A prospective evaluation of the feasibility of using Enrolled Nursing Auxiliaries to triage patients in the emergency unit of an urban public hospital in South Africa

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To my wife Charmaine

for all her love and support

Declaration:

I declare that this dissertation is my own unaided work. It is being submitted for Part III of the degree of Master of Philosophy (Emergency Medicine) to the Faculty of Health Sciences, University of Cape Town. It has not been submitted before for any degree or examination at any other university

Signed by candidate

Signed this 7 day of March 20 06

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Photo on cover: Sister Veronica Sibomzi, Registered Nurse, GF Jooste emergency unit

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GLOSSARY

ADL, Amended Discriminator List

APGAR, Newborn triage tool

ATS, Australasian Triage Scale

AVPU, Mnemonic for assessing level of consciousness: Alert, Respond to Voice, Respond to Pain, unresponsive

CTAS, Canadian Emergency Department Triage and Acuity Scale

CTG, Cape Triage Group

CTS, Cape Triage Score

CCA, Colour Code Amendment

DCS, Data capture sheet

DL, Discriminator list

ESI, Emergency Severity Index

ENA, Enrolled Nursing Auxiliary

HIV, Human immunodeficiency virus

MEWS, Modified Early Warning Score

MTS, Manchester Triage System

TF, Trauma Factor

TEWS, Trauma Early Warning Score

Chapter 1

LITERATURE REVIEW

1.1 Definition and purpose of triage

According to the Oxford English Dictionary; "Triage comes from the French word trier, meaning 'to pick' or 'to cull.' The word apparently entered English as a noun referring to the process of sorting agricultural products. Later it came to designate the lowest grade of such products – especially broken coffee beans."[1] The Mosby medical dictionary defines it as: "Fr. Trier, to sort out:

1. (In military medicine) a classification of casualties of war and other disasters according to the gravity of injuries, urgency of treatment, and place for treatment.

2. A process in which a group of patients is sorted according to their need for care, the kind of illness or injury, the severity of the problem, and the facilities available to govern the process, as in a hospital emergency unit.

3. (In disaster medicine) a process in which a large group of patients is sorted so that care can be concentrated on those who are likely to survive".[2]

Triage is not a new concept. The historical principle of triage is rightly associated with the French physician Dominique-Jean Larrey, who served as Napoleon's Chief Surgeon after joining the Army of the Rhine in 1792.[3,4] Although never using the term triage on record, Larrey applied the concept on the battlefield and refers to this in his report on the Russian campaign: "Those who are dangerously wounded must be tended first, entirely without regard to rank or distinction. Those less severely injured must wait until the gravely wounded have been operated on and dressed. The slightly wounded may go to the hospital line;

especially officers, since they have horses and therefore have transport".[5] The actual word triage was first used in World War I by the French and British armies. Patients were sorted in a field hospital and then referred to various base hospitals depending on the nature of their wounds.[6-8] The objectives of triage were firstly to conserve manpower, and secondly, the conservation of the interest of the sick and wounded.[9] World War II saw the recognition of early resuscitation and given improved sanitation, sulphur drugs, penicillin and blood transfusions, deaths were subsequently reduced.[4] Governed by strict triage protocols, air evacuation was also introduced for the first time.[10] This was further revolutionised by the helicopter in the Vietnam and Gulf wars.[11-13]

Triage concepts started taking root in numerous disciplines of civilian medicine about 50 years ago, when the advantages of early recognition of patients at risk was noted.[14] This included Intensive Care Medicine, Nephrology and Transplant Medicine, Paediatrics and, more recently, Emergency Medicine.[14-19]

Perhaps the most notable example of the utilisation of medical triage belongs to Virginia Apgar. The novel idea of using physiological markers to triage newborns in need of resuscitation was first documented in 1953 by Doctor Apgar, an anaesthetist from Columbia.[19-21] She looked at five physiological signs in newborns, namely heart rate, respiratory rate, reflex irritability, muscle tone and colour, all of which could be assessed quickly and effectively. A score of zero to two, depending on the appropriateness of the sign, is allocated per sign and then totalled. Low scores highlight the need for urgent intervention by means of resuscitation. Doctor Apgar validated the score in 1952 with 1 760 infants and again in 1958 with 15 348 infants.[21, 22] One person in the delivery room, commonly the nurse or midwife, takes responsibility for assessing this at one and five minutes after birth.[19, 23-25] Today, 50 years later, the APGAR score still radically decreases the occurrence of neonatal death. The first triage evaluation for every person born is as relevant in the prediction of neonatal survival today as back in 1953.[20,26]

Emergency units began applying triage principles when a significant increase in patient volume occurred in the late 1950s and early 1960s.[14] The growth in emergency unit use in the USA was a direct result of the increase in the number of people without a regular source of primary care, and in the United Kingdom mostly due to the lack of technologically or organisationally equipped primary care providers.[27,28] emergency units emerged as the safety nets of the health care system.[29] As stated by Julius Roth, PhD: "In view of these crucial advantages of the emergency unit over scheduled clinics and private practitioners, perhaps we should stop asking why people come to an emergency unit and instead ask why anyone gets his care anywhere else".[30]

The burden of unnecessary emergency unit visits predates the recognition of Emergency Medicine as a speciality. Patients from poor socio-economic backgrounds tend to access the emergency units more frequently with non-urgent complaints, due to a lack of health insurance, transportation problems, poor education and a lack of a regular source of care.[31,33] This in turn results in overcrowding of the emergency unit, with true emergencies left untreated for much longer than is acceptable.[29,34,35] Application of triage principles, to set priorities and maintain an orderly flow of patients, is therefore essential.[14]

Triage prioritises a person's need for medical care on arrival at the emergency unit. It aims to expedite time-critical treatment for patients with life-threatening conditions and ensures that all persons requiring emergency care are categorised according to the severity or acuity of their clinical condition.[36]

1.2 Efficacy of triage

Triage practices in Emergency Medicine evolved from the military procedure of giving priority medical care to those who were expected to benefit most.[35] Doctor Larrey recognised the need to decrease the time soldiers spent waiting for surgeons to attend to them back in 1792.[3] Doctor Jonathan Letterman, head of medical services of the Army of Potomac, reorganised the emergency services in the American Civil War (1861). He reduced the retrieval time of injured soldiers from the battlefield to field dressing stations.[3, 37]. The biggest benefit for those seriously injured was to get to an area where wounds could be attended to within the shortest possible time.[5] Therefore, in evaluating the efficiency of triage systems, researchers have measured time to treatment as an important variable directly impacting upon patient outcomes.[36, 38-41] Walk-out rate and total length of stay are also frequently evaluated but this does not impact on patient outcomes.[34] Table 1 lists the most recent literature on the impact of triage on waiting times.

Table 1: The impact of triage on waiting times

Date	Country	Intervention	Result
2001	Israel[38]	Introduction of nurse triage.	Waiting time for all reduced from 4,5 to 1,5 hours.
2001	UK[34]	Using combined nursing and physician triage for 30% of the week hours	Walkout rate before intervention: 33%. Walkout rate after intervention: 29%. Reduction in length of stay: 11%.
2002	Canada[42]	Redesigning an existing triage system to enable triage nurses to initiate diagnostic protocols.	Reduction of 46 minutes for all patients. Reduction of 76 minutes for urgent cases.
2004	UK[40]	Using a triage nurse with a physician between 09:00 and 12:00 for an eight day period.	Reduction in median waiting time to see a doctor from 32 minutes to 2 minutes.

UK=United Kingdom

1.3 Use of nurses to triage

The first person to use nurses for triage purposes was Virginia Apgar. She used midwifes and nurses to assess the need for neonatal resuscitation, as did other researchers of her score.[19, 43, 44] Worldwide it is accepted as standard labour ward nursing practice. In the 1970s, emergency unit nurses triaged patients, thought to be non-emergencies, to appropriate areas for treatment, such as outpatient clinics and different speciality areas of the hospital.[14, 45, 55] More recently, nurses are used to triage ward inpatients at risk of deterioration and possible admission to intensive care units.[15, 16, 56-60] The recognition of nurses' ability to take an accurate patient history and conduct a brief physical assessment in order to collect vital physiological measurements supports utilising them in the triage role.[36, 61] In some instances, nurses performed better in this role than doctors.[62] Recent data strongly support their use in this capacity.[38, 63-65]

The Emergency unit of the Barzilai Medical Centre, Israel, published a prospective quality assurance study documenting the consistency of nursing triage over a period of three years.[38] Triage data of patients who were assessed by a triage nurse during two randomly chosen, consecutive weeks during the years 1995 and 1998 were analysed. The authors reviewed all of the 2886 complete medical records and matched the triage category allocated by the triage nurse with that of the attending physician. Agreements were evaluated using chance corrected kappa correlations (κ). Full agreement between nurse and physician was found in 90,5% (κ=0,90) in the first period and 93% (κ=0,93) in the second period

The results were consistent and actually showed improvement over a 3-year period. The rate of agreement was lower for nurses with less experience. Table 2 lists the rate of agreement of triage codes assigned when compared to physician triage. Patients with chest pain were correctly triaged in 76,8% (κ=0,75) of the cases in the first period and in 72,4% (κ=0,70) of the cases in the second period. This was due to a higher triage category being assigned (18,6% and 20,7% respectively). The author concluded that nursing triage in their unit was safe and effective in classifying patients to appropriate categories.

Table 2: Rate of agreement between nursing and physician triage over a 3 year period in Barzilai, Israel[38]

	Compatibility/ rate of agreement (%)	
Category:	Period 1 (1995)	Period 2 (1998)
Nurse with up to 1 year experience	88,5	92
Nurse with 1- 3 years experience	91,5	93,4
All nurses	90 (κ=0,905)	93 (κ=0,93)
Chest pain	76,8 (κ=0,75)	72,4 (κ=0,70)

Beveridge et al. determined the rate of interobserver reliability using the Canadian Emergency Department Triage and Acuity Scale (CTAS).[63] 10 nurses and 10 physicians were randomly selected to review and assign a triage level on 50 case summaries from the emergency unit of Dalhousie University hospital. The outcome showed a high rate of interobserver agreement (overall agreement was κ=0,80 for all observers) in using CTAS. It was concluded that CTAS was understood and interpreted in a similar fashion by both nurses and physicians.

Evidence for nursing triage is further strengthened by data obtained from a prospective study conducted at the Manchester Royal Infirmary.[64] A four-week prospective cohort of all patients attending with chest pain (n=167) compared detection of risk by nurses to that of researchers using best available evidence-based prognostic indicators from history. The study showed that nurses, using the Manchester Triage System (MTS), had a sensitivity of 86,8% and a specificity of 72,4% when identifying high-risk cardiac chest pain.

In 2004 the Feinberg School of Medicine in Chicago selected 403 cases for a retrospective study to validate the Emergency Severity Index (ESI).[65] Twentyseven variables were abstracted, including triage level assigned, admission status, admission site and death. The true triage level was determined using a standard process and this was correlated with the triage score assigned by the nurse, using a weighted kappa and Pearson. The outcome showed that the scores assigned by nurses were very reliable (interrater correlation between nurse triage level and true triage level was $\kappa=0,89$, and the Pearson correlation coefficient $r=0.83$, $p<0.001$).

Although the correlations for all these papers were highly significant, an important question regarding incorrectly triaged patients needs some attention. Benedict reported in the Annual Trauma Review Summary for Santa Cruz County that an "acceptable" overtriage rate has been established to be between 30% and 50%.[66] Since overtriaged patients are assigned higher triage levels, this is generally regarded as safe.[31,38,66]

The American College of Surgeons Committee on Trauma (ACSCOT) stated that an undertriage rate of 5% to 10% is unavoidable and is associated with an over-triage rate of 30% to 50%.[67] An overtriage rate of up to 50% may be required to maintain an acceptable level of undertriage. In the appropriately titled paper, "Undertriage, overtriage, or no triage?", Asplin found that paramedics undertriaged 10% to 15% of patients to "no transport".[31] Although it is easy to agree that undertriaging more than 10% of patients is unacceptable, when would the sensitivity be high enough? The author agreed that when that "acceptable" sensitivity (acceptable rate of undertriage) is finally reached, the specificity would be so low that triage would no longer be useful. Newgard et al. agreed with this statement.[68] Lower undertriage leads to higher overtriage.[69-71]

Bindman noted that the importance of errors in triage is directly related to how easily they can be rectified.[35] Mistaken triage is much more problematic if the alternative site of ambulatory care is several kilometres away than if it is across the street. Overtriage is thus widely accepted in order to minimize undertriage.

Overtriaged patients can be downgraded once the error has been identified by the senior health care professional.[72]

Due to the major influence of triage decisions on patient management, training of triage nurses is integral. The positive effects of better experience and intensive training have already been demonstrated by Hay et al. in Barzilai.[38] In September 2001 the Centre for Nursing Research at the Monash Institute of Health Services Research presented a report supporting nurses in the triage role to the Victoria Department of Human Services.[73] Staff at 29 emergency units was involved in the process and a training package aimed at improved service delivery was released. In the same year, Kelly et al. suggested that a combination of educational activities, with self-directed learning packages, lectures and mentored experience, were the most common form of training used for triage nurses after conducting a postal survey, and that almost all units included in the survey offered some sort of continual training.[74]

1.4 The tools used

The first triage tools were used in the 1970s.[75-77] Their predictive abilities were poor since they had no scientific base.[78] Champion was one of the first to produce a scientific score based on an analysis of an existing trauma database.[79] Today, many different triage scoring tools are in use in emergency units worldwide. The Manchester Triage System (MTS) from the United Kingdom, the Australasian Triage Score (ATS) and the Canadian Triage and Acuity Scale (CTAS) are the most widely used scores in emergency units in the countries of origin.[80-82] The Triage Revised Trauma Score (TRTS) was designed and has been successfully used for prehospital trauma purposes.[83] Mass casualty systems like the Triage Sieve (UK, Netherlands, Sweden, India, Australia and NATO military organisations), Careflight (Australia) and START (USA) are easy to learn but since they are intended for mass casualty situations they are not used for day-today emergency unit triage.[84-86] These scores commonly co-exist with day-to-day scores but are reverted to only in the event of a mass casualty.[87]

The complexity and size of these scores as well as the time required to work out a particular triage code make their use difficult when large numbers of patients need to be triaged. The MTS uses 52 algorithms to triage patients into five groups, whilst the ATS and the CTAS, although similarly dividing patients into five groups, make use of lengthy lists of conditions to acquire the different scores used to calculate the correct triage group.[80-82] Their bulky size leads to prolonged initial assessment times and requires extensive training of triage staff on implementation and throughout the use of the score.[87] When compared to a simple score like APGAR, it becomes apparent that these scores are far too complex for routine use in high volume contexts.

Standard practice of care demands that triage nurses collect routine measurements of physiological parameters from all but the gravely ill according to Gerdtz, Goldhill and Ashworth.[36, 58, 88] Gerdtz reviewed information collected by triage nurses in a prospective observational study.[36] A total of 26 triage nurses from an emergency unit in metropolitan Melbourne, Australia, participated. They performed 404 occasions of triage. Cook et al. demonstrated that the inclusion of physiologic and anatomic indicators of injury improved overtriage without affecting outcomes.[89] Cooper et al. found that the availability of vital signs significantly changed the triage nurses' triage decision, especially in the vulnerable extremes of age groups.[61] He prospectively observed triage nurses in 24 emergency units. Triage nurses made a triage decision before and after the measurement of vital signs. It is clear that a triage score that does not incorporate physiological measurements may not adequately reflect the urgency of the patient's presentation.[61]

The Modified Early Warning Score (MEWS) (Table 3) is a simple bedside tool which nurses currently use to alert physicians to the deterioration of medical in-patients.[15, 16, 58, 90, 91] Similar to the APGAR score it makes use of five basic physiological parameters.[56, 92] A clear association has already been shown between abnormalities of these easily recordable physiological parameters and mortality.[58]

Table 3: MEWS parameters and scoring criteria[15, 16]

Score	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Respiratory rate		<9		9-14	15-20	21-29	30
Pulse rate		≤40	41-50	51-100	101-110	111-129	≥130
Systolic blood pressure	≤70	71-80	81-100	101-199		≥200	
Temperature		<35		35-38.4		≥38.5	
AVPU				**A**lert	Reacts to **V**oice	Reacts to **P**ain	**U**nresponsive

The opportunity to intervene timeously and improve outcome is apparent.[91-94] Table 4 outlines the current literature supporting the use of this score as a means of identifying sick patients requiring urgent care in a hospital setting.

Table 4: Recent literature validating the use of the MEWS

Date	Country	Sample size	Main Finding
2001	UK[16]	709	The MEWS identifies patients at risk of deterioration who require increased levels of care. Scores of five or more are associated with an increased risk of death.
2003	UK[15]	1695	Patients with a score of more than four were prospectively referred to a critical care outreach team. Data were consistent when compared to those of an observational study conducted in the same unit the previous year. There was no change in mortality of patients with a low, intermediate or high MEWS.
2004	UK[56]	Not applicable	Collectively, small changes in the five parameters are seen earlier than obvious changes in individual parameters.

UK=United Kingdom

The researchers at Wrexham Maelor Hospital, United Kingdom., have convincingly shown that the MEWS is a suitable scoring tool for early identification of patients at risk of catastrophic deterioration in the medical admissions unit.[16] This "medical triage tool" facilitates nurse practitioners and/or critical care physicians' identification of high-risk patients, thereby expediting intervention in order to improve outcome. Table 5 lists the important results of this study.

Table 5: Important findings from the 2001 MEWS validation trial[16]

Study section	Trial results
Distribution of maximum scores	Admission scores ranged from 0–9 (median of 1) with the bulk of patients scoring low and the minority high.
Median scores for each physiological parameter	Median admission scores for systolic blood pressure, pulse rate, temperature and AVPU was 0. Median score for respiratory rate was 1.
Physiological parameters of patients reaching defined endpoints	Patients who reached predefined endpoints were significantly older, and had a lower systolic blood pressure, higher pulse rate and higher respiratory rate ($p<0,05$).
Relative risk ratios for patients with scores of 1–3 when compared to patients with a score of 0.	Increased scores for individual parameters did not always translate into an overall increased risk. High scores related to low temperature and systolic blood pressure, and high scores related to pulse and respiratory rate showed an increased risk of reaching endpoints.

Mean scores ranged from 0–9 with a mean value of 2,29 (median 1, standard deviation 1,51). Endpoints were reached by 7,9% of patients with a MEWS of 0–2, 12,7% of patients with a MEWS of 3–4 and 30% of patients with a MEWS of 5–9. More than 30% of cases scored one, less than 1% of all cases scored nine. All results showed the bulk of cases appropriately placed in the lower scoring categories, which directly relates to the stable physiological features of these cases. The larger proportion of patients had scores of zero for blood pressure (91% of cases), pulse rate (78% of cases), temperature (95% of cases) and AVPU (92%).

The median score for respiratory rate was one (55% of cases). When compared, the respiratory rate scored higher median values than any of the other parameters. The pulse rate had scores in excess of zero in 22% of cases. Patients who reached predefined endpoints were significantly older, with a lower blood pressure, higher pulse rate and higher respiratory rate (Table 6). There were no significant changes in temperature, whether endpoints were reached or not. Age played a significant role when endpoints were considered.

The relative risk for patients to reach an endpoint with a low systolic blood pressure score of three was much higher (relative risk 8,6, confidence interval 0,5–139) than for patients with a high systolic blood pressure score of two (relative risk 0,5, confidence interval 0,7–4,1). Similarly, a low temperature's score had a higher relative risk (relative risk 5,9, confidence interval 1,8–19) than a high temperature's score (relative risk 0,9, confidence interval 0,2–3,8). The risk ratios for both respiratory rate and pulse rate were highest, with a high score of three, relative risk 7,9, confidence interval 1,5–42 and relative risk 3,0, confidence interval 0,9–9,5 respectively.

Table 6: Physiological parameters on admission of patients reaching or not reaching endpoints[16]

	Endpoints not reached (n=598)	Endpoints reached (n=75)	p-value
Mean age – years (SD)	62 (20)	74 (14)	<0.0001
Mean systolic blood pressure – mmHg (SD)	140 (30)	127 (27)	≤0.0001
Mean pulse rate – bpm (SD)	86 (19)	92 (23)	≤0.03
Mean respiratory rate – bpm (SD)	20 (4)	23 (7)	≤0.002
Mean temperature – °C (SD)	36,7 (0,9)	36,5 (1)	0,06

SD=Standard deviation

Both of Subbe's trials,[15, 16] as well as Goldhill's study,[95] concluded that the respiratory rate was responsible for a large component of the total score, and was the most pertinent parameter. Kenward made a similar observation after analysing the vital signs of 132 patients prior to cardiac or respiratory arrest.[96] Records showed that shortness of breath was recorded in 52% of patients suffering arrest. Fieselmann had a similar finding in 1993; 54% of patients compared to 17% of a control group had an increased respiratory rate prior to arrest.[97] Interestingly enough, it is also the least recorded parameter.[56, 96] The AVPU neurological assessment score correlates well with the more complex Glasgow Coma Score but is much easier and quicker to calculate.[98]

Following the initial successful validation of the MEWS, Subbe et al. prospectively scored 1695 patients in a medical admissions unit in 2003.[15] Patients with a MEWS of more than four were referred to the critical care outreach team. The outcomes were compared to those of an observational trial performed in the preceding year. Mortality of patients with low, intermediate and high MEWS were unchanged, confirming its use as a suitable scoring tool to identify patients at risk of deterioration. Rees stated that not all unwell patients can be managed in a high dependency unit or an intensive care setting.[56] He agreed that a MEWS of three be used in most United Kingdom units to trigger a rapid assessment of the patient by a ward doctor but acknowledged that some units used values of four and five with good outcomes. Both Ashworth and Goldhill et al. found that patients with physiological abnormalities had a higher mortality risk and that an early warning score like the MEWS was able to predict this.[58, 88] The use of early warning scores is currently encouraged by several bodies in the United Kingdom, including the Royal College of Surgeons and Physicians, the Intensive Care Society and the Department of Health.[90, 99-101]

What stands out from all these papers is that irrespective of which triage system is used, it must enable triage staff, in particular triage nurses, to assess patient acuity accurately, consistently and efficiently.[12, 14] Collection of routine observations is accepted as standard nursing practice, regardless of area or discipline. This routine collection of basic physiological parameters is vital to the triage decision.[15, 16, 36, 58, 61, 88, 91, 102] Although the collection of vital signs is advocated by many, it is not always incorporated into triage systems.[80-83] In order to increase simplicity, similar to the APGAR score, the use of physiological variables in the triage process, such as the MEWS, should be considered essential in any emergency room triage system.[13, 19, 20, 36, 43, 61]

1.5 South African perspective

There are approximately 45 million people in South Africa today.[103] The average life expectancy is estimated to be around 46,5 years for males and 48,3 years for females.[103] Human immunodeficiency virus (HIV) infection, chronic diseases, poverty-related diseases and injuries all contribute to the quadruple burden of disease visible in South Africa.[104] Currently, more than 20% of 15–49 year-olds are infected with HIV.[103] This trend has escalated over the past 10 years to establish HIV infection as the leading epidemic in South Africa, closely followed by tuberculosis. This has significantly contributed to the striking loss-of-years-of-life (38%).[104]

The remaining top ten causes of premature mortality include homicide/violence, road traffic accidents, diarrhoeal disease, lower respiratory infections, low birth weight, stroke, ischemic heart disease and malnutrition.[105-107] According to the national minister of health, Manto Tshabalala-Msimang, the majority of South Africans (84%) have access to a public medication budget of about R3 billion a year, whereas medical aid members (16%) spend about R13 billion a year on medication.[108] Given this massive burden of disease, the fact that 38 million

South Africans do not have access to private medical aid funds and have to rely on the public health care service, overcrowding at government hospitals has become the norm.[108] These data become even more relevant when the number of doctors and nurses per 100 000 population in South Africa is compared to that of First World countries (table 7).[109] Thus the burden of disease and dependence of the majority of South Africans on public health care services has resulted in excessive numbers of patients trying to access public sector emergency units. The need for triage in this context is apparent.

Table 7: Doctor and nurse rates per 100 000 population per annum for selected countries[109]

	Rate per 100 000 population/ year		
Country	Doctors	Nurses	Doctor: Nurse ratio
South Africa	69	388	1:6
Canada	209	1010	1:5
Australia	249	775	1:3
Israel	391	616	1:1,6
UK	166	497	1:3

UK=United Kingdom

There is currently no formal national triage system in use in South Africa.[87] Although MacMahon had already identified the need for triage in the 1980s, his ideas were never formally applied.[110] The system he proposed was intended for prehospital services and included the collection of physiological parameters. Patients with deviations in pulse rate and volume, pupil size and reaction, breathing pattern, skin colour and temperature as well as level of consciousness were categorised red and given preference. Those with no abnormalities were triaged to a lower green priority. He based his system of triage on 'sorting by vital signs' and not by injury. Fluctuations would alert the prehospital officer to patients at risk without requiring lengthy diagnostic procedures to be performed. Unfortunately his system was never validated or implemented on a large scale.

The need to streamline emergency services in a setting where patient numbers are vast and the pathology often more advanced is obvious.[87] The potential benefits of introducing formal triage to patients accessing South African public hospital emergency units would be little different, if not greater, than that already demonstrated in the developed world. The most important benefit would be the rapid sorting of patients, separating those requiring immediate medical care from those who could wait before being evaluated and treated.[14] This should have a dramatic impact on waiting times for urgent patients.[36]

To date, nurses have not formally assumed triage duties in South African emergency units. Given the poor doctor to nurse ratio, compared to other countries (table 7),[109] it seems sensible to use nurses to triage in South Africa, as is the case elsewhere in the world. The effective use of the APGAR score by South African midwives and nurses serves as good proof that nurse-based triage is effectively practised, although in a different setting in South Africa.[26] An emergency unit triage nurse would therefore require a triage tool with similar efficacy and ease of use as the APGAR score.[14]

As is the case with the APGAR score, it would make sense to adopt the current nursing practice of recording vital signs into a potential triage tool. The practice of using physiological parameters in triaging is already internationally advocated.[36, 61, 89] Such a tool would require validation in a South African setting in order to judge its accuracy, consistency and efficiency when used by nurses, prior to implementation. Nurses, using a simple, suitable triage tool based on simple physiological parameters, could play an integral part in South African emergency units in the same way they currently play a key role in South African midwife-run obstetrics units. By taking over a role for which adequate foreign validation already exists, doctors could be freed up to focus their attention on active clinical diagnosis and treatment of patients rather than triaging of patients.

A key outcome measure of a triage nurse's decision-making is the accuracy of the triage score used.[36] An ideal triage score should be easy to use and return a result in the minimum amount of time. It should be reliable, reproducible and applicable to the whole spectrum of case types that present to emergency units. Existing triage systems like the MTS, CTAS and ATS require extensive training, making their incorporation into the busy South African setting problematic.[80-82, 108] Their bulky size would render their use inefficient, given the number of patients attending South African public hospital emergency units.

Compared to the APGAR score, it is clear that these systems are too complex to be useful in a South African context. The Cape Triage Group (CTG) convened in April 2004, as part of the Joint Emergency Medicine Division of the University of Cape Town and Stellenbosch University in order to design a suitable triage system for local use.[87] It was decided to use the MEWS parameters as the core of the system, since it was agreed that physiological assessment should be a major component of triage. This followed the successful introduction of a MEWS/discriminator list-based triage tool at GF Jooste Hospital in Manenberg, Cape Town in March 2004. After extensive deliberation, the CTG proposed the use of the Cape Triage Score (CTS) in June 2004, which captures the basic MEWS parameters but has been extended to include:

1. Basic score of mobility, since it was recognised that the MEWS had a medical bias. It was postulated that patients with better physiological reserves but severe injuries, and consequently near normal physiology, might benefit from the addition of this parameter. The MEWS with the addition of the mobility parameter were called the Triage Early Warning Score (TEWS) (Table 8),

2. Colour-code system reflecting the urgency of the case (red being the highest urgency, followed by orange and yellow, with green being non-urgent),

3. Selected clinical discriminators added to the TEWS to aid the decision making process. These were separated into discriminators relating to mechanism of injury, medical symptoms and anatomic considerations. At least half of these discriminators are trauma-related (Appendix 1),

4. Recognition that an experienced senior healthcare professional may influence the triage decision at any given time according to his/her discretion.

Table 8: The Triage Early Warning Score (TEWS)[87]

Score	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Respiratory rate		<9		9-14	15-20	21-29	30
Pulse rate		≤ 40	41-50	51-100	101-110	111-129	≥ 130
Systolic blood pressure	≤ 70	71-80	81-100	101-199		≥ 200	
Temperature		<35		35-38,4		$\geq 38,5$	
AVPU				**A**lert	Reacts to **V**oice	Reacts to **P**ain	**U**nresponsive
Mobility				Walking	With help	Stretcher	

While this triage tool seems ideal for use in the South African setting, the use of the tool, especially by nurse practitioners, requires systematic validation in an authentic context.

Chapter 2

STUDY DESIGN AND METHODS

2.1 Purpose of the study

1. To evaluate the use of the Cape Triage Score (CTS) as a suitable tool for prioritizing the delivery of emergency care to patients presenting to an urban public hospital emergency unit, including identification of amendments to the tool that may improve its quality.

2. To determine the accuracy with which Enrolled Nursing Auxiliaries, using the CTS, are able to triage patients presenting to the emergency unit of an urban public hospital.

3. To determine the impact of nurse triaging on waiting times for patients presenting to the emergency unit of an urban public hospital.

2.2 Study Design

A two part retrospective and prospective, cross-sectional study was conducted in the emergency unit of GF Jooste Hospital in Manenberg, Cape Town, South Africa. Part of the study design included a flexible extension by one month in order to evaluate the use of an amended triage tool, should interim analysis of the prospective data suggest benefit to patient care by amending the CTS. During this month, data for both the original and the amended triage tool were collected in parallel. In an effort to expedite the triage decision and minimise the adverse impact on waiting times, nurses would only use one triage tool at a time to calculate a patient's priority colour code. The tool used would depend on the specified data collection period.

2.3 Selection of subjects

2.3.1 Retrospective data

Data from the medical admissions audit for the months March, June, August and November of 2003 (randomly selected), from the Department of Medicine of GF Jooste Hospital, were compared with data in the hospital records. Complete data sets containing the required data from both the audit and hospital records on matching cases were included in the data collection. This data was required in order to determine waiting times before the introduction of a triage system in the emergency unit.

Cases were excluded from the data pool if the hospital record did not show all of the following:

1. Time of first contact at the emergency unit;

2. Mode of mobility on arrival in the emergency unit;

3. Time when attended to by the medical officer on duty; and

4. Admission diagnosis.

2.3.2. Prospective data

Data were prospectively collected over a three-month period from 1 December 2004 to 28 February 2005. A further one month of prospective data collection, using an amended triage tool, was undertaken for the month of March 2005 following the results of an interim analysis.

Data from subjects for evaluation of the triage tool were eligible for inclusion into the study if subjects were twelve years and older, and all fields were completed on the data capture sheet (DCS) (Appendix 3). Data capture was performed between 08:00 and 17:00 on weekdays. Patients presenting with an acute life-threatening complaint (including those with an altered level of consciousness) were coded red, in accordance with the CTS discriminator list, and admitted directly to the resuscitation bay of the emergency unit. Data from these subjects were evaluated with the same criteria as for retrospective data and included where appropriate.

Five Enrolled Nursing Auxiliaries participated as partially trained triage nurses and three Enrolled Nursing Auxiliaries as fully trained triage nurses. The type and amount of training time both nurse-groups received is explained in Table 9.

Table 9: Type and amount of time spent on training for Enrolled Nursing Auxiliaries participating in the study

	Partially trained	Fully trained
Training commenced	On day of triage duty	8 July 2004
Formal training	20-minute verbal explanation of triage tool	60-minute PowerPoint presentation
Informal training	Daily in-service training for four months during data collection	Daily in-service training for five months before starting data collection, and for four months during data collection
Training aids	A3-size wall charts and credit card-size memory cards depicting the CTS carried by the triage nurse while on duty	
Total training time	Four months	Nine months

2.4 Collection of data

2.4.1 The triage tools used for data collection

Table 10 lists the components of each of the triage tools used in the study.

Table 10: The different triage tools used in the study and its components

Triage tool	Components
MEWS	Five physiological parameters (Table 3)
TEWS	MEWS with mobility parameter (Table 8)
CTS	TEWS with complete discriminator list
Amended CTS	MEWS with Trauma Factor (score of 2 added for trauma cases) and discriminator list without trauma diagnoses

The complete discriminator list (DL) (Appendix 1) was used in conjunction with the Triage Early Warning Score (TEWS). The same DL, but without the trauma diagnoses, was used in conjunction with the amended CTS (Appendix 2). For the purpose of simplicity the discriminator list (DL) is referred to as DL-T whenever used in association with the trauma factor (TF), as was the case with the amended CTS (MEWS+(DL-T)+TF).

2.4.2 Retrospective data capture

The MEWS of patients admitted to the Department of Medicine at GF Jooste Hospital during the months of March, June, August and November 2003, were extracted from the hospital records. The records were also examined in order to determine the mobility status of patients upon arrival in the emergency unit, the time of first contact with medical staff and the time when the patient was attended to by a medical officer in the emergency unit. The mobility status was necessary in order to calculate the TEWS for each patient. This was obtained from ambulance vouchers and nursing process records found in the patient's folder.

2.4.3 Prospective data capture

A triage station was set up in the patient waiting area next to the emergency unit entrance. Data were captured separately in order to blind the triage doctor to the triage score derived by the triage nurse. Table 11 lists the different stationery as well as what was captured and by whom.

Table 11: The different stationery used to capture data

Stationery used	Component captured	Captured by
Triage register	TEWS and TF if applicable	Triage nurse
	Colour code assigned by nurse	Triage nurse
CPR	TEWS and TF if applicable (copied from triage register)	Triage nurse
	Patient's main complaint	Triage nurse
	Time of triage	Triage nurse
	Colour code assigned by doctor	Triage doctor
DCS (Appendix 3)	TEWS and TF if applicable (copied from CPR)	Triage doctor
	Patient's main complaint (as an item on the discriminator list)	Triage doctor
	Colour code assigned by nurse (copied from triage register)	Triage doctor
	Colour code assigned by doctor (copied from CPR)	Triage doctor
	Time of triage (copied from CPR)	Triage doctor
	Time of assessment in EU	EU doctor
	Outcome information	EU doctor

CPR=casualty patient record
EU=emergency unit

The blood pressure and pulse rate were measured electronically using a Dinamap®. Axillary temperature was measured with a mercury-type or an electronic thermometer. The respiratory rate was counted over 30 seconds and the AVPU was scored as the best response at the time of blood pressure measurement. This was captured in the triage register, placed at the triage station, as well as on the casualty patient record (CPR) and the DCS. The CPR used in the study is the standard emergency unit stationery provided by the Provincial Government of the Western Cape, South Africa

All components of the CTS were captured for the four months of the collection period. The components of the amended CTS (MEWS+(DL-T)+TF) were captured in parallel to those of the CTS for the month of March 2005 following the interim analysis in accordance with the study design. A Priority colour code was assigned in accordance with the triage tool in use at the particular time of the study (CTS or amended CTS).

All the data recorded by the nurse in the triage area as well as the data recorded in the emergency unit regarding the patient's outcome was captured on the DCS. This included the final emergency unit outcome decision, the discipline represented by the patient's primary complaint (medical, surgical, trauma, psychiatric), the date and time when the outcome decision was made and the chief diagnosis. Figure 1 shows the strategy employed for data collection.

A. The patient arrived at the triage station in the waiting room of the emergency unit at GF Jooste Hospital.

↓

B. The triage nurse measured and documented the physiological parameters and main complaint of the patient on the CPR after taking a brief history.

↓

C. The triage nurse, using the physiological parameters and the main complaint, assigned a priority colour code category as calculated using the CTS or amended CTS and documented this in the triage register.

↓

D. Using the recorded physiological parameters from the CPR and after taking a brief history, the triage doctor (principal investigator) independently assigned a priority colour code using the CTS or amended CTS.

↓

E. The priority colour code assigned by the triage doctor was documented on the CPR. This priority colour code was used for further patient management.

↓

F. Patients were assessed by the medical officer in the emergency unit in the order determined by the colour-code category assigned to them by the triage doctor.

↓

G. Study data pertaining to triaging were captured on the DCS after the patient had been triaged. This was kept in the patient's folder until the outcome decision was made, after which it was removed from the folder and checked for completeness.

Figure 1: Strategy employed for prospective data collection.

2.5 Outcomes measured

For the CTS (or any amendments) to be regarded as a useful triage tool, the following criteria (Table 12) were defined by the principal investigator:

1. Endpoint prediction according to the targets set in Table 12 (this was used to evaluate amendments as well),

2. A significant reduction in waiting time for red, orange and yellow priority code patients. No significant reduction in waiting time for green priority code patients was expected.

The predefined endpoints were:

1. Admission to a general ward or the high care unit,

2. Death during emergency unit visit.

Table 12: Desired outcome targets set for the CTS as a triage tool:

Outcomes measured	Red	Orange	Yellow	Green
Percentage of cases reaching an endpoint	More than 50%		Less than 35%	Less than 15%
Percentage of cases dying in emergency unit	10%	5%	nil	nil
Waiting time target as set by the principal investigator	Immediate	Less than 30 min	Less than 120 min	More than 120 min
Waiting time target as set by the CTG	Immediate	Less than 10 min	Less than 60 min	Less than 240 min

Waiting time targets set by the principal investigator were longer than those set by the CTG, following a review of the literature. Hay et al. found the mean waiting time from nurse triage to physician examination to be 43,1 minutes for the highest priority category after nurse triage had been introduced in 1995. It was not until 1998 that this was reduced to 18,2 minutes.[38]

For Enrolled Nursing Auxiliaries to be regarded as efficient triage officers, the following outcomes were required to be comparable with international data:

1. Weighted Kappa correlation with doctor triage greater than 0,80,

2. Undertriage rate compared with triage doctor less than 10%,

3. Overtriage rate compared with triage doctor less than 50%.

The need for formal training of Enrolled Nursing Auxiliaries in the use of the triage tool and also the triage tool that yielded the best correlation with doctor triage were assessed as follows:

1. Significant decrease in undertriage for trained nurses or when using the better tool; and

2. Significant increase in agreement with doctor triage for trained nurses or when using the better tool.

2.6 Data analysis

Data were captured into a Microsoft Access© database. Data analysis and simulations were done using Microsoft Excel©, Statistica – version 7© software and an on-line calculator (http://www.graphpad.com/quickcalcs). Sample size calculations were done using another on-line calculator (http://www.raosoft.com/samplesize.html). Charts were generated from both Excel© and Statistica©. A p-value of 0,05 or less was regarded as statistically significant.

2.6.1 Basic descriptive statistics

Mean, median, range, standard deviation and 95% confidence intervals were used to describe different data sets.

2.6.2 Comparative analyses

Independent sample t-tests and Mann Whitney U-tests were used to compare continuous variables and a chi square test was used to compare categorical data.

2.6.3 Correlations

Kappa correlations (κ), an interrater agreement measure that takes chance into consideration, were used. A weighted Kappa, which takes the distance of a negative result from a positive result into account, and Pearson's correlations were also used.

2.6.4 Other

In order to evaluate endpoints of patients within their priority colour categories, the percentage of patients reaching an endpoint for a certain priority colour code was calculated as a function of the total number of endpoints reached by all patients. This, as well as percentage distributions, risk ratios and agreements, were calculated with a Casio Fraction *fx-82L* pocket calculator.

2.7 Ethical considerations

The fundamental purpose of this project was to implement a strategy designed to streamline and improve the efficacy of emergency care currently offered at GF Jooste Hospital emergency unit. All the physiological parameters recorded in this study currently form part of routine service provision by nurse practitioners attending to patients in the emergency unit. The basis of the study therefore falls within the scope of standard clinical practice and consent from patients attending the emergency unit during the study period was not obtained. Furthermore, there is currently no mechanism for prioritising health care delivery in the hospital's emergency unit. The use of a colour-coded system, based on peer-reviewed objective criteria, represents an enormous improvement in current practice. The study was approved by the Research Ethics Committee of the University of Cape Town (ref. no. 396/2004)

2.8 Conflicts of interest

None. The topic of triage is currently also being evaluated in South Africa by the researchers listed below. The questions being addressed by these researchers do not overlap with those of this dissertation.

1. Doctor Lee Wallis. *Validation of the Paediatric Triage Tape.* In progress. MD thesis, Edinburgh University.

2. Ms Michelle Twomey. *Determination of a paediatric version of the Cape Triage Score.* In progress. PhD thesis, University of Cape Town.

3. Doctor Sean Gottschalk. *Evaluation of the Modified Early Warning Score as a triage tool in the Western Cape emergency healthcare services.* In progress. M.Phil. emergency medicine dissertation, University of Cape Town.

4. Doctor Shaheen de Vries. *A prospective evaluation of the Cape Triage Score as a pre-hospital triage tool.* In progress. M.Phil. emergency medicine dissertation, University of Cape Town.

Chapter 3

RESULTS

3.1 Brief description of GF Jooste Hospital

According to Statistics South Africa, there were approximately 1,1 million people living in the GF Jooste Hospital drainage area during the Census of 2001.[111] Given the growth rate in this area between 1996 and 2001, this number is now estimated to be well over 1,3 million, and thus roughly a third of Cape Town's population.[111] With about 43% of the labour force unemployed and more than 41% of households living in informal dwellings, it is also the poorest community in the Cape Town metropole.[111, 112, 113] It is currently estimated that more than 65% of this area's inhabitants are living under the poverty line.[111, 112, 113] Furthermore, a disproportionate burden of premature mortality exists due to a quadruple burden of disease.[114] Compared to other areas, this area has a higher than average burden of communicable diseases and nutritional conditions, a significant burden due to non-communicable diseases and injuries (both accidental and non-accidental) and, lastly, also carries the additional burden of HIV/AIDS.[114]

GF Jooste Hospital first opened its doors in 1976 as a convalescence unit. After local government recognised the quadruple burden of disease in the area, the convalescence unit was closed, refurbished and reopened as an adult Emergency Care Hospital in September 1996. The emergency unit consists of a fifty-seat triage area, fourteen acute care beds, four monitored beds used for resuscitation, two seven-bed and twenty-seat patient holding areas used for patients awaiting admission, review or discharge, as well as a streaming clinic for minor complaints and follow-up.

The unit is staffed around the clock by medical officers, five during the day until early evening and three during the night, with two daily consultant ward rounds. A full-time consultant heads the unit. Nursing care consists of twelve Enrolled Nurses or Nursing Auxiliaries per shift and two Registered Nurses, who act as the shift leaders. The unit deals with approximately 4500 consultations per month and about 13% of patients require inpatient treatment.[115, 116] During the study period the hospital had an inpatient capacity of 205, which included eight high-care beds.

3.2 Quality of data capture

Table 13 shows the percentage of retrospective and prospective data capture achieved.

Table 13: Quality of data capture

	Retrospective component		Prospective component	
	Number	% of total	Number	% of total
DCS sent out	719		1000	
DCS received	345	48%	832	83%
DCS with all fields complete	319	44%	823	82%

DCS=data capture sheets

Table 14 shows the sample size calculation parameters (for a p-value<0,05 and confidence intervals of 95%) and the actual sample sizes collected as determined with a power calculation. The retro- and prospective population were estimated for a four month period for medical admissions and emergency unit consultations respectively.

Table 14: Sample size calculation

	Retrospective component	Prospective component
Population estimate over 4 months for: - Medical admissions[116]	2400	n/a
- Emergency unit consultations[115]	n/a	18 000
Required sample size	332	377
Actual sample size	319	823

n/a=not applicable

3.3 Basic patient demographics

Table 15 shows the gender distribution and the age demographics for the retrospective and prospective components of the study.

Table 15: Gender distribution and age demographics

	Gender distribution:			Age:		
	All (n=)	Male (n=)	Female (n=)	Mean ± SD	Median	Range
Retrospective: -Medicine	319	n/a	n/a	42 ± 16	40	13–93
Prospective: -All	823	338	485	39 ± 15	35	13–88
-Medicine	464	209	255	41 ± 16	39	13–86
-Surgery	262	71	191	35 ± 14	33	14–87
-Trauma	65	41	24	37 ± 16	36	13–88
-Psychiatry	32	17	15	28 ± 10	25	14–53

n/a= not applicable

3.4 Reason for emergency unit attendance:

Of 823 patients prospectively evaluated, medical patients made up 56% of consultations, while surgery and trauma contributed 32% and 8% respectively. Psychiatric patients made up 4% of emergency unit consultations (Figure 2). Since psychiatric patients made up such a small component, this group was not further analysed.

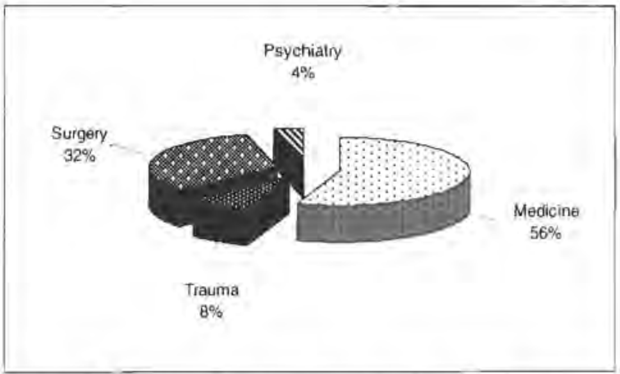

Figure 2: Reason for emergency unit attendance

3.5 Overall patient outcome

Of 823 patients prospectively evaluated during the study, 41,2% (n=345) reached an endpoint. As shown in figure 3, specific endpoints were 314 admissions to a general ward (38,2%), 28 admissions to the high-care ward (3,4%) and three deaths (0,4%).

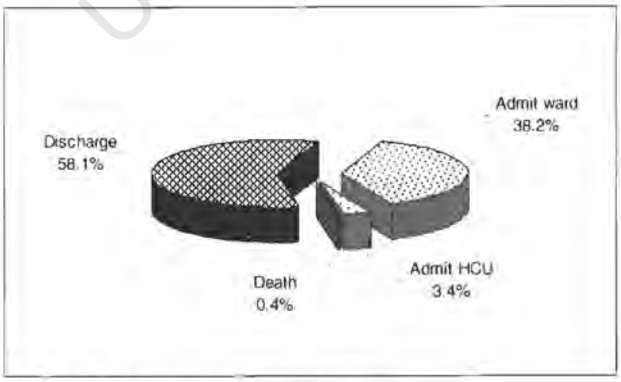

Figure 3: Overall patient outcome

3.6 Evaluation of the Cape Triage Score (CTS)

3.6.1 Outcome related to CTS colour code

The final outcome of the emergency unit visit was analysed according to the priority colour code assigned on arrival. Colour codes were assigned using the CTS, unless otherwise stated. Figure 4 depicts the overall distribution of patients, according to assigned priority colour codes, presenting to the emergency unit during the study period. It should be noted that half (50%) of patients seen were assigned a yellow priority code. Patients coded green and orange both made up 23% of emergency unit visits, while the red priority code was assigned to 4% of patients.

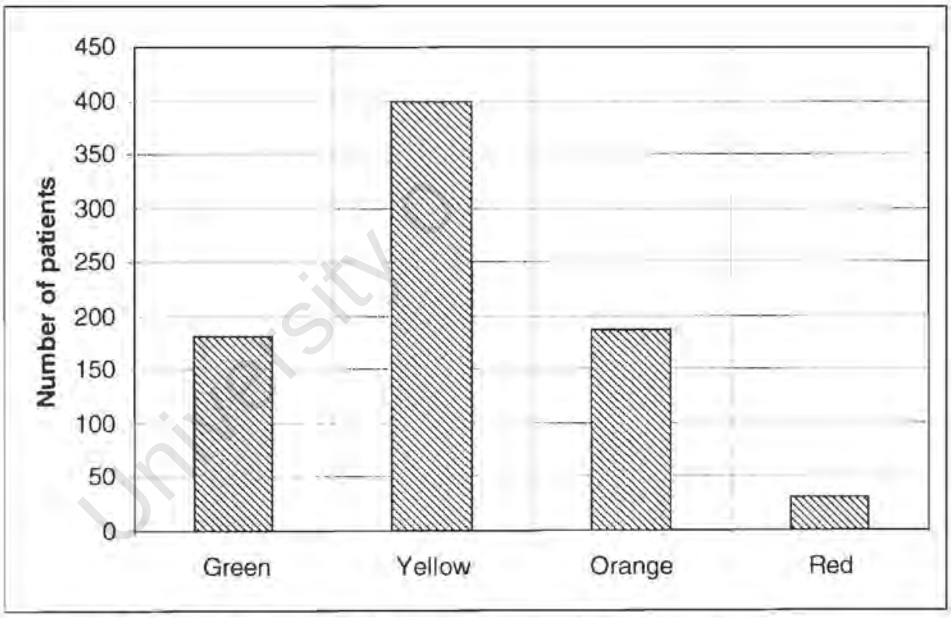

Figure 4: Overall distribution of colour codes assigned to patients

Figure 5(a) demonstrates the distribution of patients according to priority colour code reaching an endpoint (admission or death) as a percentage of all patients reaching an endpoint. The data shows that the majority of admissions were derived from the yellow priority code (46%) followed by the green and orange priority codes (25% each). Figures 5(b)–(d) show the distribution of patients, according to colour code, reaching an endpoint in the three major categories of patients presenting to the GF Jooste Hospital emergency unit

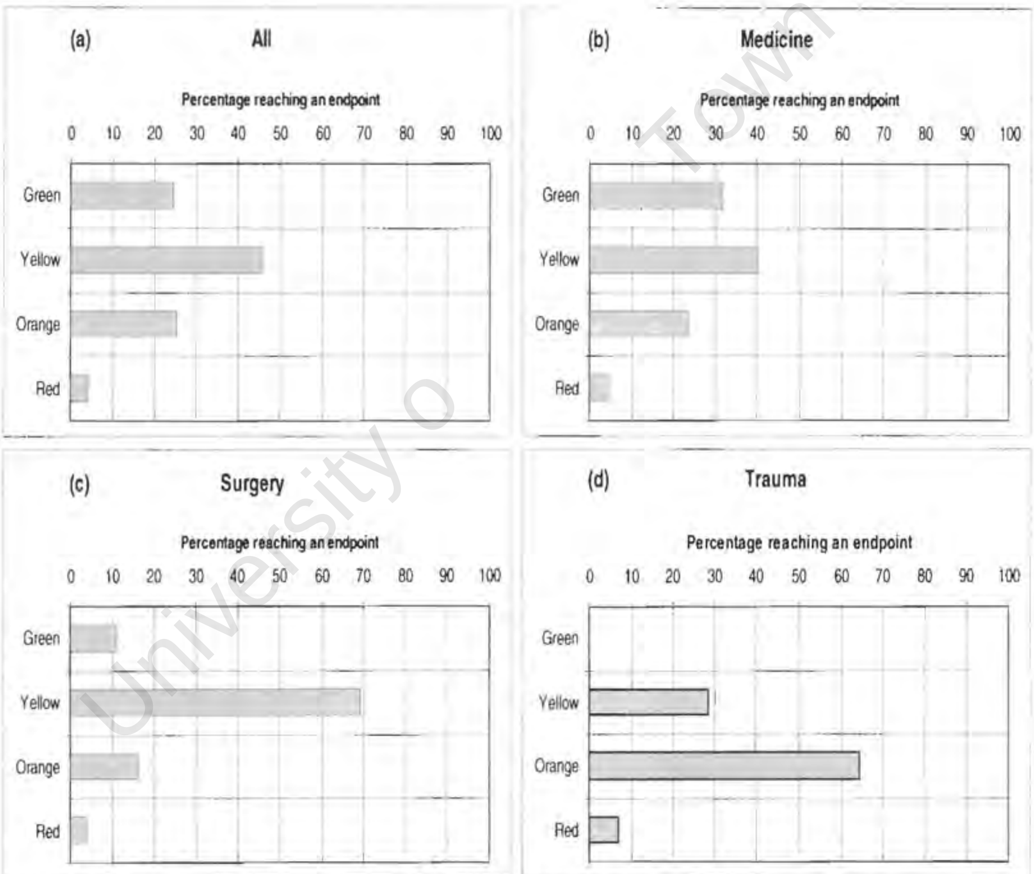

Figure 5(a)–(d): Percentage of cases reaching an endpoint in each CTS priority colour code

3.6.2 Components of the CTS

3.6.2.1 Modified Early Warning Score (MEWS)

Table 16 shows the mean MEWS of all patients seen in the emergency unit during the study period. The mean MEWS of medical patients was significantly higher than that of surgical (p=0,01) or trauma cases (p=0,005).

Table 16: Descriptive statistics for MEWS

Disciplines	n=	Mean ± SD	Median	Range
All	798	2,98 ± 1,88	2,5	0–10
Medicine	442	3,20 ± 1,91	3	0–9
Surgery	259	2,77 ± 1,86	2	0– 10
Trauma	65	2,51 ± 1,62	2	1–8

Table 17 shows the relative risk ratios for patients reaching an endpoint with a MEWS of one, two and three, when compared to patients with a score of zero, for each of the components of the score.

Table 17: Relative risk ratios for patients reaching predefined endpoints with scores of 1, 2 and 3 when compared to patients with a score of 0

Parameter	3	2	1	0	1	2	3
Systolic BP	1,26	1,73	1,16			0,95	
Pulse rate		n/a	0,78		1,20	1,54	2,30
Respiratory rate		n/a			1,89	2,67	3,74
Temperature		1,00				1,62	

n/a=not applicable or insufficient data to calculate risk ratios

The data in Table 18 compares the mean physiological parameters. These were significantly more abnormal in patients requiring admission as compared to those discharged from the emergency unit.

Table 18: Comparison of physiological parameters of patients reaching or not reaching endpoints

	Endpoint not reached (n=469)	Endpoint reached (n=329)	p-value
Age (years)	38 ±16	39 ±15	0,96
Systolic BP (mmHg)	125 ±23	120 ±25	0,005
Pulse rate (bpm)	94 ±23	108 ±26	<0,00001
Respiratory rate (bpm)	22 ±5	25 ±7	<0,00001
Temperature (°C)	36 ±0,8	37 ±1,1	0,001

Figure 6 shows the relationship between the MEWS and the likelihood of reaching an endpoint.

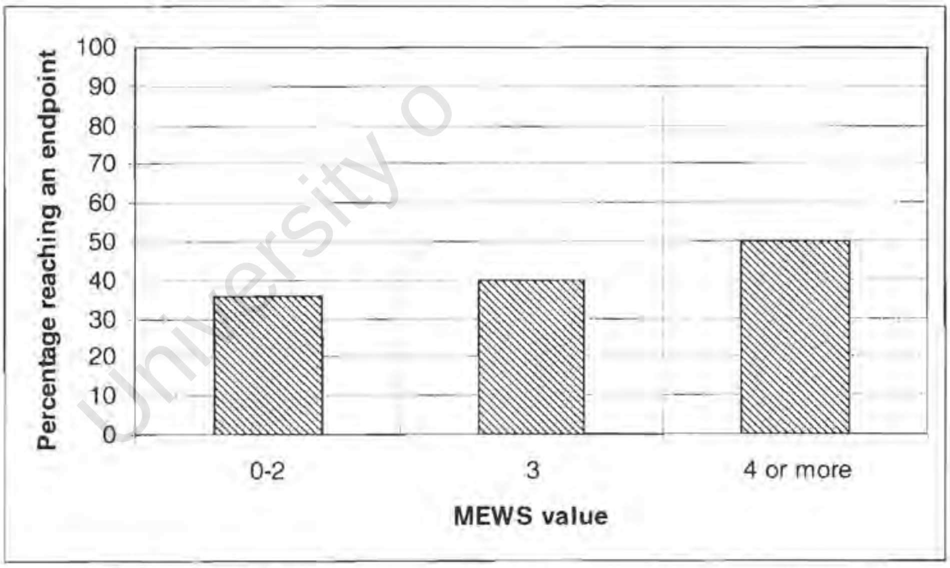

Figure 6: Percentage distribution of all subjects reaching an endpoint for the respective MEWS values

3.6.2.2 Mobility parameter

Significantly fewer walking patients, 35% of 602, reached an endpoint, compared to 61% of 221 patients requiring some assistance, including wheelchairs, walking aids or stretchers ($p<0,00001$). This is demonstrated in Figure 7.

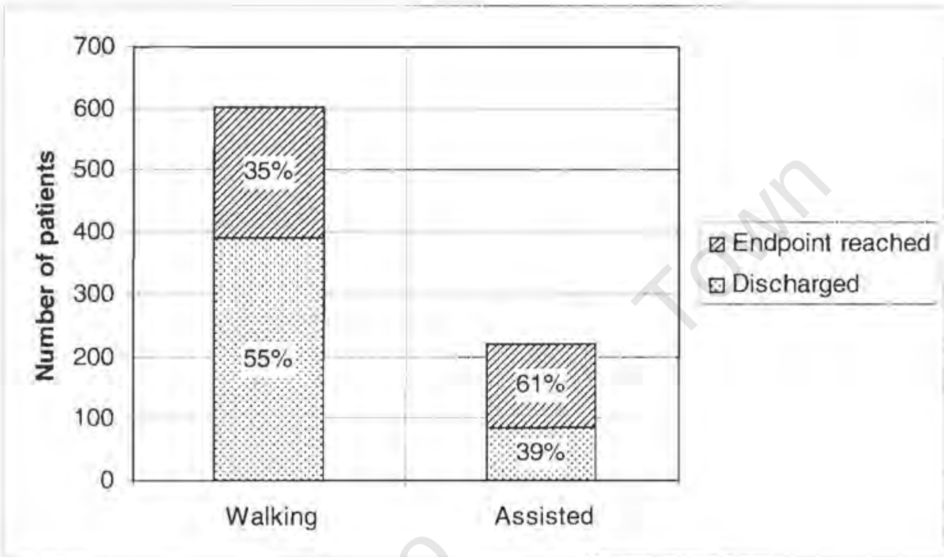

Figure 7: Distribution of endpoints reached for walking and assisted patients

While a similar proportion of medical and trauma patients arrived at the emergency unit requiring some form of assistance with mobility (32% vs. 22%) the likelihood of reaching an endpoint was significantly greater for medical cases than trauma cases; 64% as compared to 21% (p=0.02). During the study period 11% of surgical cases required assistance with mobility on arrival at the emergency unit; 71% of these patients reached an endpoint. There were no significant difference in the likelihood of reaching an endpoint for surgical cases when compared to medical cases (p=0.47). These findings are demonstrated in Figure 8.

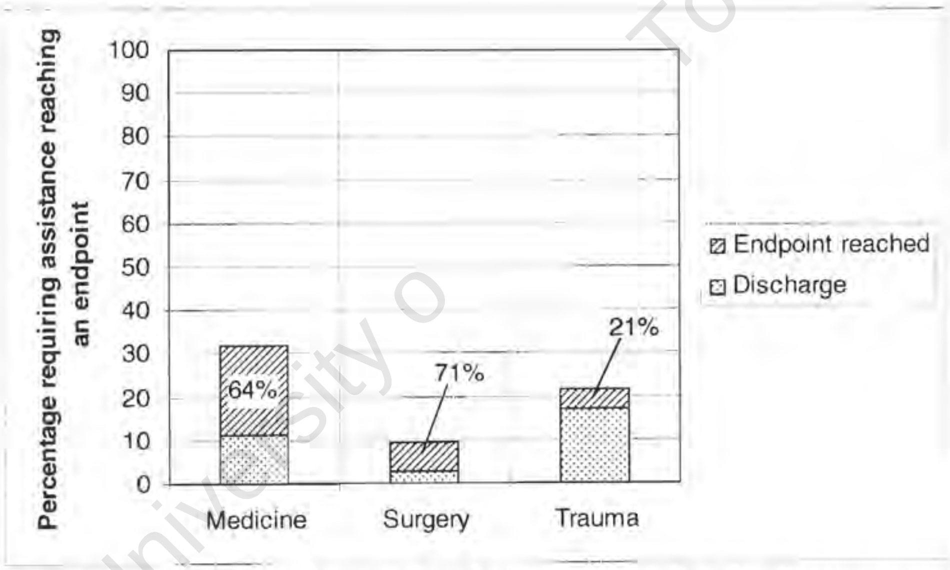

Figure 8: Percentage distribution of endpoints reached for all patients requiring assistance

The mobility parameter's significance was further analysed by comparing the mean MEWS and Triage Early Warning Score (TEWS) of emergency unit patients. A significant difference between the MEWS and TEWS of patients was observed in the medical patient group. There was no significant difference observed in trauma or surgical cases (Table 19).

Table 19: Impact of adding a mobility parameter to the MEWS

Discipline	N=	Mean MEWS (95% CI)	Mean TEWS (95% CI)	p-value
All cases	798	3,0 (2,8- 3,1)	3,2 (3,1- 3,4)	0,009
Medicine	442	3,2 (3- 3,4)	3,5 (3,3- 3,7)	0,026
Trauma	65	2,5 (2,1- 2,9)	2,8 (2,3- 3,2)	0,405
Surgery	259	2,8 (2,5- 3)	3,0 (2,7- 3,2)	0,257

3.6.2.3 Discriminator list (DL)

Table 20 shows the discriminator list with the mean TEWS for each discriminator, the colour code according to the mean TEWS, as well as the colour code assigned by the CTS for that particular discriminator. The percentage distribution of endpoints reached for patients with a particular condition on the discriminator list is also given. Thirteen conditions on the discriminator list were never diagnosed during the study period; these are tabled in Appendix 2. The TEWS did not predict the CTS assigned colour code for 79% of the conditions on the discriminator list. Matching priority colour code predictions occurred in only 21% of cases.

Table 20: Discriminators, mean TEWS scored by each, colour code derived from TEWS, colour code as indicated on the CTS discriminator list (DL) and percentage of cases reaching endpoints

Symptom/ diagnosis on discriminator list	N=	Mean TEWS	Colour code using TEWS	Colour code using DL	% of cases reaching endpoint
Abdominal pain	139	3	Yellow	Yellow	32
Asthma, not status	1	2	Green	Orange	All discharged
Asthma, status	1	1	Green	Red	All discharged
Burns > 20%	2	3	Yellow	Orange	50
Chest pain	34	3	Yellow	Orange	35
Dislocation, minor joint	5	4	Yellow	Yellow	All discharged
Fracture closed	15	2	Green	Yellow	7
Fracture open	1	2	Green	Orange	All discharged
Haematemesis, fresh blood	8	4	Yellow	Orange	50
Hypoglycaemia < 2,2	1	3	Yellow	Red	100
Overdose/poison	16	3	Yellow	Orange	31
PV bleed BHCG+	61	3	Yellow	Yellow	25
Psychosis	23	3	Yellow	Orange	48
Seizure, current	1	5	Yellow	Red	All discharged
Seizure, post-ictal	8	4	Yellow	Orange	25
Trauma abdomen	5	3	Yellow	Orange	60
Trauma chest	8	3	Yellow	Orange	75
Trauma head	6	2	Green	Orange	33
Trauma limb	21	3	Yellow	Yellow	10

The impact of adding the discriminator list to the TEWS and thereby producing the CTS is shown in Figure 9. As demonstrated, the percentage of green code patients reaching an endpoint were significantly reduced overall (p=0,0001). This was especially true for surgical (p<0,00001) and trauma cases (p=0,01). Furthermore, the percentage of orange (p=0,02) and red (p=0,05) priority colour code patients reaching an endpoint was significantly more. The improvement seen with medical patients was clinically insignificant.

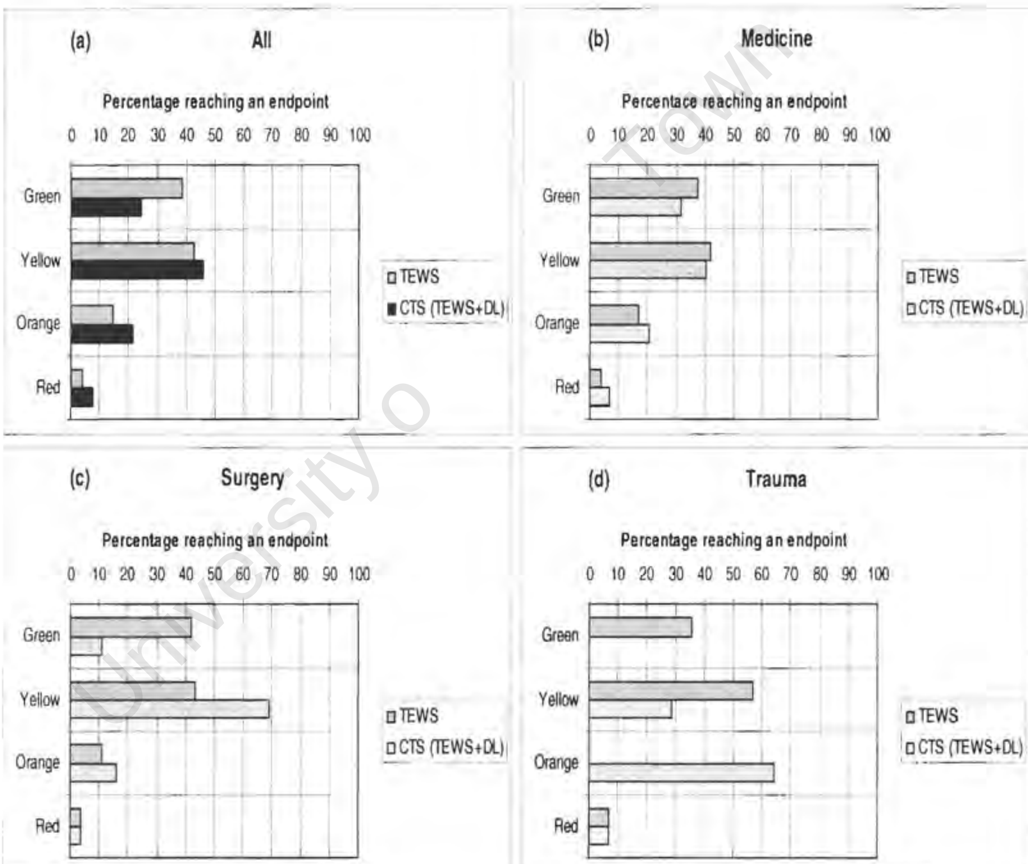

Figure 9(a)–(d): Comparison of the percentage cases reaching an endpoint using the TEWS and the CTS

3.7.1 Simulation 1: Colour code amendment (CCA)

From prior data it was already apparent that cases with a higher MEWS were more likely to reach an endpoint (Figure 6). The priority colour coding was therefore scrutinised to establish the MEWS at which a significantly higher risk of achieving an endpoint was observed. A significant p-value was observed between a MEWS of three and four (Table 22).

Table 22: Comparison of percentage cases reaching an endpoint using MEWS

MEWS		Endpoints reached: lower score (%)	Endpoints reached: higher score (%)	p-value
Lower score	Higher score			
≤1	2	36 %	35 %	0,85
2	3	35 %	40 %	0,40
3	4	40 %	51 %	0,09
4	5	51 %	49 %	0,72
5	6	49 %	45 %	0,63
6	7	45 %	61 %	0,22
7	≥8	61 %	50 %	0,50

Based on this finding, the suggested colour code amendment (CCA) is shown in Table 23. A comparison with the priority colour codes assigned by the CTS is shown in the same table.

Table 23: Comparison of proposed CCA of the CTS priority colour code categories

	Red	Orange	Yellow	Green
CTS colour code	8 or more	6–7	3-5	2 or less
Recommended CCA	6 or more	4–5	2-3	1 or less

3.7 Simulations proposing amendments to the CTS

An interim analysis of the prospectively gathered data was done by creating simulations to explore potential amendments to the CTS. These simulations are listed in Table 21. The most pertinent results are described in this section.

Table 21: Description of simulations

	Description:
Simulation 1	MEWS + colour code amendment (CCA)
Simulation 2	MEWS + CCA + amended discriminator list (ADL)
Simulation 3	MEWS + CCA + ADL + trauma factor (TF)

In each of the simulations the MEWS, rather than the TEWS, was used as the basic score to which a number of parameters were added. This was done because data already described showed that the mobility parameter significantly increased the triage score of medical patients only, thereby potentially biasing the score in favour of medical patients (Table 19). Furthermore, a near-perfect correlation between the MEWS and TEWS, Pearson correlation coefficient r=0,98, permitted the substitution.

The impact on the colour code change on the distribution of cases when MEWS+CCA were used instead of the CTS is shown in Figure 10 (a) – (d).

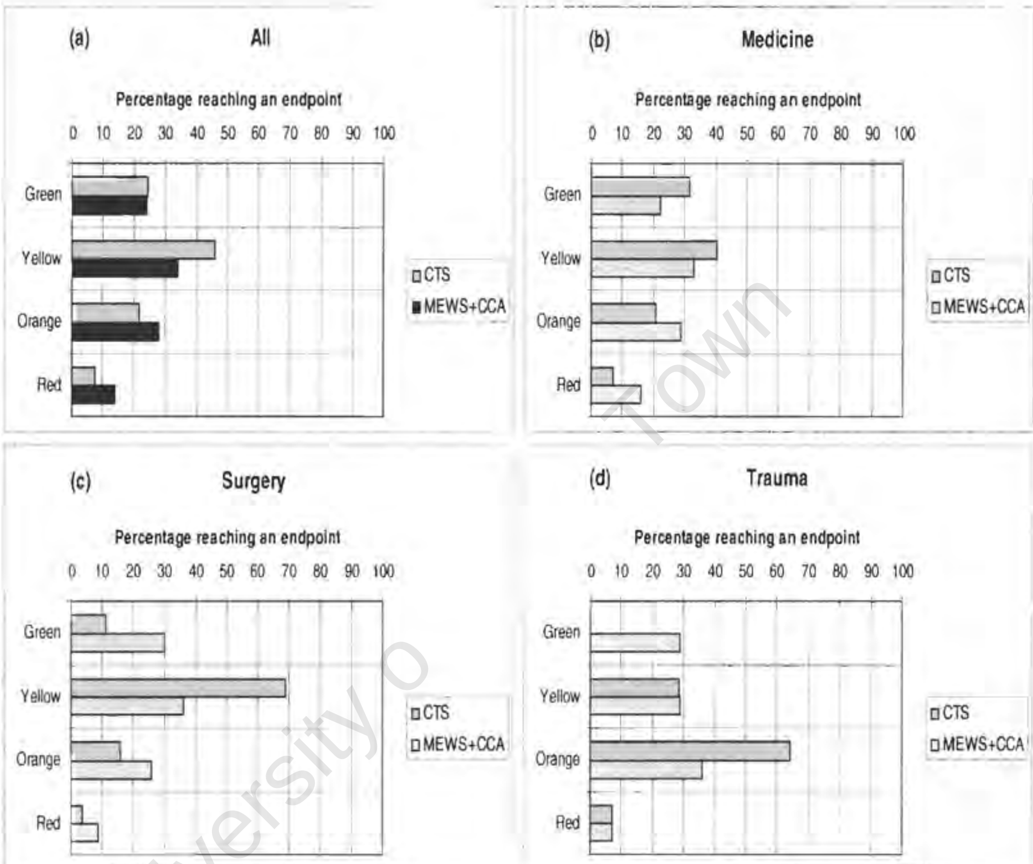

Figure 10(a)–(d): Comparison of the percentage cases reaching an endpoint using the CTS and the MEWS+CCA

Figure 10(a) demonstrates a significant increase in code red (p=0,01) and code orange patients (p=0,05) reaching an endpoint, while a significant decrease in code yellow patients (p=0,001) were observed. For the medical cases seen in Figure 10(b), a significant increase in endpoints reached for code red (p=0,003) and code orange patients (p=0,04) and a decrease in code yellow (p=0,12) and code green patients (p=0,02) was seen. The number of surgical patients in Figure 10(c) that reached an endpoint did not increase significantly for code red (p=0,19) and code orange patients (p=0,12), but decreased significantly for code yellow (p<0,00001). Code green surgical patients reaching an endpoint demonstrated a significant increase (p=0,003). Figure 10(d) shows the significant increase that was demonstrated for code green trauma patients reaching an endpoint (p=0,03). A decrease in code orange patients (p=0,13) was observed.

3.7.2 Simulation 2: Amended discriminator list (ADL)

There were eight conditions, not listed on the CTS discriminator list, which demonstrated a high risk of reaching an endpoint (Table 24). The MEWS alone was not sufficient to generate an appropriate colour code for true priority. The CCA of simulation 1 is also shown for these conditions.

Table 24: Mean MEWS and CTS priority colour code with and without the proposed colour code amendment of diagnoses frequently reaching an endpoint

Diagnosis	n=	Endpoints reached (%)	Mean MEWS	CTS colour code	With colour code amendment
Diabetic ketoacidosis	12	100	3	Yellow	Yellow
Major haemoptysis	10	100	3	Yellow	Yellow
Stroke	15	67	3	Yellow	Yellow
Suspected pulmonary tuberculosis	100	60	3	Yellow	Yellow
Community-acquired pneumonia	87	52	3	Yellow	Yellow
Suspected tuberculous meningitis	41	68	3	Yellow	Yellow
Renal failure	30	73	4	Yellow	Orange
Deep venous thrombosis	23	70	3	Yellow	Yellow

In simulation 2, the CTS discriminator list was thus amended to include three conditions into the orange colour category. These were diabetic ketoacidosis, stroke and major haemoptysis. The impact on the colour code distribution of the case load when MEWS+CCA+ADL were used instead of the CTS is shown in Figure 11.

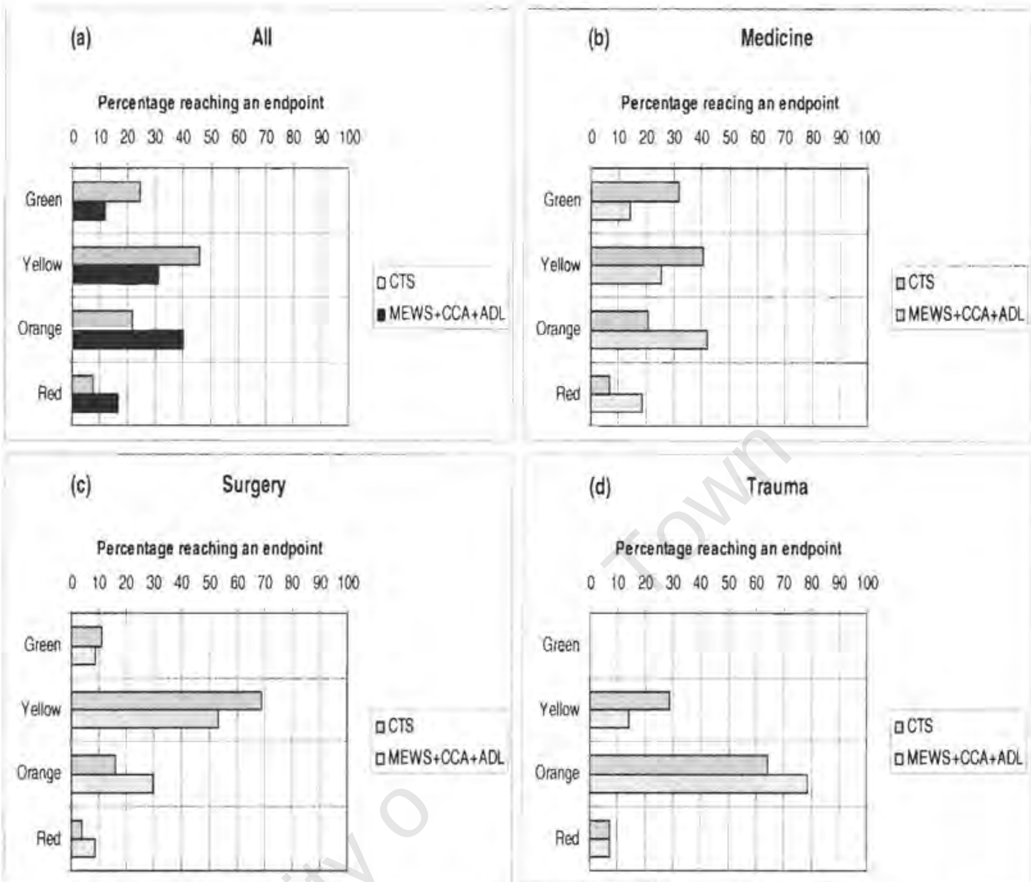

Figure 11(a)–(d): Comparison of the percentage cases reaching an endpoint using the CTS and the MEWS+CCA+ADL

Figure 11(a) demonstrates the significant increase in patients coded red (p=0,0002) and orange (p<0,00001), as well as the significant decrease in patients coded yellow (p=0,001) and green (p<0,00001) when all patients that reached an endpoint were considered. For medical cases (Figure 11(b)), an increase in patients reaching an endpoint coded red (p=0.0002) and orange (p<0.00001) was observed, as well as a significant decrease in patients coded yellow (p=0,0005) and green (p<0,00001). For surgical cases (Figure 11(c)), the increase in code red (p=0, 19) and decrease in code green cases (p=0,6) were not significant, but the increase in code orange (p=0,04) and decrease in code yellow cases (p=0,04) were. Figure 11(d) shows the insignificant change in trauma patients coded orange (p=0,40) and yellow (p=0,36) reaching an endpoint; cases coded red and green remained unchanged.

3.7.3 Simulation 3: Trauma factor (TF)

In an attempt to simplify the amended discriminator list and better prioritise trauma cases, a defined constant value of two, called the "trauma factor" (TF) was added to the MEWS of all patients, irrespective of the nature of the injury. All trauma diagnoses on the CTS discriminator list (DL) and amended discriminator list (ADL) were thus removed. For purposes of simplification the DL or ADL is referred to as DL-T or ADL-T whenever used in association with the TF (omissions tabled in Appendix 2). The impact on the colour code distribution of trauma cases when MEWS+CCA+(ADL-T)+TF was used instead of the CTS is shown in Figure 12.

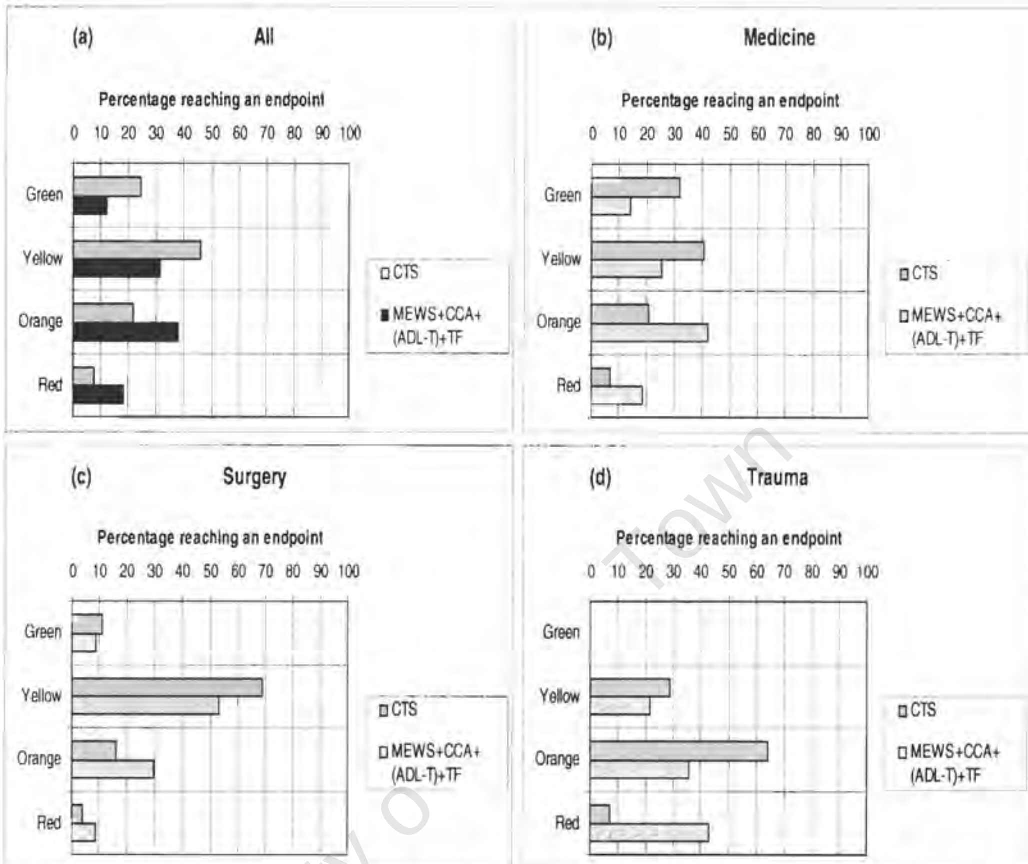

Figure 12(a)–(d): Comparison of the percentage cases reaching an endpoint using the CTS and the MEWS+CCA+(ADL-T)+TF

Figure 12(a) shows a significant increase for all patients reaching an endpoint coded red ($p<0,00001$) and orange ($p<0,00001$) and a significant decrease in patients coded yellow ($p=0,0001$) and green ($p<0,00001$). A significant increase in trauma patients reaching an endpoint coded red ($p=0,03$) and an insignificant decrease in patients coded orange ($p=0,13$) and yellow ($p<0,66$) is demonstrated in Figure 12(d). Cases coded green remained unchanged. Medical and surgical endpoints remained unchanged from those in Figure 10, which is expected since the addition of the TF only altered the distribution of trauma cases.

3.7.4 Summary of simulation findings

The percentage of cases reaching an endpoint as a function of all endpoints reached is shown in Table 25. The data are clustered into three groups (red-orange, red-orange-yellow and green), using the CTS as well as the various amendments to the CTS.

Table 25: Percentage of cases reaching an endpoint as a function of all endpoints reached in clustered colour codes

	Red-orange	Red-orange-yellow	Green
CTS	29%	75%	25%
MEWS+CCA	42%	76%	24%
MEWS+CCA+ADL	57%	88%	12%
MEWS+CCA+(ADL-T)+TF	56%	88%	12%

In Table 26, the data show that 36,3% of all patients coded red, orange or yellow reached an endpoint using the MEWS+CCA+(ADL-T)+TF triage tool. This was significantly more than the 31% that was achieved using the CTS without amendments (p=0,05). Table 26 also shows that significantly fewer cases coded green reached an endpoint with the use of the amended triage tool (MEWS+CCA+(ADL-T)+TF), than compared to the CTS (p=0,001)

Table 26: Percentage of cases reaching an endpoint as a function of the total number of patients (n=798).

	CTS	MEWS+CCA	MEWS+CCA+ ADL	MEWS+CCA+ (ADL-T)+TF
Green	10%	10%	5%	5%
Yellow	19%	14%	13%	13%
Orange	9%	12%	17%	16%
Red	3%	6%	7%	8%
Red/Orange/ Yellow	31%	31%	36.5%	36.3%

3.8 Evaluation of the accuracy of nursing triage

Kappa correlations were calculated using the triage codes assigned by the Enrolled Nursing Auxiliaries (ENA) and the triage codes assigned by the triage doctor. Interrater agreement results for nurses using the two triage tools are listed in Table 27. It can be seen that fully trained nurses performed better than partially trained nurses. The data furthermore suggests that partially trained nurses found the amended CTS (MEWS+(DLT)+TF) easier to use than the CTS.

Table 27: Interrater agreement for nurses (ENA) using the two triage tools as compared with the triage doctor

	CTS (TEWS+DL)			Amended CTS
	All nurses (n=8)	Fully trained nurses (n=3)	Partially trained nurses (n=5)	Partially trained nurses (n=8)
Number of cases	467	103	364	331
Kappa (ϰ)	0,73	0,87	0,73	0,78
95% CI	0,70–0,79	0,78–0,96	0,67–0,79	0,72–0,84
Weighted Kappa (ϰ)	0,77	0,89	0,77	0,82

Table 28 lists the overtriage, undertriage and agreement rate for trained and partially trained nurses in the use of the CTS. Fully trained nurses undertriaged significantly less often than partially trained nurses.

Table 28: Overtriage, undertriage and agreement rate for partially and fully trained ENA using the CTS

	Fully trained nurses (n=3)	Partially trained nurses (n=5)	p-value
Overtriage	13,6	10,7	0,42
Undertriage	7,8	17,0	0,02
Agreement	78,6	72,3	0,19

Table 29 shows that undertriaging or overtriaging did not differ significantly with the use of the amended CTS as compared to the CTS.

Table 29: Overtriage, undertriage and agreement rate and p-value difference for nurses using the amended CTS and nurses (all, fully and partially trained) using the CTS

	Amended CTS, all nurses (n=8)	CTS, all nurses (n=8)		CTS, fully trained nurses (n=3)		CTS, partially trained nurses (n=5)	
	%	%	p-value	%	p-value	%	p-value
Overtriage	8,5	11,4	0,18	13,6	0,12	10,7	0,31
Undertriage	12,7	15	0,36	7,8	0,16	17,0	0,11
Agreement	78,9	73,7	0,09	78,6	0,96	72,3	0,04

3.9 Evaluation of the impact of nursing triage on patient waiting times

Waiting times were significantly reduced in all but one colour code category after introduction of a triage system. Table 30 lists the waiting times before and after the introduction of the triage system. The most dramatic reduction in waiting time was observed in the red code category. The waiting time in the green code category did not change significantly after introduction of triage.

Table 30: Waiting times before and after the introduction of triage (in minutes)

Colour code category	Waiting time in minutes before implementing triage (n=319)	Waiting time in minutes after implementing triage (n=823)	p-value
Red	216	38	<0,00001
Orange	213	119	<0,00001
Yellow	258	155	<0,00001
Green	245	199	0,13
All patients	237	146	<0,00001

Chapter 4

DISCUSSION

4.1 Quality of data capture

Of all the data capture sheets (DCS) sent out prospectively, 82% were retrieved with all fields completed. The prospective sample size calculation showed that a sufficient number of cases were enrolled to allow the findings to be regarded as significant and relevant. The quality of the prospective data capture was therefore very good. These data were used in all the sections of the results chapter. In comparison, retrospective data were used (in conjunction with the prospective data) for the waiting time section only. Similar to Hay et al., who collected all their data retrospectively, this part of the data capture was low (56% for the study of Hay et al. and 44% for this study).[39] The retrospective sample was just 4% short of the calculated sample size. Nevertheless, given the highly significant findings of the section where retrospective data were used, it can be assumed that sample size did not significantly bias this result. Insufficient record-keeping was found to be the main reason for incomplete retrospective data.

4.2 Basic patient demographics

A good correlation was shown between the mean and median ages retrospectively taken from the Department of Medicine's admissions audit and that of the prospectively collected medical component. The mean age overall was 39 years. Bearing in mind that the mean current life expectancy for South Africans is only 47 years, this finding highlights the changing demography of health care in South Africa.[103] There were more female patients than male patients in the surgical group, which was due to the inclusion of gynaecological problems into this group. More male patients accessed the emergency unit for trauma-related problems.

4.3 Emergency unit attendance and overall outcome

Medical patients contributed more than half (56%) of the prospective study population. This was expected, given that medical conditions account for most of South Africa's high burden of disease and mortality.[103, 104] Almost half of patients reached an endpoint. The largest portion of these was for general admissions (38,2%), followed by high care ward admissions (3,4%). Death in the emergency unit was rare (0,4%).

4.4 Evaluation of the Cape Triage Score (CTS)

4.4.1 Outcome related to CTS colour code

Cases in this section were allocated priority colour codes using the CTS. About a quarter (23%) of patients was allocated to the "stable" green priority code, with the rest of the patients allocated to the more "unstable" codes (yellow, orange and red). Patients in the yellow priority code made up 50% of the total number of patients.

The percentage of the green priority code cases reaching an endpoint (25%) was much higher than the unavoidable 5–10% accepted for undertriage.[67] This was especially true for medical cases. Surgical and trauma cases were more appropriately prioritised by the CTS. In order to address the shortcomings of the tool, the different components of the CTS had to be studied individually. Table 31 lists the problems that required attention.

Table 31: Problems identified during validation of the CTS

1.	Medical MEWS significantly higher than trauma MEWS
2.	Mobility parameter increased medical TEWS significantly, but not the trauma TEWS
3.	Undertriaging of medical patients

4.4.2 Components of the CTS

4.4.2.1 Modified Early Warning Score (MEWS)

The mean MEWS for medical patients was significantly higher than that of both surgical and trauma patients. The MEWS clearly allocated higher values to medical patients, which is quite acceptable since the MEWS was specifically designed with medical patients in mind.[15, 16] Physiological parameters were significantly more abnormal in patients who reached an endpoint. In fact, the higher a patient's MEWS, the higher the patient's risk of reaching an endpoint.

When the MEWS was analysed according to the separate physiological parameters, those parameters with higher scores demonstrated a higher relative risk of reaching an endpoint. This was true for a high respiratory rate, pulse rate, temperature and low systolic blood pressure. A similar observation was made by Subbe during his MEWS validation study, with the exception of the temperature parameter.[16] When viewed in the context of the higher prevalence of infectious diseases in South Africa, this was not an unexpected finding.[104] As found by Subbe and others, the respiratory rate, of all the parameters, was also shown to be the most pertinent parameter in predicting an endpoint.[15, 16, 95, 96, 97]. It is thus clear that the MEWS is able to predict endpoints in the South African context; similar to what has been described in the United Kingdom.[15, 16, 58, 88] If it can then be assumed that more ill patients would more readily require admission, the use of the MEWS as a basis for a triage tool is sound.

4.4.2.2 Mobility parameter

Almost two thirds (61%) of patients that required assistance to enter the emergency unit reached an endpoint. This was significantly more than the 35% of walking patients reaching an endpoint. Mobility predicted endpoints for both medical and surgical cases, with 64% and 71% of patients reaching endpoints requiring assistance respectively. There was no significant difference between endpoints reached for these two groups. The opposite was true for trauma, with only 21% of patients requiring assistance reaching an endpoint. The likelihood of immobile trauma patients reaching an endpoint was thus significantly lower than that of immobile medical patients even though the proportion of patients requiring assistance, 22% and 32% of trauma and medical cases respectively, was similar. Thus, even with comparable proportions of patients requiring assistance, medical patients were more likely to reach an endpoint, while trauma patients were likely to be discharged.

It has already been shown that the mean MEWS for medical cases was significantly higher than that for surgical and trauma cases. With the addition of the mobility parameter as suggested by the Cape Triage Group (CTG), thereby creating the Triage Early Warning Score (TEWS), this difference became even more apparent. Medical cases showed a significant increase in their TEWS as compared to MEWS. Surgical and trauma cases failed to show a significant increase. The problem of using mobility as a component of the triage tool becomes clear when these findings are considered in the light of the CTG's postulate that patients with better physiological reserves but severe injuries (trauma), and consequently near normal physiology, might benefit from the addition of mobility as an additional parameter to the MEWS.[87] Instead of improving early warning scores for trauma cases, the mobility parameter only increased the early warning scores for medical cases.

It has to be pointed out though that the number of medical cases enrolled in this study were far more than the number of trauma cases enrolled. It can therefore not be assumed with absolute certainty that the mobility parameter only influenced medical cases. Whether this finding will hold true for a larger trauma sample size is beyond the scope of this study and will require further investigation.

4.4.2.3 Discriminator list

It is clear that even though medical cases generated the highest TEWS they still ended up being poorly prioritised. On the contrary, trauma cases, which generated the lowest TEWS, were prioritised quite well. The CTG foresaw this potential problem and added selected clinical discriminators to the TEWS to improve the prioritising of serious conditions not necessarily reflecting abnormal physiological parameters (Appendix 1).[87] This was an appropriate addition since 79% of conditions listed on the discriminator list were responsible for raising the priority colour code of cases from the inappropriately low priority code generated by the TEWS alone. A significant reduction in code green patients reaching an endpoint was shown, as well as a significant increase in code orange and code red patients reaching an endpoint. Thirteen items on the discriminator list were never used during the study period (Appendix 2). These items as well as the four items that were appropriately prioritised by the TEWS require careful re-evaluation to assess whether they are all applicable. This is beyond the scope of the current study.

The discriminator list made a considerable impact on prioritising trauma cases. Given this, and the fact that the TEWS also generated low values for trauma patients, it is fair to question the value of using the TEWS for prioritising trauma patients at all. Medical cases were the least affected by the discriminator list although improvements were noted. Since the percentage of code green medical patients who reached an endpoint still remained quite high even after applying the discriminator list, it could be safely assumed that not all potential medical discriminators were included.

4.5 Proposed amendments to the CTS

The basic principle of the CTS was sound. However, it appeared as if small alterations and additions to the existing framework could improve its efficiency. A number of amendments were proposed and three simulations were done to test the validity of the suggested amendments.

It was decided to use the MEWS as basic score for the simulations instead of the TEWS because the results suggested that the mobility parameter did not achieve its intended purpose as proposed by the CTG.[87] The significant difference that already existed between the mean medical and trauma MEWS increased even further with the addition of the mobility parameter. In fact, the imbalance created by the addition was exactly opposite to its originally proposed purpose. Given these findings and the close correlation between the TEWS and the MEWS, it made sense to use the MEWS without the mobility parameter.

Table 32 lists the problems found with the CTS and the simulations used to amend them.

Table 32: Simulations used to amend problems identified with the CTS

Problems identified with CTS:	Simulation used to amend problem:
- Medical MEWS significantly higher than trauma MEWS	1. Colour code amendment 3. Trauma factor
- Mobility parameter increased medical TEWS significantly, but not the trauma TEWS	1. Colour code amendment 3. Trauma factor
- Undertriaging of medical patients	1. Colour code amendment 2. Amended discriminator list

4.5.1 Simulation 1: Colour code amendment (CCA)

The MEWS was designed for medical patients and the data have shown already that a higher MEWS reflected a higher likelihood of reaching an endpoint. This suggested that if medical patients were undertriaged it had more to do with the priority colour codes reference ranges than with an actual inherent flaw in the MEWS. The early warning score ranges for colour codes were originally set by the members of the CTG. Since no evidence existed at the time to guide the process, ranges were empirically set.

Subbe identified a MEWS value, namely the 'critical score', above which endpoints became more likely.[16] Simulation 1 postulated that if colour code ranges were based on the 'critical score' for this study's data, prioritising would be more reliable. The critical score was found to be between three and four. Cases scoring a MEWS of four or more were significantly more likely to reach an endpoint than those of three and below. Given this amendment, an appropriately significant increase was seen in red and orange code medical patients. This was accompanied by a significant decrease in green code patients. Although this result was much better than with the use of the CTS, undertriage still remained high for the green priority code (approximately 20%).

4.5.2 Simulation 2: Amended discriminator list (ADL)

The original discriminator list, as suggested by the CTG, significantly decreased undertriaging of surgical and trauma cases only. It was thus assumed that not all relevant medical discriminators were accounted for in the original discriminator list. The study database was reviewed to identify the unlisted conditions reaching an endpoint despite a low MEWS. Eight conditions were found. These conditions were reviewed and three were considered to be life-threatening if left unlisted: diabetic ketoacidosis, haemoptysis and stroke. Three of the conditions were identified as slowly progressive conditions (deep venous thrombosis, pulmonary and meningeal tuberculosis) and therefore did not require higher priority colour coding. Community-acquired pneumonia cases were considered to have been prioritised appropriately in the yellow colour code, and with the use of an amended colour code renal failure cases were prioritised as orange, which was also considered appropriate.

For simulation 2 the original discriminator list was thus amended to include diabetic ketoacidosis, haemoptysis and stroke as orange colour code discriminators. Medical undertriage was reduced to 14%. Given that about a third of medical conditions reaching an endpoint were considered slowly progressive (deep venous thrombosis, pulmonary and meningeal tuberculosis) and therefore not considered high priority, the undertriage rate was accepted as such. Medical cases also showed a significant increase in red and orange colour code cases following the amendment. There was no significant difference expected or shown for trauma cases, since no trauma discriminators were added.

4.5.3 Simulation 3: Trauma factor (TF)

It has already been shown that a significant difference existed between the mean MEWS of trauma and medical patients. This difference was anticipated by the CTG. According to them, this was due to trauma patients' better physiological reserves, even with severe injuries, and consequently a near normal physiology.[8] A mobility parameter was introduced in order to balance out the differences but instead it did the opposite. Trauma patients turned out to be far less dependent on assistance than medical and surgical patients. Since both the early warning scores (MEWS and TEWS) triaged trauma patients too low, trauma prioritising became most dependent on the discriminator list. This was actually quite effective in prioritising patients accurately, but was also responsible for about a third of the conditions on the discriminator list, which had grown even longer following the amendment proposed in simulation 2.

Simulation 3 thus postulated that trauma early warning scores could be improved by adding a defined constant value of two to all trauma cases. It would therefore not be dependent upon the discriminator list and all trauma conditions could be removed from the list, resulting in a more manageable list. The constant factor was called the "trauma factor". The value of two was derived from the interim analysis, which showed that the difference between the mean medical and trauma MEWS was two. A significant increase in red priority code patients was shown. The differences for both yellow and orange were insignificant. With no green code patients and a steady increase from yellow to orange to red code patients the postulation was proven correct. The trauma factor significantly improved the early warning scores for trauma patients. Separate trauma discriminators were thus not required and the length of the amended discriminator list was markedly shortened.

Since the trauma factor only affected trauma cases, medical and surgical scores remained unaffected. It is recognized that the sample size for trauma cases were small. Still, it is clear that the trauma factor may have a beneficial role in amending the MEWS for trauma triage. Whether the factor's value needs to remain at two or be altered slightly will require a separate study with a larger trauma sample size.

4.5.4 Summary of proposed amendments to the CTS

In summary then, endpoints were most appropriately predicted when simulations were combined. The amendments led to a significant reduction in undertriaging and consequently a significant increase in endpoints reached in the higher priority colour code categories. The optimal triage tool was achieved by making all three suggested amendments to the original CTS:

1. Use the MEWS as the basis of the triage tool

2. Amend the colour code categories as follows:

a) Green:	0-1
b) Yellow:	2-3
c) Orange:	4-5
d) Red:	6 and more

3. Amend the discriminator list as follows:

a) Additions:	Diabetic ketoacidosis, stroke and major haemoptysis
b) Remove:	All trauma content

4. Add a score of two to the MEWS of all trauma patients

4.6 Accuracy of nursing triage

Two things need to be explained about this section before the results can be discussed. The first concerns the interim analysis. As discussed in the study design, an extra month of data capture was undertaken with an amended CTS, after an interim analysis suggested potential benefit to patient care based on the amendment. The amendment involved the use of simulation 3 (substitution of the mobility parameter with the trauma factor and removing all trauma diagnoses from the discriminator list). Triage nurses used the CTS from December 2004 until February 2005 and then used an amended CTS (MEWS+(DL-T)+TF) for March 2005. This allowed comparison of both tools in order to establish which tool was preferred.

The second point considers the use and interpretation of Kappa correlations. Kappa measures the percentage of data values in the main diagonal of a table (given any 2 x 2, 3 x 3 or n x n table) and then adjusts these values for the amount of agreement that could be expected due to chance alone. It is thus a very strict measure of agreement. Table 33 gives an interpretation of Kappa values. Kappa correlations are used throughout the referenced literature, hence it was used for data analyses in this study as well.[38, 63, 65] For purposes of this study, interrater agreement was measured as nursing triage against doctor triage (principal investigator); this is explained in the methods chapter.

Table 33: Interpretation of Kappa values

Kappa value	Level of agreement
Less than 0,20	Poor agreement
0,20 to 0,40	Fair agreement
0,40 to 0,60	Moderate agreement
0,60 to 0,80	Good agreement
0,80 to 1,00	Very good agreement

Given the higher Kappa values, it is clear that fully trained nurses showed better interrater agreement than their partially trained counterparts. The results show that the most significant benefit with training was the reduction in undertriaging of patients. Fully trained nurses undertriaged 7,8% of cases. The Committee on Trauma of the American College of Surgeons (ACSCOT) has suggested than an undertriage rate of 5–10% cannot be avoided.[67] The undertriage rate of fully trained nurses in this study was thus acceptable. Overtriage, similar to findings in referenced literature,[69 71] increased with lower undertriage, though insignificantly. Hay et al. found the Kappa correlation between nurse and doctor to be 0,90, following introduction of nursing triage at Barzilai Medical Centre, Israel. He also found the rate of agreement to be lower for nurses with less experience.[38] Using the Emergency Severity Index (ESI) Tanabe et al. found the Kappa correlation between nurse and doctor to be 0,89, and Beveridge et al. found it to be 0,84 for nurses using the Canadian Triage and Acuity Scale (CTAS).[63, 65] These Kappa values compare well with the study results for fully trained nurses (κ=0,89). It is clear that trained Enrolled Nursing Auxiliaries in this study demonstrated highly accurate triage skills; training was integral to the process.

Nurses were only offered training in the use of the amended CTS on the day of their triage duty. They were given a 20-minute verbal explanation of the tool and how it differed from the CTS. An amended A3 wall chart was also used. For this reason, all nurses who participated in the last month of the study were regarded as partially trained. The highly insignificant difference between the agreement rates of fully trained nurses using the CTS (78,6%) and nurses using the amended CTS (78,9%) is therefore noteworthy. This result is concordant with the significant difference (p=0,04) shown between partially trained nurses using the CTS (72,3%) and nurses using the amended CTS (78,9%). Since the same nurses participated in both parts of the study, it is likely that the triage tool used was responsible for the improvements seen. Given the shorter discriminator list and the substitution of the mobility parameter with the trauma factor it can be assumed that the amended CTS was less complex, probably easier to use and thus required less training. The use of the principal investigator as the gold standard to which nursing triage was compared may be considered a potentially biasing factor, but was unavoidable, however.

4.7 The impact of nursing triage on patient waiting times

The dramatic reduction in patient waiting times following the introduction of triage is undoubtedly the most significant finding of the study (Appendix 4). The red priority code decreased from a mean of 216 minutes to 38 minutes (median of 25 minutes), allowing critically ill patients to be seen in a significantly shorter time. It has to be kept in mind though that the emergency unit of GF Jooste Hospital dealt with an estimated 20 000 patients over the four month prospective study period. If not viewed from this context the waiting times after introduction of the triage system would still appear relatively high. A similarly significant reduction was seen for orange and yellow priority code patients. The reduction for green coded patients was not significant. Since green coded patients were not regarded as urgent priority patients, this was an expected and acceptable finding.

Interestingly, the overall waiting time showed a significant reduction as well. Staff numbers and level of experience were comparable for both the retro- and prospective study periods, leaving the introduction of triage as the only major variable. In this case it would seem that triage not only allowed critically ill patients to be timeously prioritised, but also reduced overall waiting times. It can thus be speculated that effective triage improved the overall flow of patients through the emergency unit. Irrespective of the reason, the beneficial impact of nurse triage on the high patient volumes accessing this public sector emergency unit is apparent.

4.8 Outcomes reached compared to targets

The targets set in the methods section for patients reaching endpoints were met only when the CTS was used with all of the proposed amendments. Used on its own, the CTS failed to reach any of these targets. The percentage of patients dying during the study period was negligible and thus not investigated further.

Only trained Enrolled Nursing Auxiliaries using the CTS fulfilled all the criteria set to be regarded as efficient triage officers. Even though the improved agreement rate when compared to partially trained nurses was not significant, the significant decrease in undertriage highlights the importance of proper training before commencing triage duty. The nursing group using the amended CTS (all partially trained) showed an insignificant decrease in undertriage rate compared to partially trained nurses using the original CTS, though the significant improvement in agreement rate probably indicates that the amended tool was simpler to use.

The CTS, used on its own and with all the amendments, only reached the time targets set for the green priority code group. None of the other priority colour code groups met any of the waiting time targets set by the principal investigator or those proposed by the CTG. All of the priority colour code groups, with the exception of the green code group, however, did show highly significant reductions in waiting times. Despite not reaching ideal targets, the significant reduction in waiting time for the higher priority colour codes represents a major success of the study. Other factors that may also have had an impact on waiting times include the number and level of training of medical staff compared to the number of high priority or complex cases and total case load, lack of resources, delayed patient transfers and delays in the return of special investigation results. Further study would be required to determine whether waiting times could be further reduced by reducing the impact of these variables.

Chapter 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Triage is not a new concept. It was used by Napoleon's Army in the war of the Rhine in the eighteenth century, the American Civil War in the nineteenth century and World Wars I and II, in the twentieth century. It has been part of Intensive Care Medicine, Nephrology, Transplant Medicine, Obstetrics, Paediatrics and Emergency Medicine for over fifty years. Virginia Apgar was made famous for developing a triage tool to prioritise treatment offered to newborns at birth. The scoring system she devised was simple enough to be used by labour ward nurses and was responsible for a drastic decrease in neonatal mortality. Emergency unit triage, successfully driven by nurses, has been the norm in the developed world, following an increase in patient numbers during the late 1950s and early 1960s. Triage tools were developed by various health authorities to safely streamline the process. Tools like the Manchester Triage System (United Kingdom), Canadian Triage and Acuity Scale and Australasian Triage Score, though excellent triage tools, are all quite complex, leading to prolonged initial assessment times and the need for extensive training and time to master their use.

Until now, triage has not been formally practised in South Africa and no triage tool exists for use in the South African context. With the annual medication budget set at R3 billion, an average life expectancy of approximately 47 years due to HIV/AIDS, homicide/violence and tuberculosis as the top three causes of death and with 38 million impoverished South Africans relying on public sector health services, the increased patient flow to public sector emergency units over the last 10 years is not at all surprising. This information is of even greater concern given the lack of doctors (approximately 69 per 100 000 population, compared to 209 for Canada, 249 for Australia and 166 for the United Kingdom).

Given the high volume of patients accessing the public healthcare service, the low number of doctors and relatively high doctor: nurse ratio (1:6), it was inevitable that triage driven by nurses should also be considered in South Africa. It was clear that the bulky tools used elsewhere would be inappropriate for use in the South African context and that a simple system capable of dealing with large patient volumes, similar to the APGAR, was required. Such a simple triage tool, the CTS, based on the MEWS score, was devised by the CTG for exactly this purpose. It was the purpose of this study to:

1. evaluate the use of the CTS as a suitable triage tool and identify potential amendments to improve it;

2. determine the accuracy with which Enrolled Nursing Auxiliaries could use this tool for triage; and

3. the impact of triage on patient waiting times in a busy public hospital emergency unit.

The three parts of the CTS (MEWS+mobility parameter+discriminator list), were carefully evaluated. The medical MEWS was significantly higher than the trauma MEWS. The mobility parameter, introduced to improve the early warning scores for patients with better physiological reserves but severe injuries (trauma), only improved the early warning scores for patients who already had high scores. Given the already low trauma MEWS, the trauma TEWS was now so low in relation to the medical TEWS that trauma became almost completely dependent on the discriminator list. It was also found that the CTS undertriaged medical patients at an unacceptably high rate. Still, given the MEWS' proven prediction capability and the effectiveness of most of the contents of the discriminator list, the CTS was not fundamentally flawed.

Four amendments were suggested to improve the CTS. These were tested using three simulations. The basic MEWS without a mobility parameter was used following the parameter's poor performance in its intended purpose. The colour code range was amended after establishing the critical score above which endpoints became more likely, and the discriminator list was amended to include three serious medical conditions that had been repeatedly undertriaged with the MEWS alone. Finally, a constant trauma factor of two was added to the MEWS of all trauma patients. All trauma-related conditions were then removed from the discriminator list. The result was an amended triage tool with an acceptably low undertriage rate capable of predicting endpoints over the widest spectrum of emergency unit presentations.

Fully trained nurses showed a high rate of interrater agreement and low undertriage rate when compared to doctor triage. The use of a simplified amended CTS (MEWS+(DL-T)+TF) further improved the triage score accuracy of partially trained nurses. Most significantly, nurse triage resulted in an overwhelming reduction in the waiting times of patients. Triage not only reduced waiting times for patients with serious illness or injury but the overall waiting time as well.

5.2 Recommendations

Based on the significant results of this study the following recommendations are made:

1. Consider removal of the mobility parameter to use only the basic MEWS. A study with a larger trauma sample size is required to assess the validity of this recommendation.

2. Incorporate the colour code amendment and discriminator list amendment in the CTS. Both amendments are based on significant results from adequate sample sizes. Further study may be required to determine the relevance of the unused discriminators and discriminators triaged appropriately by the MEWS alone.

3. Consider the inclusion of a trauma factor. A larger trauma sample size is required to confirm the significant findings of this study. Such a study should be able to determine the most appropriate constant for the trauma factor as well.

4. Nurses at the level of Enrolled Nursing Auxiliary appear highly suitable to perform emergency unit triage duties following adequate training in the use of the amended CTS. Further research aimed at comparing interrater and intrarater reliability should be considered to confirm the findings.

5. Following the amendments to the CTS and adequate training of nurses, it is recommended that a multicentre study (incorporating primary health care emergency units in order to access a larger sample size) be done to confirm the improvements.

Triaging in public sector emergency units is long overdue and offers a solution to the overcrowding that severely hampers efficient service delivery in these institutions. Given the dire shortage of doctors in the public sector and the current multiple burdens of disease, doctor-based triage is a luxury ill afforded in South Africa. Nurses, using the CTS with the amendments proposed in this study, should play an integral part in emergency unit triage in South Africa's public health care sector.

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APPENDICES

Appendix 1: The Discriminator List [87]

	Red	Orange	Yellow	Green	BLUE IS DEAD
TEWS	>7	6–7	3–5	0–2	
Mechanism of injury	Entrapment	Impact – high	Impact – low		
Symptoms					
Pain		Severe	Moderate	Mild	
Respiratory	Asthma – status	Asthma			
Cardiac		Chest Pain			
Vascular		Haemorrhage – arterial			
Neurological	Seizure- current	Seizure – postictal			
	Unresponsive	Responds to pain	Responds to voice	Alert	
Psychiatric		Psychosis/ aggression			
Orthopaedic		Limb – threatened			
		Dislocation – major joint	Dislocation – minor joint		
		Fracture – open	Fracture – closed		
Burn	Burn face/ inhalation	Burn>20%	Burn – minor		
Metabolic	Hypoglycaemia< 2,2	Overdose/ poisoning			
Intestinal		Haematemesis	Abdominal pain		
Obstetric		Pregnancy-trauma	Pregnancy – PV bleed		
Anatomy	Trauma – airway	Trauma – head/neck/torso/ evisceration	Trauma – limb		
Senior Healthcare Professional's discretion					

Appendix 2: Discriminator list (DL) contents when used with the different triage tools and contents never diagnosed during study period

	DL used with TEWS	DL used with MEWS+TF (all trauma removed)	DL contents never diagnosed during study period
Mechanism of injury	Entrapment, high & low impact		Entrapment, high & low impact
Symptoms: Pain	Severe, moderate & mild	Severe, moderate & mild	Severe, moderate & mild
Respiratory	Asthma – status & not status	Asthma – status & not status	
Cardiac	Chest pain	Chest pain	
Vascular	Arterial haemorrhage		Arterial haemorrhage
Neurological	Current seizure, postictal state & AVPU	Current seizure, postictal state & AVPU	AVPU
Psychiatric	Psychosis & aggression	Psychosis & aggression	
Orthopaedic	Threatened limb, major & minor dislocations, open & closed fractures		Threatened limb & Major dislocations
Burn	Face/inhalation, >20% & minor		Face/inhalation & minor
Metabolic	Hypoglycaemia, overdose & poisoning	Hypoglycaemia, overdose & poisoning	
Intestinal	Haematemesis & abdominal pain	Haematemesis & abdominal pain	
Obstetric	Trauma & PV bleed in pregnancy	PV bleed in pregnancy	Trauma in pregnancy
Anatomy	Trauma- airway/ head/neck/torso/ evisceration/ limb		Trauma- airway/ evisceration
Additions to original DL	Diabetic ketoacidosis/ stroke/ major haemoptysis	Diabetic ketoacidosis/ stroke/ major haemoptysis	

Nursing Triage Study Data Capture Sheet

Name: Patient sticker Age: Gender: **M / F**

File nr: Area:

Fill in with ADMISSION

TRIAGE ON ARRIVAL

Date	DD / MM / YY
Time	HH : MM

Nurse:	Red	Orange	Yellow	Green
Doctor:	Red	Orange	Yellow	Green

TIME OF **ASSESSMENT**

Date	DD / MM / YY
Time	HH : MM

Referred from			Transported with	
Private	State	Self	Ambulance	Self

Fill in with OUTCOME

D/C	Transfer	RHT	Refer/ admit	Death

DISCIPLINE

Medicine	Psych	Trauma	Surgery	Other

Chief diagnosis	
Date	DD / MM / YY
Time	HH : MM
Name	Print & Signature

✓ TICK OFF TEWS & SYMPTOM COMPLEX

								Actual values:
SBP	< 70	71-80	81-100	101-199		>200		
Pulse		< 40	41-50	51-100	101-110	111-129	>130	
RR		< 9		10-14	15-20	21-29	>30	
Temp		< 35		35-38.4		> 38.5		
AVPU				A	V	P	U	
Mobility				Walking	With Help	Stretcher		

SYMPTOM COMPLEX

- Abdo pain
- Asthma, not status
- Asthma, status
- Burns, face/ inhalation
- Burns > 20%
- Burns minor
- Chest pain
- Dislocation, major joint
- Dislocation, minor joint
- DKA
- Evisceration
- Fracture closed
- Fracture open
- Haematemesis, fresh blood
- Haemoptysis
- Haemorrhage, arterial
- HONKC
- Hypoglyc < 2.2
- Limb threatened
- Overdose/ poison
- PV bleed BHCG+
- Pregnancy trauma
- Psychosis
- Seizure, current
- Seizure, postictal
- Trauma abdomen
- Trauma airway
- Trauma chest
- Trauma head
- Trauma limb
- Trauma neck
- **Not on the list**

Figure 13: Data capture sheet

Appendix 4: Pie charts comparing retro- and prospective waiting times

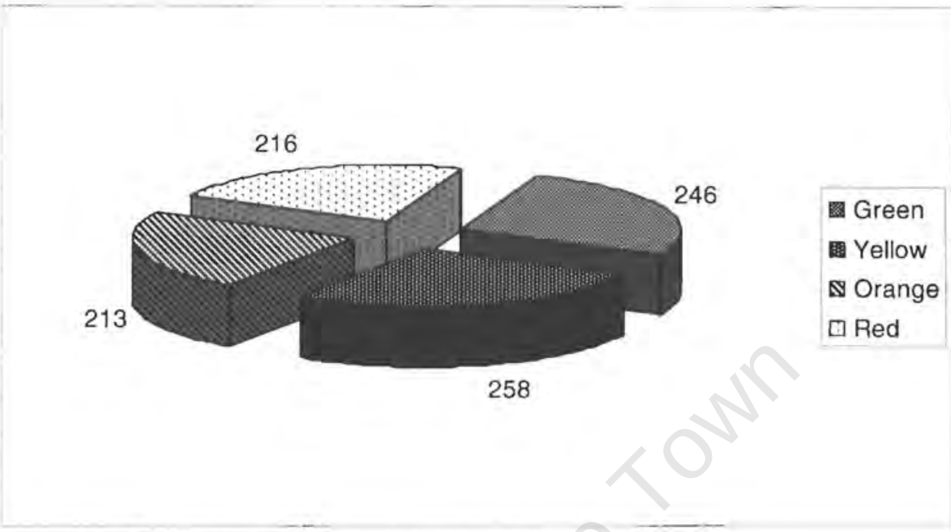

Figure 14: Mean retrospective waiting times in minutes

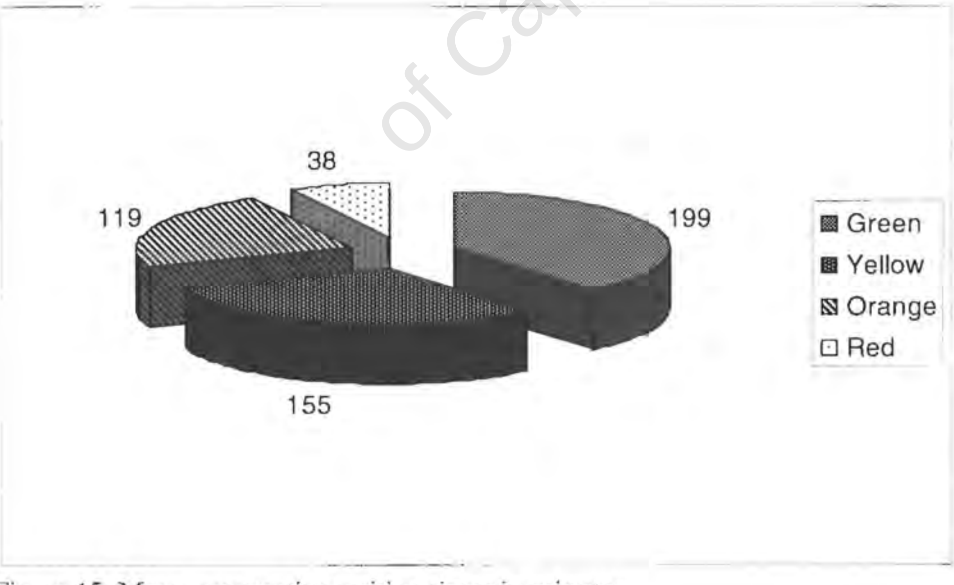

Figure 15: Mean prospective waiting times in minutes

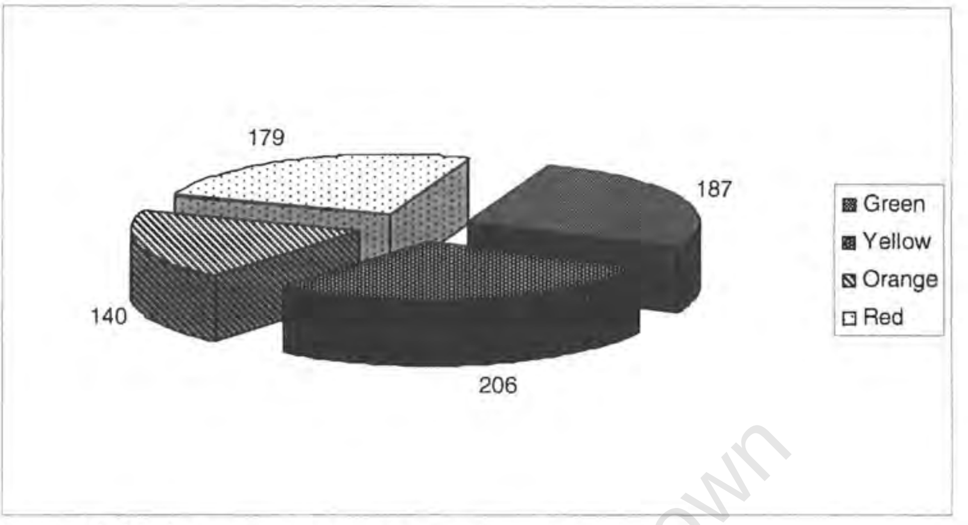

Figure 16: Median retrospective waiting times in minutes

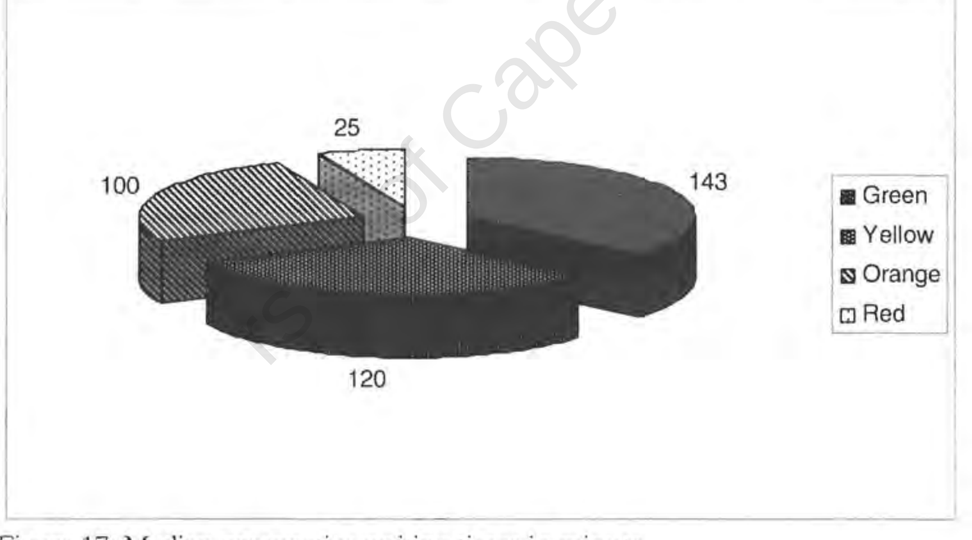

Figure 17: Median prospective waiting times in minute