script: "Thank you for taking the time to discuss with me your opinions about TEWS and SATS in the prehospital environment I'm **(facilitator name)**, and I will be facilitating the discussion, and this is **(other researcher's name)** and she will be taking notes and observing. I am a doing research through the University of Cape Town and the University of Colorado to better understand how to improve triage in the prehospital environment. Please keep in mind, there are no 'right' or 'wrong' answers to any of the things we talk about today. This interview is designed to learn more about your knowledge, experiences, feelings and opinions. I'm interested in talking about this with you because I would like to improve care provided to patients and training of EMS providers.*

The interview should take about one hour. All of your responses will be kept private and confidential. I would like to tape record this interview, so I don't have to take so many notes. However, no names or identifying information will be kept on this recording.

Before we begin, let me mention a few things about how we usually conduct these groups:

1) *I will be the facilitator for the group. My role is to ask the questions we have for the group and to encourage everyone to participate. I won't be doing much talking, but may ask you to explain more or to give an example. Also, it's my job to see that everyone has a chance to voice their opinions, as well as to keep us moving along so that we have time to discuss all of the questions. So, at times, it might seem as though I am cutting you off, and this is not meant to be rude, but rather to make sure that we have time to have a complete discussion of each question.*

2) *It's really important that everyone hear this: THERE ARE NO RIGHT OR WRONG ANSWERS!!! Each person's experiences and opinions are valid, and we want to hear a wide range of opinions on the questions we'll be asking. So, please speak up, whether you agree or disagree with what's being said, and let us know what you think.*

3) *Sometimes participants bring up sensitive issues during these discussions, and we want to be sure that everyone agrees that anything of a personal nature that is mentioned in this room will NOT be repeated to others outside of this discussion group. Can I see a nod from everyone showing me that you agree with this confidentiality ground rule?* ***Facilitator: If anyone is not willing to give their consent to confidentiality, they may be excused from the group.***

4) *Let me tell you about our recording process. As you can see, we are using 2 digital recorders to record our discussion. We usually record these focus groups because we want to capture everything that all of you say, and we simply can't write fast enough to get it all down. We'll be using only first names in the group discussion, and when we put together the results from all the groups, we won't include any names at all.*

5) *It is very important that we speak <u>one at a time</u>, so that the recorder picks up everything that is said. So, now that you know what our process is, is everyone OK with being recorded?*

6) *I'm also going to pass out note cards to each of you. I will collect these at the end of the session. If there is any feedback that you would prefer not to share out loud, that you prefer not to be recorded, or that you didn't have a chance to say, please write it down on these cards and then give them to us after the focus group is over or talk to me after the focus group is over. Anything that you say during the group and decide that you don't want to be included on the recording will be deleted from the recording. Just let us know after the session if there is anything that you said that you would like deleted.*

7) *We plan to be finished with our discussion by **(time)**. Are there questions about any of this?*

8) *Please be sure to shut off any phones/pagers you have with you tonight.*

9) *Lastly, we need you to understand that the focus group is not an educational session where we give advice.*

Let's get started."

Interview guide for focused group discussion:

1. *Tell me what the South African Triage Scale (SATS) is?*

2. *How did you originally get trained or taught about calculating and using TEWS and SATS?*

3. *Since then, what further training, if any, have you received on TEWS and SATS?*

4. *What kind of feedback do you get on your use of TEWS and SATS?*

5. *What do you think about the daily use of TEWS and SATS by Western Cape medics?*

    a. *Ease of use…*
    b. *Ease of documenting…*
    c. *Relevance to patient care...*

d. *Relevance to triaging…*

e. *Relevance to destination facility…*

6. *What are the challenges to using SATS in the prehospital setting?*

    a. *Calculating TEWS…*

    b. *Using discriminators…*

    c. *Final SATS colour…*

7. *Tell me about cases that prove difficult to calculate TEWS and SATS?*

8. *Tell me about cases that are easy or convenient to calculate TEWS and SATS.*

9. *What do you think are the benefits of using TEWS and SATS?*

10. *We have found that Western Cape EMS medics incorrectly calculate SATS about 2/3'rds of the time.*

    a. *Why do you think that is?*

    b. *Where do you think the challenges lie?*

11. *Can you kindly give me at least 2 suggestions on how you can use TEWS & SATS more often and accurately?*

12. *How can you and your EMS system better use information gained from TEWS and SATS?*

Appendix 10: Turnitin report

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